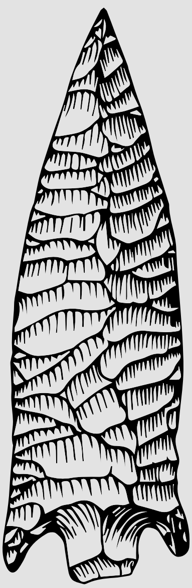
Revolutions

THE NEOLITHISATION OF THE MEDITERRANEAN BASIN: THE TRANSITION TO FOOD-PRODUCING ECONOMIES IN NORTH AFRICA, SOUTHERN EUROPE, AND THE LEVANT

Joanne M. Rowland
Giulio Lucarini
(eds.)
Geoffrey J. Tassie



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THE NEOLITHISATION OF THE MEDITERRANEAN BASIN involved a change from a procurement to a productive economy. Although the domestication of most of the plants and animals associated with the Old World Neolithic occurred in the Levantine Fertile Crescent, the Second Neolithic Revolution that resulted in elements of the Neolithic such as domesticates and objects occurring in North Africa and throughout Europe, is arguably just as important a process. Archaeological attention has been focused primarily on the initial domestication process, and only latterly on the spread of food producing economies.

In recent years, research into the Neolithisation of both Europe and North Africa has been increasing, notably so into the process by which varied communities adopted new food producing strategies. The implementation of new technology, methods, and theories have contributed to refinements in the timing of change in economies, analysis of the types of food eaten, and the reasons behind these transformations.

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Geoffrey John Tassie 'Tass' † (17th April 1959 – 28th March 2019)

Geoffrey John Tassie ('Tass') was at the heart of the Revolutions' workshop as a postdoctoral fellow at Topoi. His fieldwork in Egypt remained tightly aligned with the transitions to the first settled communities and transitions to statehood. He worked in the Fayum, at Neolithic Sais, Merimde Beni Salama, and Kafr Hassan Dawood, and played a key part in a prehistoric heritage planning project at St Katherine's Protectorate, in the Sinai. Tass co-founded the Egyptian Cultural Heritage Organisation (ECHO) in the late 1990s and remained its driving force until his passing, co-editing *Managing Egypt's Heritage* and *The Management of Egypt's Heritage*. His determination and dedication led to the publication of *Prehistoric Egypt* and *Standards of Archaeological Excavation* and in 2018 Tass instigated the *Naqada Regional Archaeological Survey* and *Site Management Project*. Loved by his friends and colleagues of all countries, he made a huge impression on his new colleagues at the Grand Egyptian Museum, where he had worked since September 2018. A gentle man, Tass always had time to discuss research and offer advice and encouragement to colleagues and students. Tass worked tirelessly on the editing of this volume, and we all dedicate this book to his memory.

Joanne M. Rowland, Geoffrey J. Tassie (†), Giulio Lucarini

Revolutions. An Introduction

Summary

This volume is the result of the two-day workshop organized in Berlin on the Neolithisation of the Mediterranean Basin. The implementation of new technology, methods, and theories have contributed to refinements in the timing of the changes in economies, analysis of the types of resources exploited, and the reasons behind these transformations. The papers herein seek to link theories and models with evidence from case studies around the Mediterranean Basin and along the Nile valley. The approaches of the authors range from scientific analyses, to theoretical approaches and artefact-based analysis. We hope to contribute to the debate about the various processes involved in the Neolithisation of the regions around the Mediterranean Sea.

Keywords: Neolithisation; Neolithic; climate change; environment; domesticates; food production; Mediterranean

Dieser Band ist das Ergebnis des zweitägigen Workshops über die Neolithisierung des Mittelmeerbeckens, der in Berlin organisiert wurde. Die Implementierung neuer Technologien, Methoden und Theorien trug bei zur Verbesserung zeitlicher Abläufe in der Bewirtschaftung, der Analyse der Art der Lebens- und Futtermittel und den Gründen hinter diesen Transformationen. Die Beiträge wollen Theorien und Modelle mit Evidenz aus Fallstudien im Mittelmeerraum verbinden. Die Ansätze der Autorinnen und Autoren reichen von wissenschaftlichen und Artefakt-basierten Analysen bis zu theoretischen Annäherungen. Wir hoffen damit zur Debatte über verschiedene Prozesse der Neolithisierung in Ländern am Mittelmeer beizutragen.

Keywords: Neolithisierung; Neolithikum; Klimawandel; Umwelt; Nutztiere; Nahrungsmittelproduktion; Mittelmeer

The editors would like to extend special thanks to Mary Beth Wilson who went to great lengths to bring this volume to completion, and in the final proof stages to Joselin Düsenberg. We appreciate it very much.

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Most studies on the processes of Neolithisation have focused on the mode of introduction or acquisition of the so-called 'Neolithic package' (i.e. pottery, polished stone tools, cultigens, and domestic animals). Recent research, however, is showing that separate elements of this 'package' appeared at different times around the Mediterranean Basin, and experienced variable longevity after its uptake and variability in terms of what was taken up. When Vere Gordon Childe coined the term Neolithic Revolution in the 1920s, he did not have the benefit of the radiometric dating methods we have today.[1] With the benefit of absolute chronologies of increasing precision, the timing of Neolithisation on intra- and inter-regional scales is now attainable. The chronology and pathways in which domesticated plants and animals, and other Neolithic practices, spread throughout Europe and North Africa from the core area of the Levant were the main focus of the workshop *"Revolutions. The Neolithisation of the Mediterranean Basin: The Transition to food Producing Economies in North Africa, Southern Europe and the Levant"*. The revolutionary character of this process was questioned throughout the discussions and more nuanced reconstructions of the reality that has been witnessed in several areas around the Mediterranean.

Research on the process of Neolithisation has generally concentrated on 'traditional' sources of archaeological data (e.g. archaeobotany and archaeozoology), with recent contributions from archaeogenetic analyses aimed at establishing whether animals were domesticated locally or not[2] and examining the evolutionary dynamics of plant domestication. Archaeogenetics is also being used to trace human movements across continents.[3] Traditional methods of analysis have now been joined by recent innovative scientific methods: organic residue analysis and stable isotope analysis, as well as Accelerator Mass Spectrometry (AMS) radiocarbon dating.[4] One of these methods, organic residue analysis, can tell us much about ancient diet, through the lipids that come from the fats, oils, and waxes of the substances originally held in the vessels. In recent years, researchers have been able to identify the processing of ruminant and non-ruminant carcass and ruminant milk products, aquatic products, plants, beeswax, and tree resins in ceramic vessels across a wide range of geographical and chronological contexts[5]. The potential for radiocarbon dating these lipids[6] opens up new possibilities for direct dating of species, and for charting the changing use and decline of species within food production through the Neolithic. Another key method, stable isotope analysis (carbon, oxygen, nitrogen, and strontium), has revolutionized how archaeologists reconstruct diet, how they examine the movement of populations of humans and animals,[7] and how they understand cultural interaction.

On Thursday the 29th of October 2015, the Revolutions Workshop was opened by the Speaker of Topoi for the Freie Universität Berlin, Michael Meyer.[8] Following his introduction, the first of the three keynote speakers was introduced, Barbara E. Barich, who stimulated us with her lecture, *"Rethinking the North African Neolithic: The Multifaceted Aspects of a Long-Lasting Revolution"* (see B. E. Barich in this volume). The applicability of the term Neolithic to the various modes of food production in Africa has been questioned, but as of yet no better term has been proffered. Barich looked at the long developmental period that led to this drastic economic change, examining the climatic changes and the human adaptations, using various datasets emerging from new research in North Africa to examine how and why this change occurred. Barich furthermore discussed the social dimensions that led to the acceptance of new domesticates, the new environment into which they were introduced, and how ways of life changed.

On Friday 30th October, the morning session opened with the second keynote lecture, delivered by Graeme Barker.[9] This keynote addressed the highly relevant theme of *"Where Has 50 years of Research on the Mediterranean Neolithic Got Us To?"* In 1965, Grahame Clark published two classic papers in *Antiquity* and the *Proceedings of the Prehistoric Society* in which he argued that the initial suite of ^{14}C dates from Early Neolithic sites in Europe suggested a spread of farming from the Near

1 Childe 1936.
2 Decker et al. 2014.
3 D'Atanasio et al. 2018; Fregel et al. 2018.
4 Zakrzewski, Shortland, and Rowland 2015.
5 Dunne, Evershed, et al. 2012; Dunne, Mercuri, et al. 2016; Roffet-Salque et al. 2016.
6 Casanova et al. 2020.
7 Leppard 2014.
8 Not published in this volume.
9 Not published in this volume.

East into Europe in two major streams between around 8000 BP and 5000 cal BP.[10] Barker examined the extent of our knowledge and understanding today on this topic, decades after the publication of these seminal papers, and the extent to which progress has been made and how the research agenda could develop.

The last of the keynote lectures, by Fekri A. Hassan, closed the Friday sessions, *"Ingenuity, Contingency and Exigency: A New Model of the Origins and Spread of Food Production in Southwest Asia and North Africa"* (see F. A. Hassan in this volume). Peoples' responses to the environmental changes that occurred as the world started to warm up after the Last Glacial Maximum have been of great interest for many years. The degree to which these changes affected people over the superregional level, particularly those that occurred in North Africa and the Levant, and the interconnectedness of the wider region, were central to this lecture. It also examined how mobility and demographic flexibility combined with reliance, as a matter of insurance, on low risk, labor-intensive foodstuffs were originally pursued, finally, hypothesizing how food production was originally practiced in the Levant ca. 10 000 years ago and how domesticates spread into Africa.

Session One of the workshop on Friday 30th October, "Ecology, Plants, and Animals", was chaired by Eva Rosenstock and comprised four papers, opened by Veerle Linseele, who addressed the appearance of early livestock within the parameters of archaeozoological research in northeastern Africa (see V. Linseele in this volume). There has been much new faunal evidence for early livestock discovered within the borders of modern Egypt, and Linseele discussed its implications for the timing and routes of dispersal of domesticates. This contribution raised one of the most debated topics, the autonomous domestication of cattle in Egypt, suggesting that the evidence now seems to favor the introduction of domesticated cattle from the Levant mixing with the wild cattle in Egypt, creating African taurine.

Elena Marinova then examined the use of wild plant resources in the early Neolithic as an indication for continuity between the Mesolithic and Neolithic plant-based subsistence economies in southeastern Europe[11] and northeastern Africa.[12] She considered evidence from the Bukova Pusta, Middle Danubian Plain, Romania, and Tell el-Iswid in the Eastern Nile Delta, Egypt. The results suggest that there was a persistence of Mesolithic/Epipalaeolithic traditions, but also that their geographic positions allow for researchers to trace the cultural interactions with the Near East; use of wild fruits or starch rich tubers, rhizomes, etc. are visible in both areas.

Giulio Lucarini and Anita Radini examined the importance of wild plants in the economy of North African prehistoric groups (see G. Lucarini and A. Radini in this volume). A relatively new approach that combines use-wear analysis of grinding tools and plant micro-residue analysis is helping to elucidate the diet of Early and Mid-Holocene communities. In particular, Lucarini and Radini used starch analysis on the grinding stones from Haua Fteah and Farafra to help clarify their function and determine the types of plants processed by the Holocene communities. This type of analysis shows that a variety of wild grasses were gathered and processed for food in different North African contexts during the Mid-Holocene, and that wild plants represented a primary source of food[13].

Continuing the theme of using new methods to look at utilitarian objects, Julie Dunne, presenting on behalf of herself and colleagues[14] examined the inception of dairying in Holocene North Africa, using organic residue analysis on ceramic sherds. This technique can reveal much about the ancient diet, as the lipids that are extracted from the pots come from the fats, oils, and waxes of the substances stored or cooked in the vessels. Mainly focused on Algeria, Libya, and the Sudan, the results presented show that the exploitation of milk and milk products occurred contemporaneously (in the seventh millennium cal BP) in the Mediterranean, the Nile Valley, and Saharan North Africa. The use of secondary products, such as dairying, now appears to have occurred concurrently with the first exploitation of domesticates, and played an important role in the subsistence economies of Neolithic peoples.

Session Two moved from the micro to the macro. "Modelling Neolithisation" was chaired by Nick Barton. It looked at the process of Neolithisation on a

10 Clark 1965a; Clark 1965b.
11 Marinova, Filipović, et al. 2012/2013; Marinova and Krauß 2014.
12 Not published in this volume.
13 Lucarini, Radini, et al. 2016; Lucarini and Radini 2020.
14 Not published in this volume.

large-scale, and the various means that enabled its spread over large distances. Katie Manning and Adrian Timpson[15] then stayed in North Africa to look at the peopling of the "Green Sahara". The timing and development of Holocene human occupation in the Sahara has been linked to climate change, demography, and cultural adaptation for a long-time. Using summed probability distribution from 1011 calibrated ^{14}C dates gathered from Epipalaeolithic and Neolithic sites, a major and rapid demographic shift can be seen to have occurred in the African Humid Period (10 500 cal BP and 5500 cal BP),[16] which was interpreted as revealing that climate was the prime factor driving broad-scale population dynamics in Northern Africa. The movement of people into what is now arid desert appears to correspond with changes in the environment; as the climate became wetter new plants and animals populated this region, and as the region became again more arid, people sought refuge in the better-watered regions, such as oases and the Nile Valley.

Moving from North Africa to the islands of the Mediterranean Sea, Helen Dawson examined the Neolithisation of these often overlooked pieces of land, showing that many were first colonized during this period. However, many of the larger islands (Sicily, Sardinia, Corsica, Crete, and Cyprus) were colonized prior to the Neolithic and an increasing number of smaller islands in the Aegean (see H. Dawson in this volume). Dawson suggested that after the Neolithic, an island's size and distance were no longer key parameters affecting colonization. As people began to use boats and ships more frequently, communities were more able to overcome geographical constraints and sustain long-term population through economic and social interaction.

Moving to the north coast of the Mediterranean, Marcello Mannino[17] presented on the isotopic research that he has been carrying out with colleagues. This paper examined the use of AMS radiocarbon dating and stable isotope analyses (carbon, nitrogen, and sulphur) on bone collagen of domestic fauna from Neolithic levels at Grotta dell'Uzzo.[18] These new analytical methods provided data on the timing, origin, and management of domesticates at the inception of the Neolithic in north-western Sicily. Long-distance maritime voyages were indicated, highlighting the need to rethink the mode and trajectories of the dispersal of agro-pastoralism across the Mediterranean, and also the role of islands in this movement.

Moving eastward from Italy into the Balkans, the last paper in this session was presented by Marc Vander Linden on behalf of himself and colleagues (see M. Vander Linden et al. in this volume). He examined the various means by which the Neolithic process moved across the Balkans, presenting findings on the two streams of Neolithisation that swept across the Western Balkans (one along the Adriatic coast with the *Impresso* culture and the other overland across the continent with the *Starčevo-Körös-Criş* complex). The use of a suite of radiocarbon dates allowed comparisons to be made on the pace and spatial structure of each stream. Differences were noted in preferences for animal and plant domesticates between the streams, but there were several shared factors.

The papers in Day Two's (Saturday 31st October) morning session dealt with "Transitions to Food-Producing Economies", a very central theme within our discussions, looking from regional perspectives. The regions covered included Morocco, Nubia, and Egypt. The session was chaired by Steven A Rosen, whose work focuses upon the Levant and the Negev. Discussion of a range of regions within this session allowed for stark comparisons and also for contrasts to come to the fore. The starting place for the session was Morocco and the Epipalaeolithic, as Nick Barton examined the period before the introduction of farming (see N. Barton et al. in this volume). Barton examined potential reasons why groups already living in certain cave sites in Morocco, notably the study he and his team made of Taforalt, experienced a significant rise in particular types of foodstuffs, as well as the appearance of the first cemeteries. One of the reasons he explored featured frequently throughout the workshop: the climate. Barton also considered the extent to which the changes witnessed in the cave sites data could be in response to the wider shift to more sedentary lifeways. Certainly, this type of shift was quite early in the region and he shows how the changes did not result in full agriculture. The diversity, in terms of

15 Not published in this volume.

16 Manning and Timpson 2014.

17 Not published in this volume.

18 Mannino, Talamo, et al. 2015; Mannino, Lightfoot, and Stevens 2016.

which areas did and did not maintain and develop agricultural practices, was a very striking outcome over the two days of the workshop.

The geographic focus remained in Morocco, in the northeast, as Jörg Linstädter moved on to examine the transition to the Neolithic.[19] Through examination of the material culture, as well as the botanical and faunal record, Linstädter highlighted how close the Neolithisation processes are to those in the Western Mediterranean. Environment was focal again as he considered the relationship between certain subsistence strategies and the semi-arid environment.[20] The importance of palaeoenvironmental reconstruction within a sound chronological framework, another key theme within the discussions, was also focal in this paper, with the earliest evidence for plant cultivation being cited in northeast Morocco at ca. 7600 cal BP. Linstädter concluded that the environment and climate had a significant impact upon prehistoric Holocene settlement in the region, rather than upon the actual Neolithisation processes in northeast Morocco, which appear to have been largely related to other cultural processes, the spread of which was encouraged by the maritime networks possibly in existence in the Epipalaeolithic.

Maria Carmela Gatto turned the focus for the remainder of the morning to the east, as she reviewed recent and older data and how they can inform the process of Neolithisation in Nubia (see M. C. Gatto in this volume). Various factors in the process of Neolithisation were examined: economic, ecological, social, and cognitive. This process was tracked from its beginning during the Last Glacial Maximum (24 000 cal BP) to a full food producing economy (6800 cal BP), within the framework of Bruce Smith's influential theory on the four stages to food production.[21] Smith's article on low-level food production was also utilized by Barich in her lecture and again by Tassie in his paper. In Nubia a multi-spectrum economy seems to have developed, with communities along the Nile mainly relying on fishing and foraging/farming, while those in the desert mainly lived on animal husbandry and hunting.

Two papers brought the region of interest to Egypt, the first reviewing 100 years of research into the Neolithic as Agnieszka Mączyńska brought us up to date slowly on the progress of archaeologists working in prehistoric contexts, notably the boom of research into the Neolithic in the 1920s and the impact of scholars such as Childe (see A. Mączyńska in this volume). Mączyńska looked at how our research into the Egyptian Neolithic has been punctuated by key methodological changes, as well as new discoveries. Notably, she discussed the availability of radiocarbon dating, as well as the much-debated discovery of presumably domesticated cattle at Nabta Playa, which have driven new research perspectives. Perhaps surprisingly, she discussed how despite the rise in scientific methods being applied in prehistory, Egypt remains somewhat behind in terms of research into the processes of Neolithisation when compared to other regions.

One of the sites that Mączyńska introduced, Merimde Beni Salama, was the focus of Joanne Rowland's discussion, as she began her re-evaluation of the Neolithic data from the site (see J. M. Rowland in this volume). Rowland picked up upon some of the analyses introduced in the previous discussion, stressing the impact that they can have on newly excavated contexts, as well as data from former excavations. She presented the first ever set of AMS radiocarbon dates from this unique farming site in the Western Nile Delta, discussing the extent to which data from former excavations can be of serious scientific value, as well as looking to the future to suggest what methods may still have an impact on museum-based material.

The afternoon session's focus was on cultural, environmental, and technological processes, chaired by Maria Carmela Gatto. Annett Dittrich moved the focus down to the Sudan to Mograt Island and the theme of Holocene riverscape dynamics (see A. Dittrich in this volume). This discussion was concerned with the impact of the rain and dropping river levels in the eighth millennium cal BP leading to major changes in occupation strategies. The farming methods that might have been employed were considered, an aspect that can be difficult to approach but which played a major part within Dittrich's discussion. Although we normally think about the dependence of agriculture on the yearly rainfall, she also noted other existing methods of irrigation.

19 Not published in this volume.
20 Linstädter, Broich, and Weninger 2018.
21 Smith 2001.

Karin Kindermann and Heiko Riemer moved the geographical focus into the Eastern Sahara to investigate the origins of the Neolithic (see K. Kindermann and H. Riemer in this volume). They highlighted the multiple causes that impacted early food-producing communities, including environmental and climatic impacts, as well as communication between communities. They noted the early date of domesticated species in this area by 8000 cal BP onwards within a very different cultural landscape to the first Neolithic evidence in the Nile Valley or Delta. This exhibits yet another different aspect of the Neolithic, with pottery production and increasing social complexity existing amongst hunter-gatherer communities. The great similarity in terms of the lithics between oases sites and the Faiyum Neolithic was noted, suggesting the origins of at least some communities within the Eastern Sahara.

Moving to the northeast, Steven A Rosen's contribution dealt with the processes of Neolithisation in the Levant (see S. A Rosen in this volume). This discussion, in many ways, brought up aspects that were becoming increasingly clear as the conference progressed, notably, just how different the appearance, nature, and uptake of Neolithic aspects are dependent upon the history of the area, and the extent to which environmental and climatic change impacted upon different regions in varied ways and affected the timing of change. Rosen looked to the existence of specific processes within Neolithisation – from the adoption of species by desert groups, their transition to herder-gatherers with a changing toolkit, to more permanent settlement at a large-scale, in terms of population.

Opening the final part of the session, Noriyuki Shirai tackled the issues of how human groups dealt with adapting domesticated species within the Egyptian environment (see N. Shirai in this volume). Shirai's focus was the lithic repertoire from the Faiyum, as he examined the adoption of technological innovation and the importance of considering two key local factors at the time of adoption, notably, the population and the carrying capacity of the local environment. Shirai approached these issues from the standpoint of cultural evolutionary theory.

The final discussion remained within Egypt, in this instance Northern Egypt, as Geoffrey Tassie applied a multiple-scale approach to aspects of Neolithisation in this region (see G. J. Tassie† in this volume). Tassie looked to balancing the issue of large-scale adaptations, but also stressed the importance of taking local change into account and looking at changes that occur over a longer timescale, as well as in the shorter-term. Tassie emphasized the need to focus upon the different ways in which domesticated animals and plants arrived in Egypt, and the impetus for the movement of plants, animals, and people from the Levant. Tassie was concerned with the four key sites in Egypt essential within this research, notably, Merimde Beni Salama, el-Omari, Sais, and the Faiyum, examining the changes that occurred at these sites.

The Revolutions Workshop was initially envisaged as a means to bring together a group of archaeologists and related specialists to highlight key research themes and areas of progress, as well as outstanding issues relating to our research into Neolithic contexts. This aim was conceived with the main purpose of pushing forward the research of like-minded (and not so like-minded) colleagues through a coming together in a forum conducive to sharing new results, theories, new ideas, new techniques, and methods, with plenty of time set aside for discussion. Discuss we did – each session was accompanied by about 45 minutes of round table discussion, firstly between the panel members from the foregoing session and then the floor was opened to all workshop delegates, which promoted some additional fruitful lines of discussion. The workshop culminated in a much longer roundtable discussion among the delegates, re-visiting the topics that had been presented over the preceding days.

Some key elements that came through in the papers were, unsurprisingly, the importance of a robust chronological framework for charting processes of Neolithisation, and a number of papers raised the issue of climatic change. What was also apparent is that in many cases global climatic change was cited as of importance, notably the abrupt 8200 cal BP cooling event. However, this highlighted a point quite clearly – that it is crucial that we all look to obtain as much specifically local climatic and environmental data as possible, and avoid trying to pin changes upon such global events. This was demonstrated in the paper by Annett Dittrich, Barbara E. Barich, Nick Barton, Jörg Linstädter, Marc Vander Linden, and Maria Carmela Gatto, amongst others.

Fig. 1 Revolutions Workshop participants outside the Topoihaus: *Top Row* (L-R): Heiko Riemer, Mennat Allah El-Dorry, Maria Carmela Gatto, David Warburton, Fekri Hassan, Geneviève Protière Lebrun, Annett Dittrich, Nick Barton, Karin Kindermann, and Marc Vander Linden; *Middle Row* (L-R): Julie Dunne, Barbara E. Barich, Giulio Lucarini, Veerle Linseele, Helen Dawson, Jörg Linstädter; and *Bottom Row* (L-R): Noriyuki Shirai, Agnieszka Mączyńska, Geoffrey J. Tassie†, Joanne Rowland, Marcello Mannino, Graeme Barker, Steven A Rosen.

The workshop also served as a very effective forum for contacts between colleagues working with specific methods and, notably, for the Neolithic of the Delta project; Rowland subsequently entered into collaboration with Dunne to reveal the still present lipids from ca. 7000–6000 cal BP in a whole range of ceramic types from Merimde Beni Salama.[22]

The nature of direct or indirect transmission of technology was another major discussion point with varied views put forward from the colleagues present, and again very much connected with local resources, and coming hand-in-hand with other domesticated species. The idea of a 'Neolithic package', where all elements spread out of a core area at the same time was generally rejected in favor of a more gradual spread of various elements. The conference title was perhaps somewhat partly provocative, highlighting also the issues with using the term Neolithisation at all – and certainly at any pretense that there are a set of processes that play out in a similar manner in different areas. Although many aspects remain far from clear, what is plain is that the archaeological contexts presented and discussed throughout the workshop suggest that many factors led to the uptake – or not – of a few, or many, aspects of what was originally coined as the 'Neolithic package', and that there is huge diversity in terms of what is adopted on a more permanent basis. As Veerle Linseele highlighted, caprines spread out of the Levantine core area several hundred years prior to domesticated plants, however, cultivation and use of wild plants had been taking place already in both North Africa and Europe in the Epipalaeolithic/Mesolithic, as highlighted by the research of Giulio Lucarini and Anita Radini, and that of Elena Marinova.

It is hoped that a similar workshop can take place again in the coming years, with additional colleagues present, to chart the progress of research into the Neolithic. The bringing together of people who normally focus on evidence from either the northern or southern regions of the Mediterranean basin added new dimensions to the discussion. Looking at the processes that led to the development of food production at a supra regional level allowed us to recognize with more clarity the similarities and differences, and reminded everyone that the events that occurred in the ninth to seventh millennia cal BP occurred over a very large, and very interconnected area.

22 Dunne 2016.

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Rethinking the North African Neolithic – The Multifaceted Aspects of a Long-Lasting Revolution

Summary

The renewed interest in post-Palaeolithic societies and Neolithisation in northern Africa entails the rethinking of various issues, starting with Africa's autonomy in the Neolithisation process, with respect to the Near East. This paper aims to review this issue by discussing data emerging from new research conducted in North Africa. In particular, it illustrates how the space between hunter-gatherers and agriculturalists (the so-called 'middle ground') can be the key to answering many questions about the emergence of food production in northern Africa. It also analyses how Near Eastern domesticated animals became a part of North African cultures and focuses on the dynamics of transmission and on the reactivity of social groups, in light of both timing and mechanisms behind propagation.

Keywords: Northern Africa; Near East; food production; fieldwork; middle ground economy

Das wieder erwachte Interesse an post-paläolithischen Gesellschaften und an der Neolithisierung in Nordafrika bringt eine Neubewertung verschiedener Themen mit sich wie der Autonomie Afrikas vom Nahen Osten in Bezug auf den Neolithisierungsprozess. Anhand neuer Daten aus Nordafrika will der vorliegende Beitrag dieses Thema überprüfen. Insbesondere wird gezeigt, wie der Raum zwischen Jägern und Sammlern einerseits und Ackerbauern andererseits (der sogenannte *middle ground*) Antworten auf viele Fragen zur Lebensmittelproduktion in Nordafrika bereithält. Auch wird analysiert, wie Nutztiere aus dem Nahen Osten Teil der nordafrikanischen Kultur wurden. Überdies werden die Dynamiken von Übertragung und von Reaktivität sozialer Gruppen betrachtet, einerseits im Hinblick auf Zeiträume, andererseits auf Mechanismen der Ausbreitung.

Keywords: Nordafrika; Naher Osten; Lebensmittelproduktion; Feldarbeit; *middle ground economy*

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1 Introduction: Neolithic vs food production in the African continent

The changes that took place at the end of the Pleistocene and which are manifested through major transformations in the structure of human societies have recently been at the forefront of North African studies. We are witnessing a renewed and increasingly strong interest in the social and economic aspects that took place at this time, thus giving greater meaning to the abstract definition of the Neolithic, always oscillating between an emphasis on technological innovations and the revolution represented by food production. The latter definition – the Neolithic as a new organization of economic activities and of the social and symbolic structure of human groups – currently represents the prevailing paradigm. However, this paradigm had to first overcome the purely ideological debate about the proper use of the word 'Neolithic' in the African context, and the initial rejection to using this expression in order to safeguard the originality and autonomy of the processes that took place on this territory.[1]

Early definitions of North African and Saharan cultural spheres, formulated on the basis of techno-typological considerations, have gradually been enriched with environmental and territorial research data that have greatly expanded our knowledge of what took place at the very beginning of the Holocene. However, the true renewal of this research theme and its paradigms can be seen in the greater attention placed on the sites themselves and, especially, in careful intra-site investigations. Thanks to these new strategies, issues related to the organization of society, settlement patterns, and the use of resources have come to the foreground of this research and the Neolithic has come to mean, above all, food production.

This paper aims to review these issues in depth taking account of material culture data, environmental markers, and chronologies that have emerged or are emerging from new research in North Africa. Theoretically, the work illustrates how the space of economic activities referred to as the 'middle ground',[2] halfway between hunter-gatherers and agriculturalists, is a true link between two different strategies with which people interact with the environment, and can be the key to answering many questions that still remain unanswered on the emergence of activities related to food production. Further answers are also provided by the various research avenues taken by bioarchaeological studies on the domestication phenomenon and by our better knowledge of the genetic properties behind its success.

The arrivals from the Near East are re-evaluated by focusing attention on the dynamics of transmission and on the reactivity of social groups, taking into consideration both the timing and the dynamics of propagation and the way in which novelties were integrated into new geographical contexts. This is obviously a delicate task that requires extreme scientific objectivity in order to avoid once again advancing an anti-historical diffusionist paradigm.

2 The beginnings: redundancy of the 'Neolithic of Capsian Tradition' in the northern territories

We can take the 1960s, as the foundation period for the studies on the Holocene and food production in Africa north of the equator (Fig. 1). An important role was played by the fieldwork activities undertaken in the Nile Valley, prior to the construction of the new Aswan high dam. Investigations between the second cataract in northern Sudan and the latitude of Luxor in Upper Egypt led to the recognition of a sequence of occupation phases between the Late Pleistocene and Early Holocene. The Early Holocene phase during which the Sahara and the Nile Valley represented a single large container was then brought to the foreground. Previously Arkell had coined for this phase the term 'Neolithic of Sudanese Tradition'[3] for which later Gabriel Camps proposed the label 'Saharo-Sudanese Neolithic',[4] inspired by the same historical-cultural model. It assimilated human societies into large cultural spheres, placing at the forefront the morpho-typological aspects of material culture and almost completely ignoring the economic ones. It was precisely to these environments that J. Desmond Clark looked for direct antecedents of food

1 Sinclair, Shaw, and Andah 1993; Wotzka 2016.
2 B. D. Smith 2001.
3 Arkell 1953.
4 Camps 1974.

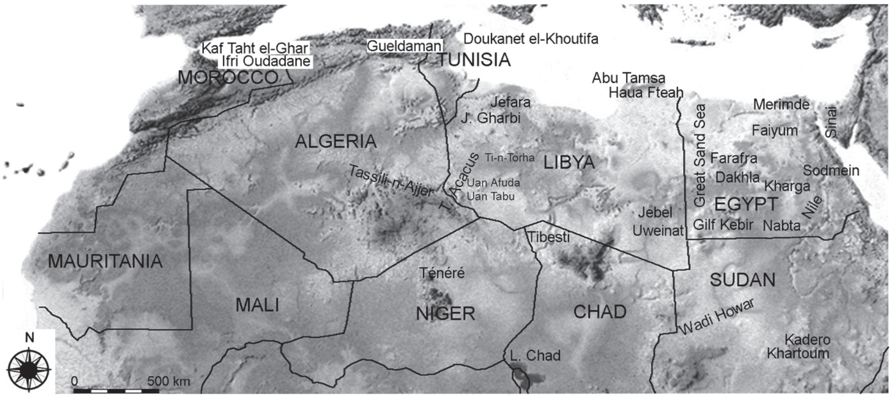

Fig. 1 Map of Northern Africa with location of sites cited in the text.

producing conditions.[5] Clark was the first to talk about 'pre-adaptation' to food production.

What for the Sahara was the 'Saharo-Sudanese Neolithic', for the North African coast was the 'Neolithic of Capsian Tradition'. This definition introduced by Raymond Vaufrey in the 1930s[6] has been the model indiscriminately applied to the Holocene archaeology of much of the coastal regions, with the exception of Morocco and Egypt. Today this definition is challenged, being acceptable only for Tunisia, where the human occupation immediately preceding the Neolithic is precisely the Capsian. It is also true that the same definition of 'Capsian' appears as the residue of an outdated approach. What differentiates the Capsian from the Epipalaeolithic technology that is generally widespread throughout North Africa from Morocco to the Nile Valley? Its hallmarks are some stylistic characteristics typical of the Tunisian groups, but just as many specificities could be assigned to the neighboring communities. Beyond specific traits, in all these industries we can recognize the distinguishing features of the microlithic 'revolution'.

The historical-cultural model (that had produced the term 'NTC') proved to be highly resistant to change, and there was therefore a dearth of social dynamics perspectives on African archaeology. The territoriality hypothesis drove desert research in the 1980s, on the principle that the spatial distribution of sites and their interrelations would represent the distribution of hunter-forager groups. As these sites were almost totally devoid of food remains, they were generally registered as simple assemblages. This allowed the archaeologists to traverse large distances and record many sites during their surveys. The inclusion of environmental studies, particularly geoarchaeology which was integrated into this territorial research,[7] helped in the development of ecological models to explain the past in terms of interaction between people and their natural habitats. However, considerations linked to social and economic issues were often overlooked. While there was a hiatus in fieldwork along the coast, these principles were applied to research conducted in the Central and Eastern Sahara. However, next to the typical strategy of desert archaeology – that is, prospecting and long-distance surveys – more time was given for systematic procedures of stratigraphic excavation and intra-site analysis.

This research scenario began to change during the 1990s in parallel with the new trends current in post-processual archaeology.[8] There were also new research designs and approaches in fieldwork. Although little new or continuous fieldwork was being conducted in the territories facing the Mediterranean, further south, in the Central and Eastern Sahara, important expeditions integrating the territorial approach with the re-evaluation of sites were taking place. Thanks to the investigation of key cave and open-air sites with significant stratigraphic deposits, these projects opened up new areas of research that helped to significantly modify the horizon of knowledge.

The Rome Sapienza University's archaeological project in the Tadrart Acacus Mountains in the Libyan Sahara integrated a territorial model with accurate stratigraphic investigations, shifting the research focus towards people's lifeways. It has done so by establishing

5 Clark 1976.
6 Vaufrey 1933.
7 Butzer and Hansen 1968; Butzer and Cooke 1982; Kuper and Kröpelin 2006; Petit-Maire and Riser 1983; Petit-Maire 1991.
8 Hodder 1982; Hodder 1987; Earle and Preucel 1987.

Fig. 2 Wadi Ti-n-Torha, Tadrart Acacus (Libya). Panoramic view of the wadi as seen from Jebel Ghelou.

Fig. 3 Wadi Ti-n-Torha, Tadrart Acacus (Libya). One of the 'huts' inside the Ti-n-Torha East Shelter.

the economic changes that took place during its occupation.[9] Increasing intra-site investigations, together with a greater interest in contextual data, have made it possible to recover and analyze a large amount of floral and faunal remains, along with the associated artefacts.[10]

In the Acacus, human occupation (or reoccupation) began in the Early Holocene. The lowest archaeological horizon (Early Acacus as defined by Di Lernia and Garcea)[11] indicates that the economy was based on wild resource exploitation, mainly centered on specialized hunting of Barbary sheep (*Ammotragus lervia)*.[12] The sites of Uan Afuda and Uan Tabu represent specialized camps for the hunting of this caprid. The middle layers at Ti-n-Torha East indicate the onset of economic change through (Figs. 2 and 3): the increasingly significant presence of grinding stones; the exploitation of small animal species and, conversely, a clear decrease in the number of macro fauna; and a more sedentary way of life entailing the use of houses with slab stone circles and greater storage capacities, alongside the presence of elaborate ceramics. Furthermore, the upper horizon at Uan Afuda (i.e. Late Acacus) showed special adaptations to the inside of the shelter, suggesting long-lasting management and control of *Ammotragus.*[13] Finally, the last centuries of the 7th millennium cal BC represent a transition to a pastoral occupation of the Acacus, which starts around 6400 cal BC and continues to the proto-historic peopling of the region.

Further east, in the Nubian Desert, research carried out in the Nabta Playa region by the Combined Prehistoric Expedition during the early 1960s played a fundamental role in our understanding of the Neolithic in this region.[14] Despite their interest in the environment, clearly manifested through geoarchaeological and palaeoenvironmental models, the authors also paid great attention to the excavation of large sites.

The contextual approach used in the study of these settings highlighted the Early to Mid-Holocene tradition (e.g. Sites E-91-1, E-75-8: aspects from Al-Jerar to El-Ghanam and El-Baqar: overall from about 6600 to 4500 cal BC), the complexity of these sites in terms of settlement organization; the prolonged stays at the sites thanks to water and food storage systems ('delayed use of resources'); the intensive use and processing of plants; and the presence of domestic animals, at first cattle then goats. Also evident are the technological advances throughout the area: plentiful pottery; the development of lithics including bifacial types; and the import of exotic objects from the Nile Valley and the Red Sea coast. Furthermore, using the stylistic method proposed by Close to study lithics,[15] several traditions and technological individualities were recognized among the stone tool assemblages.

9 Barich 1987b; Cremaschi and Di Lernia 1999; Di Lernia 2002; Garcea 2001.

10 Barich 1992; Gautier 1987b; Mercuri 2001; Mercuri 2008; Wasylikowa 1992.

11 Di Lernia and Garcea 1997.

12 Cancellieri and Di Lernia 2014, 46.

13 Di Lernia 1999.

14 Wendorf and Schild 1980; Wendorf, Schild, and Close 1984; Wendorf, Schild, and Associates 2001.

15 Close 1977.

These investigations by the CPE were the first to suggest an autochthonous domestication of cattle, and at an earlier date than in the Near East. The few cattle bones found at Bir Kiseiba and Nabta Playa suggest a date in the 9th millennium cal BC.[16] However, a consensus on this is yet to be reached: whilst the genetic data support the idea of a pre-domestic separation of African and Asian bovines,[17] more recent studies point to a wild African aurochs introgression that would explain the divergences between African and Asian cattle.[18] In the publications on the Tadrart Acacus[19] the numerous possible connections with the Nubian region were highlighted, suggesting it was the original area for these putative domestic cattle. The presence of domestic cattle in the Acacus can be dated to the last centuries of the 7th millennium cal BC,[20] which precedes all of the thus far documented examples of cattle further north. Caution is therefore needed before our interpretations, based on extensive research and careful observation, are rejected on the basis of information derived from genetic analyses of, at times, problematic samples and that do not take archaeological contexts into account.

No less important is the research conducted into the Early to Mid-Holocene communities in the Central Sudan. When first defined by Arkell, the material discovered at the Khartoum Hospital site was referred to as 'Mesolithic' ('Early Khartoum'),[21] and although this definition does not seem adequate within an African context, it continues to be used. Its lithics included microlithic tools made from small quartz pebbles collected from the river bed: lunates, disc-shaped tools, backed bladelets, and endscrapers. There were also grinding stones, perhaps used to process meat or dried fish, and bone harpoons. Based on technological considerations – the change in the pottery decoration – Arkell pointed out the presence of a later horizon ('Khartoum Neolithic').[22] This identification, for the first time, highlighted the problem of the penetration of domesticated elements and, therefore, also of the transition from an acquisitive to a production economy. All of the research that followed – starting from the 1980s onwards – focused on the sites themselves.[23] While on the one hand this has given rise to a better understanding of the logistic model of land use, on the other, it has also placed greater attention on the social and demographic spheres. The excavation of several cemeteries at Kadero 1 revealed the presence of various forms of social differentiation. Numerous burials and groups of burials within particular locations (clusters of adult male graves or clusters of children's graves), indicated through the varying richness of grave goods the higher social status and greater wealth of certain individuals. Krzyżaniak noted that this society's hierarchical social arrangement could be compared to that of chiefdoms.[24]

3 The 'middle ground' space vs. binary models of social development: low-level food production

The research into the post-Pleistocene highlighted above illuminated the intensive use of plants and the initial experiments with animal husbandry. However, the issue of the status of these societies remains unsolved; currently described as 'pre-adapted' to food production,[25] they fully meet all of the requirements of a 'middle ground territory' described by Bruce Smith.[26] This 'middle ground' was an intermediate level, a kind of 'no-man's land', standing between hunter-fisher-foragers and agriculturalists and/or pastoralists.

Chronologically in North Africa, this level of economic development affects the very later stages of the Pleistocene and the Early Holocene, representing several thousands of years. This stage of economic development is also recognized in the Near East. In the anthropological theoretical debate[27] this range of economic activities has been described as a phase representing the expansion of the resource exploitation spectrum (the so-called 'broad spectrum revolution' model first put forward by Binford in 1968).[28] However, so far the focus

16 Gautier 1984; Gautier 1987a, 177; Jórdeczka et al. 2013.
17 Bradley et al. 1996; Hanotte et al. 2002.
18 Decker et al. 2014.
19 Barich 1987b; Barich 2002.
20 Di Lernia 2002, 229; Biagetti and Di Lernia 2013, 310.
21 Arkell 1949; Dittrich 2011.
22 Arkell 1953.
23 Caneva 1983; Caneva 1988; Haaland 1987; Haaland 1992; Krzyżaniak 1991; Krzyżaniak 1998; Usai 2005; Salvatori 2012.
24 Krzyżaniak 1991.
25 Clark 1976.
26 B. D. Smith 2001, 6–14.
27 Hayden 1981; Testart 1982; Rindos 1984.
28 Binford 1968.

has concentrated mainly on the human/environment interaction and has failed to consider the consequences on the structure of the social groups; the debate therefore remains open and has yet to incorporate the conclusions derived from the new paradigm that field research has been gradually confirming.

Intra-site research in the Sahara, the Egyptian Western Desert, and in the Nile Valley (especially Sudan), have provided an enormous amount of data useful to our rethinking of the nature of these groups and to corroborate the existence of the 'middle ground'. By contrast, the task of an objective illustration of the new repertories that have been brought to light, and the effort involved in their classification and analysis, meant that little was said about the actual societies.

Although the current availability of large bioarchaeological collections in some areas has encouraged economic and social interpretations, the status of these societies has so far not been sufficiently explored. They have been hastily defined as Neolithic groups[29] or innovatively described as cattle-keepers, pastro-foragers, or forager-herders.[30] The challenge seems rather to recognize the middle ground as an autonomous economic and social space, which enables the perfecting of the evolutionary vision and breaks away from the 'dualist' model of either hunter-gatherers or agriculturists that Smith referred to.[31]

Even the studies in the 1980s and 1990s that reconstructed final Pleistocene scenarios, while producing an expansion of the hunter-gatherers domain through the notion of complexity and affluence,[32] perpetuated this same 'dualist' model.[33] The two extremes were still hunting and gathering and agriculture, while pastoralism was seen as an asset reabsorbed into the latter. Indeed, the expansion of skills and processing capabilities attributed to complex hunter-gatherers, rather than make way for a new social subject strengthened the dichotomy between hunter-gatherers on the one hand and agriculturalists/pastoralist on the other.[34]

This space of diffuse economic activities has been described using various names, all referring to crops (e.g. cultivation, horticulture, and proto-agriculture). Names which were strongly opposed by the more traditional palaeobotanical studies and, by implication, also by the authors who, using expressions such as 'complex hunter-gatherers',[35] perpetuate the separation between the wild sphere of the hunter-gatherers and that of agriculturalists. From the traditional point of view, hunting and gathering and agriculture represent two quite distinct economic lifeways, so that the transition from one to the other must be seen as a sharp break (a 'revolution' in fact). The strongest argument of this paradigm is that a successful domestic condition can be proven only and exclusively by genetic modifications highlighted in the botanical or animal species. However, there is a sphere of human interaction with plants and animals that could be called 'cultural domestication',[36] which precedes the former and would be a serious mistake to ignore.[37] The authors more open to processual principles wrote in favor of this behavioral domestication, providing compelling evidence in favor of this change in perspective.[38] The present author, taking account of her own field research, has composed a panorama of the Holocene events between the Sahara and the Nile Valley to showcase the gradual achievements of the human groups within their primary areas as part of the domestication phenomenon.[39]

Even the contribution from nonconformist bioarchaeologists has helped to look at domestication from a new perspective, one open to cultural considerations. One important consequence of this has been to argue against the notion that the process was accomplished in a short space of time.[40] In contrast with this view, the '*protracted Neolithic domestication model*'[41] states that morphological changes can act very late in the long process of domestication and, therefore, it is wrong to restrict the whole process to morphological alterations. In both plants and animals the morphological indicators of domestication that are archaeologically detectable appear only when plants and animals have been isolated from

29 Wendorf, Schild, and Close 1984.
30 Banks 1984; Riemer 2007; Barich and Lucarini 2014.
31 B. D. Smith 2001, 2.
32 Zvelebil 1986; Zvelebil 1994; Zvelebil 1995; Testart 1982; Price and Brown 1985.
33 B. D. Smith 2001, 2–3.
34 B. D. Smith 2001.
35 Zvelebil 1986; Hayden 1981.
36 Zvelebil 1995, 98.
37 B. D. Smith 2001, 13.
38 Harris 1989; Harris 1996; Higgs 1972; Rindos 1984; Zvelebil 1986.
39 Barich 1987a; Barich 1998.
40 Zeder 2011, S230–231; Fuller, Willcox, and Allaby 2012, 617.
41 Contra see Heun et al. 2012.

free-living populations, avoiding occasions of introgression between managed elements and those entirely wild: "Concentrating solely on this late stage of the process will not help us understand how it began".[42]

The efforts of human groups to effect a broad-based change of environment and biotic communities to promote plants and animals of economic interest were the basis that led to their domestication.[43] Human intervention in the lifecycle of plants and animals began with the control of the reproduction steps, which in turn, led to progressive morphological changes. Any form of control starts with collection, storage, and replanting. In this way plants are free from natural selective pressures but, at the same time, different forms of selection are put in place. All of this will lead to various morphological transformations (in cereals, a change from brittle to tough rachises; in pulses, an increase in the size of the seeds; and in animals, a decrease in the degree of sexual dimorphism). Therefore, domestication is recognizable at the end of a long path, which obviously precedes the concrete organization of an agricultural or agropastoral system.

Some authors have put together diagrams synthesizing this process.[44] However, nobody has yet been able to quantify the gradual increasing contribution these activities had to the human diet, which is why terms such as 'incipient' or 'proto' agriculture continue to be vague expressions.[45] Few studies, in fact, have focused on trying to describe these changing societies.[46] A normative, or category, definition of human-plant (or human-animal) interactions is a distinctive element of the middle ground societies. In practical terms these categories may be reduced to a continuum of increasing human intervention in the lifecycle of the various plant or animal species. On the other hand, despite the limits imposed by this 'behavioral' explanation, it can still build a broad model (or template) within which to place specific societies.[47] Basically people, and human societies, determine physical or genetic changes (or even a combination of both) in specific species of plants or animals, so that the new domesticates from that moment on can no longer survive without the continuous care and protection provided by humans.[48]

4 Low-level food producers in North Africa and the Near East

The Western Desert, one of the areas where research has been focused over the past 20 years, is the region that offers a perfect example of a level of social organization that meets the requirements of middle ground space. This area has attracted interest due to the outstanding evidence found within it of the use and early manipulation of plants in the process of domestication, and its integration with the first herding practices, as well as for providing answers to anthropological questions on how these two sectors could co-exist within ancient societies.

The plants recorded are all adapted to the monsoonal rainfall regime. They grew abundantly on the edges of playas, seemingly responding to the nourishment demands by human groups. This self-sufficient type of economy may explain the delay in the adoption of the Levantine domesticated crops, which several authors have emphasized.[49] Nabta Playa was the first region to offer the most obvious evidence of an organized use of local plants, among which *Sorghum*, the African plant par excellence, dominates. The Al-Jerar middle Neolithic horizon showed that from ca 6800 cal BC human groups could live in the area throughout the year using new strategies with a settlement pattern much more stable than before.[50] Edible plants were ripened during the first part of the winter and stored in primitive silos for delayed use in less productive periods. The edible grass seeds included: *Echinochloa, Sorghum, Panicum, Digitaria, Setaria, Brachiaria,* and *Urochloa,* alongside others used for their fruits, tubers, or leaves.[51]

At the Site E-91-1 (6900–6800 and 6300 cal BC) semi-subterranean dwellings with a circular profile and diameters close to three meters were discovered with hearths both inside and outside the structures. Storage pits were used to preserve the intensively collected plants and were

42 Zeder 2011, 230.
43 Zeder 2011.
44 Harris 1996, fig.15.2; Zvelebil 1996, fig.18.1.
45 B. D. Smith 2001, 9.
46 McDonald 2008; Barich 2012; Barich and Lucarini 2014.
47 B. D. Smith 2001, 14.
48 Ford 1985; Harris 1996.
49 Madella et al. 2014; Phillipps et al. 2016.
50 Wendorf and Schild 2002.
51 Wasylikowa 2001, 589, Table 21.28.

accompanied by numerous grinding stones. There were also deep wells, the excavation of which allowed the groups to remain near their home bases, situated in the deepest parts of the basins, from late autumn until the return of the rains in May. A certain degree of sedentism is proved also by the abundant ceramics manufactured with mud sourced from the local playa. In terms of the lithic industry, few formal classes of tools can be recognized, mainly denticulates, notches, and drills, these were probably linked to the processing of plants. Animal remains consisted primarily of gazelles and hares, but also included some birds, porcupines, and jackals, all taxa found in semi-arid terrains, as well as the remains of terrestrial mollusks. There are also remains of domestic cattle, although in small numbers. With the return of rains in the spring, groups were able to resume hunting activities and herd their cattle on the pasturage, venturing farther from their core settlements. In this way a dual model of residence was established, with the community divided into two segments, with some individuals committed to the care and harvesting of plants remaining near the main residential base for the entire period, whereas between autumn and winter a segment of the community looked after the herds on the surrounding plateaus.[52]

In Dakhla and Kharga[53] and also further north in the Farafra Oasis, comparable sites have been discovered.[54] The latter, alongside the oasis of Dakhla, yielded the clearest evidence that groups selected these basins where water and edible plants were concentrated as settlement areas. These areas were occupied in a semi-permanent manner judging by the clusters of dwellings built using a large number of slabs obtained directly from the local rock substrate. Large sites with dwellings built using multiple rows of slabs are widespread in several areas of the Egyptian Western Desert, with the most ancient found in the cultural units of Masara C at Dakhla, and Midauwara at Kharga (both from 8300 to 7400 cal BC),[55] followed by the late 7th–6th millennium cal BC slab structures at Farafra in the Late Wadi El Obeiyid Phase, the Dakhla Bashendi Units, the Kharga Early Baris Unit, in addition to those of Abu Ballas, the Great Sand Sea, the Gilf Kebir, and, further south, those of Karkur Talh and Jebel Uweinat. The term 'villages' may be used to refer to these agglomerations, the number and size of which could also indicate a substantial population increase.[56] These groups intensively used the grasses growing wild on the edge of the playas; with the evidence from Farafra representing the greatest proof of this practice. The charred remains of the *Brachiaria, Cenchrum, Digitaria, Echinochloa, Panicum, and Setaria,* genera pertaining to the Paniceae tribe, and Andropogoneae's *Sorghum*[57] have been found in the abundant fireplaces of the Hidden Valley Village at Farafra (Figs. 4 and 5). The Mid-Holocene habitat of Farafra was that of a dry savannah dominated by African plants growing with summer rains. However, between 6000 and 5500 cal BC the presence of plants that grew with winter rains proves that the Mediterranean winter front had moved southwards, resulting in a bimodal rain regime.[58]

This strong presence of plants in the diet of these human groups could justify their definition as 'foragers', however, from about 6200 cal BC plants appear associated with the remains of goats, which establishes links with the Near East. The remains of goats (*Capra aegragus* f.hircus) documented in the Hidden Valley at Farafra are dated by seven dates ranging between ca. 6200 and 5600 cal BC.[59] Caprines are known also from Djara 90/1, Dakhla Bashendi B horizon, and perhaps even from Bashendi A.[60] Regarding this sudden appearance of goats in the Western Desert context (an issue discussed below), it is useful to remember the evidence from the plain of El-Qaa in the southwestern Sinai facing the Red Sea, cited by Close, in which for the same period (6400–5200 cal BC) the remains of goat were found in stone structures that resemble those of the Western Desert.[61]

A high degree of social complexity accompanies these communities that – as stated earlier – have been described as 'forager-herders' or 'pastro-foragers' or even

52 Wendorf and Schild 2002.
53 McDonald 2006; McDonald 2009.
54 Barich 2008; Barich and Lucarini 2008; Barich, Lucarini, Hamdan, et al. 2014.
55 McDonald 2006; McDonald 2013.
56 McDonald 2008; Barich 2012.
57 Fahmy 2014, 334.
58 Arz et al. 2003; Barich and Lucarini 2014, 467; Fahmy 2014, 344.
59 Gautier 2014.
60 Kinderman 2003, 60; Linseele 2013; Linseele, Van Neer, et al. 2014.
61 Close 2002, 462–466.

Fig. 4 Farafra Oasis, Western Desert (Egypt). Panoramic view of Hidden Valley in Wadi el Obeiyid.

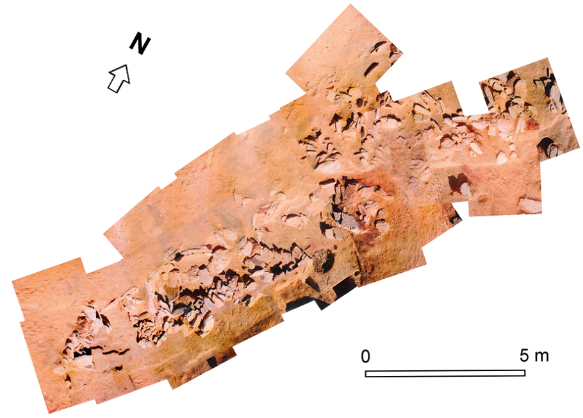

Fig. 5 Farafra Oasis, Western Desert (Egypt). Planimetry of Hidden Valley Village.

'cattle-keepers'.[62] In terms of their economic and technological level, they can represent the socio-economic and ideological level typical of 'Neolithic' groups, but it is equally certain, in light of the cultural data and theoretical considerations set forth, that they comply with the 'low-level food production' stage discussed so far. Furthermore, it is now clear that in post-Pleistocene times, similar new forms of subsistence were experienced everywhere throughout the southern Mediterranean coast.

The scenario emerging from recent research appears to disprove the supposed differences in the development trend between North Africa (including the Sahara) and the Near East. According to various authors, in the former, animal domestication preceded the cultivation of plants, which is a reversal of the Levantine model.[63] Thus, the arrival of agriculture and related practices should be understood as a revolution, a genuine transplantation from the east, and a clear break in the local tradition. This view, however, does nothing but reflect the stereotype of the hunting-farming-herding sequence. Instead, it must recognize the existence of a broad 'middle ground' following hunting and gathering that both North Africa and the Near East experienced, with the latter showing chronological distance and precocity in the steps towards domestication, due to the environmental requirements and the genetics of Levantine plants, which were more inclined to be domesticated.

Similarities between the North African and Near Eastern spheres in terms of the interest in the plant world are particularly striking. Since the Early Holocene (and even before) plants were used and processed by North African and Saharan societies[64] with an intensity comparable to that reported for the Near East. The long and complex plant cultivation processes evolved separately and proceeded at different rates in these two regions. Clearly the choices made by North Africans and Levantine groups during the process towards full domestication was influenced by the territorial characteristics, the climate, and the prototype genetics which were different in the two regions.

A significant paradigm shift has resulted in a challenge to the predominant view that in the Near East the process of crop domestication was accomplished in a short space of time.[65] At some of the most important Near Eastern sites (Fig. 6) the process of plant domestication – despite their greater susceptibility to being domesticated in comparison to African plants – was already under way at the end of the Pleistocene in Natufian contexts (ca. 12 900–10 100 cal BC). These practices were intensified during the Late PPNA phase (ca. 9700–9000 cal BC), paving the way for a truly agricultural way of life during the Middle PPNB (ca. 8500–7500 cal BC).

62 Banks 1984; Riemer 2007; McDonald 2009; Barich and Lucarini 2014.

63 Marshall and Hildebrand 2002; Garcea 2004.

64 Hillman, Madeyska, and Hather 1989; Wasylikowa 1992; Wasylikowa 2001; Barich 1992; Barich 1998; Neumann, Butler, and Kahlheber 2003; Morales, Pérez-Jordà, et al. 2013; Morales, Mulazzani, et al. 2015.

65 See Hillman and Davies 1990; Heun et al. 2012.

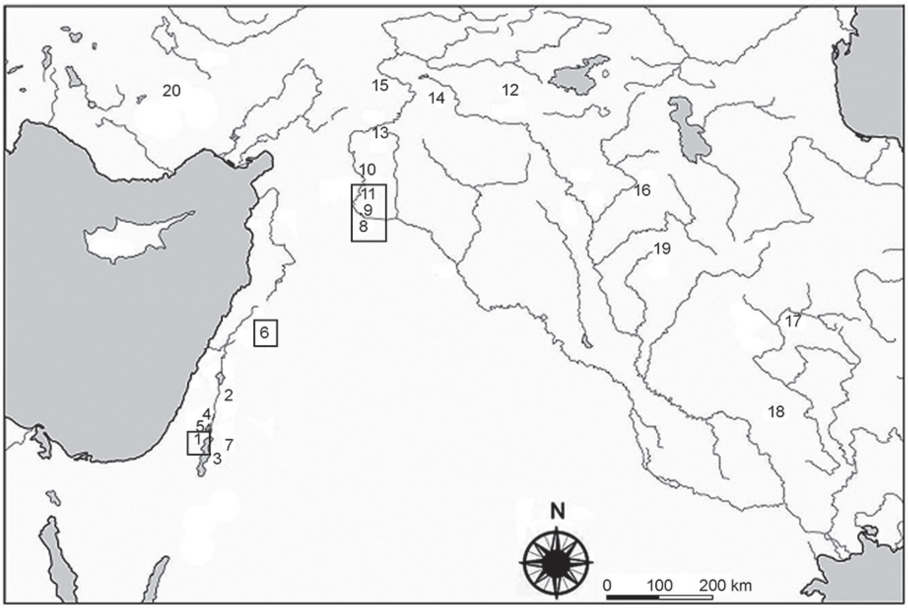

Fig. 6 Map of the Near East showing the distribution of the principal Neolithic sites. In rectangles the sites mentioned in the text. Source: B. E. Barich (Drawing by M. Pennacchioni). *Key*: 1) Jericho, 2) Iraq ed Dubb, 3) Dhra, 4) Netiv Hagdud, 5) Gigal I, 6) Tell Aswad, 7) Wadi el-Jilat, 8) Abu Hureira, 9) Mureybit, 10) Dja'de, 11) Jerf el Ahmar, 12) Hallan Çemi, 13) Nevali Çori, 14) Çayönű, 15) Cafer Höyűk, 16) Zawi Chemi Shanidar, 17) Ganj Dareh, 18) Ali Kosh, 19) Jarmo, and 20) Çatal Höyűk.

At Tell es-Sultan, the local name of the site of Jericho in the Jordan Valley in Palestine, human occupation formed one of the most powerful stratigraphic deposits known in the ancient world.[66] The first to use the local wild cereals were the hunter-fishermen Natufian groups ca. 10 000 cal BC.[67] The subsequent occupations belonging to Jericho I (PPNA: ca. 9000 cal BC) have subterranean dwellings and the first evidence of semi-domesticated grains. Only in the following Jericho II horizon (PPNB: ca. 7700 cal BC), were domesticated einkorn (*Triticum monococcum*), emmer wheat (*Triticum dicoccum*), barley (*Hordeum vulgare*), and pulses (*Lens culinaris*; *Pisum sativum)* found.[68] At that point, Jericho had taken on unusual dimensions for a site of such antiquity, comprising even architectural arrangements and funerary rituals.

Some sites in the Euphrates Valley in northern Syria have also shown an equally ancient dependence on cereals. On the southern side of the Euphrates Valley, the Abu Hureyra's Tell covers an area of around 11.5 hectares. The earliest record belongs to horizon I (ca. 10 600 cal BC), which was inhabited by semi-permanent hunter-gatherers who left plentiful remains of edible plants. However, the *Triticum monococcum* found was, although collected intensively, still wild as were *Linum usitatissimum* and *Lens culinaris*, while a semi-domestic status has been observed on rye (*Secale* sp.).[69] A significant decrease in the site's occupation is recorded at the end of Abu Hureyra I, in close relation with the cold arid phase, the Younger Dryas. Whereas, during the next phase (Abu Hureyra II, ca. 7400 cal BC) the settlement underwent a considerable expansion with the appearance of rectangular mud-brick houses. At that point, the new villagers could count on a broad spectrum of domestic plants, from einkorn and emmer wheat (*Triticum dicoccum*), to barley (*Hordeum vulgare*) and lentils (*Lens culinaris*). At the same time, the fauna, which still included a large percentage of gazelle, sees the addition of domestic sheep and goats.

Two other sites, Jerf el-Ahmar and Mureybet, located a few kilometers from each other not far from Aleppo, have offered many elements for the study of the early stages of domestication. At Jerf el-Ahmar in the latter part of the 10th millennium cal BC, cereals such as wild barley (*Hordeum spontaneum*), wall barley (*Hordeum murinum*), and einkorn (*Triticum monococcum*), along with pulses (lentils, peas, vetch) formed a staple part of the diet. These are 'adventitious' plants, whose germination is favored by working the ground.[70] However, no domestic animals were discovered apart from

66 Kenyon 1960.
67 Bar-Yosef 1986.
68 Fuller, Willcox, and Allaby 2012, 626, Table 3.
69 Fuller, Willcox, and Allaby 2012.
70 Stordeur, Helmer, and Willcox 1997, 283;

the dog, most certainly used in hunting. The importance of cereals at Jerf el-Ahmar is also attested by the earliest evidence of silos for storage. The EA30 building, a semi-subterranean structure, built employing an advanced technique, was located in the center of the village and – as has been emphasized – such an impressive construction would have certainly required a community's commitment.[71]

The earliest levels of the nearby site of Mureybet (located on the bank of the Euphrates, 80 km from Aleppo) represent a station for hunter-gatherers who exploited a wide spectrum of local resources, such as a wide range of grasses and animals available all year round.[72] However, during levels III A and B (PPNA 9500–8700 cal BC) a change in the lifeways of the community took place. Cereals, the grains of which show an advanced stage of domestication, appeared at the site for the first time in the form of einkorn (*Triticum boeticum*), *Hordeum vulgare*, and *Secale* sp., along with *Linum usitatissimum, Lens culinaris*, and *Vicia ervilia*. Rectangular buildings at the site allude to the presence of cereal storage,[73] while smaller circular dwellings were probably used as living spaces. The emergence of independent granaries, in the center of the village as communal property, represent an undeniable social evolution in the organization of the human group.

Further south in Syria, about 30 kilometers from Damascus and on the edge of the Syrian Desert, the Tell Aswad site occupies an intermediate position, closer to the Tell es-Sultan region. The site, which had an early pre-ceramic occupation, shows a considerable expansion during the PPNB (between 8000 and 7500 cal BC) covering a territory of about 5 ha. Archaeological and palaeobotanical data show that during this time the site witnessed its sedentary organization with semi-subterranean dwelling structures being built. Meanwhile, the inhabitants had a fully agricultural economy based on emmer wheat (*Triticum dicoccum*), pasta wheat (*Triticum durum/aestivum*), and two-row barley (*Hordeum vulgare* var. *distichum*), along with domestic pulses (*Pisum sativum* and *Lens culinaris*). However, the presence of storage pits in the settlement has not yet been reliably confirmed.[74] The rich lithic industry from Tell Aswad comprises tools used in agricultural activities such as sickle blades and possibly notched pieces as well as other more archaic types, such as borers, endscrapers, and burins. The presence of tanged arrowheads in the earlier phases of the settlement indicates that hunting took place during this time, whereas the polished axes, and the human and animal figurines pertain to a later phase of occupation.

The abovementioned Levantine sites offer evidence of the early stages of the domestication process, and how their location, very close to the corridors leading to the Delta and the Nile Valley, might have influenced the events taking place in Egypt. They stand alongside other study cases that research has revealed in Near Eastern territories (Fig. 6). Compared to the early hypothesis regarding the existence of an original restricted area for cultivation in southeastern Anatolia (the 'core area' hypothesis),[75] over the past two decades discoveries in the Near East have led us to identify various contemporary domestication experiments carried out on both plants and animals in a wider geographical area: from a northwestern boundary corresponding to the Taurus (southeast Anatolia), with the Upper and Middle Euphrates and the western side of the Zagros as the eastern border, and the Jordan Valley as a southern limit.[76] While so far a gap of about a millennium between the domestication of crops and that of animals has been postulated, in light of the recent discoveries it seems that the two events happened more or less simultaneously.[77]

'Cultivation', 'gardening', and 'horticulture' are the terms most commonly used to indicate the initial management of plants several millennia before the beginning of agriculture *sensu stricto*. This phase, as reported earlier, in the Levant can be placed between 9000 and 8500 cal BC.[78] The term 'cultivation' comprises various degrees of specificity, from a general meaning like 'encouraging the development of plants with work and attention' to 'tilling the soil, destroy the herbs, etc.' However, they are all actions that do not interfere with the life cycle of the plant. In Early Holocene North African deposits the grasses, all tropical species that grew with the

71 Stordeur 1999, 144.
72 Cauvin 1979, 40.
73 Van der Stede 2010, 21.
74 Van der Stede 2010, 66–68.
75 Lev-Yadun, Gopher, and Abbo 2000.
76 Fuller, Willcox, and Allaby 2012, 621.
77 Zeder 2011, S230.
78 Fuller, Willcox, and Allaby 2012; Larson and Fuller 2014.

summer rains, do not bear any signs of domestication. In the Western Desert, signs of the initial stages of domestication were only detected in sorghum remains.[79] The fact that in this case domestication occurred very late[80] can be attributed to the biological nature of the plant, to the climatic conditions, and also to the gathering methods used by people.

The examples discussed on in this section allow us, on the one hand, to bring together early Holocene developments in the Near East and North Africa. On the other hand, a clear question arises: how to define this transitional stage? In the Near East, the situations and events reported above are presented as an early phase of agriculture and are included within the Neolithic. In contrast to this, similar situations in North Africa are described and regarded as an expression of the maximum development of foragers. It is clear that if, in either case, societies would receive the name of 'low-level food producer societies', with reference to a specific and autonomous development condition, this would help to overcome these contradictions. Finally, although North African plants do not present any morphological transformations that would suggest they are a domestic type, they nonetheless played a major role in the social sphere, leading to changes in diet, technology and in the settlement itself. Finally, they played a crucial role in shaping society by making it receptive to the later successful integration of Asian crops among the resources used.

5 The spreading of domesticates: a possible scenario

In the Near East the outcome of the first Levantine experiments in a genuine agricultural 'Neolithic' system is believed to have required more than 2000 years to take place; these partly overlapped with the climatic optimum period that followed the Younger Dryas, ending with a worsening climate phase, the apex of which is recognized in the arid event that took place at ca. 6200 cal BC (i.e. 8.2 kyr cal BP). This event in the Levantine territories, the effects of which are recorded all around the Mediterranean,[81] encouraged a larger use of caprines. This became a characteristic of the PPNC around 6500 cal BC.[82] It is around this time that contacts between the two cultural spheres facing the Mediterranean, which separately experienced similar forms of control and exploitation of the environment, become evident. In this phase, the North African low-level food producers receive exotic elements unquestionably coming from the southwest Levant.

The 'uprooting' phenomenon from the original territories can be explained using several models, but there are two main scenarios to be considered.[83] The continued expansion of the groups is represented through the 'wave of advance' model[84] or – following a model more suitable to the southern Mediterranean environment – through intermittent actions related to movements and subsequent contacts established by small groups. A spreading by land may have involved the territories of the southwest Levant most immediately in contact with Egypt and the eastern regions of North Africa. The River Nile, in particular, may have acted as a crossroads on which movements and exchanges of peoples from the desert to the southwest and the Levant to the east, converged.

Small groups of immigrants may have directly imported the new resources and, in certain cases, new technologies. However, the same result could have been obtained via indirect diffusion, by means of cultural transmission through the exchange of goods and artefacts. In either case, it is highly plausible that various experiments and attempts were needed before the innovations were successfully adopted. The appearance of the domesticates in the archaeological record should have been preceded by many experiments and failures in the adaptation to new habitats. This was certainly one of the main reasons why in most of the North African regions the consumption of wild local plants lasted for longer and was preferred over the use of domesticates of Levantine origin.[85]

In Egypt the cultivation of domesticated grains follows the appearance of animal domestication. It could have succeeded because of temporary changes in the

79 Wasylikowa 2001; Fahmy 2014.

80 Today the first proofs in Sudan are dated to the 6th millennium cal BC (Beldados 2015).

81 Berger and Guilaine 2009.

82 Shirai 2006; Fuller, Willcox, and Allaby 2012; Rosen 2015; Rosen 2016.

83 For a review of this topic see Linstädter et al. 2012.

84 Ammerman and Cavalli-Sforza 1971.

85 Lucarini 2013; Lucarini et al. 2016.

rainfall regime[86] or because of the adoption of more sophisticated agricultural techniques supported by run-off irrigation, as a way to overcome the difficulty represented by the natural rain cycle. However, since it has been noticed that those who travel carry with them the whole of their properties,[87] the absence of domestic crop remains in the archaeological deposits does not rule out that immigrants tried to introduce them, but failed to start full-farming cultures. As such, these experiments may not have left traces in the archaeological record, or remain isolated cases.

This could be the case for the recent discoveries made at R12 in the Dongola reach in Nubia, which, based on phytoliths and dental calculus, indicate the use of Levantine wheat and barley at ca. 5000 cal BC.[88] This represents quite an early period when compared to the fully agricultural Neolithic contexts found in the Nile Delta (ca. 4500 cal BC).[89] In the territory between Lower Nubia and Central Sudan the successful adoption of domesticates may have been favored by a phase of increased humidity and by the use of décrue techniques exploiting the Nile floods.[90] It should also be noted that if during the long process of domestication human's care and intervention suddenly ceased, there would probably be a rapid regression of the domesticated plants, leading to their return to a wild state.[91]

It was supposed that the diffusion phenomenon related to a combination of resources moving out of the Levantine Fertile Crescent as a group. That is implicit in the use of the term 'Neolithic package' (made up of barley, wheat, and pulses, along with sheep/goat, cattle, and pig). However, as mentioned above, this definition is not always proven by archaeological observations, especially with regard to the oldest evidence of the movements, which seem to comply with the model of intermittent movements involving small groups. The antiquity of the presence of goats in the eastern part of North Africa, in direct communication with the territories of the southwestern Levant, has been highlighted by various authors.[92] In light of our current knowledge, the first introduction was around the end of the 7th millennium cal BC. At Sodmein Cave sheep/goats are dated between 6200 and 5800 cal BC, while in the Hidden Valley at Farafra the presence of sheep/goats is documented by seven dates between ca. 6200 and 5600 cal BC.[93]

This chronology is consistent with the increased pastoral characteristics of the Early Timnian of the southern Negev and Sinai during the PPNC, after the collapse of the PPNB system around 6700 cal BC.[94] In this regard, it is useful to remember that Rosen, by highlighting the reluctance of desert hunter-gatherers to accept within their system the new herding practices, emphasizes the revolution in the system of good procurement and exchange that followed the collapse of the PPNB.[95] This may have made available previously inaccessible goods including goats. It should also be noted that the low-level food producers of the Egyptian Western Desert, groups who had already progressed from 'simple' hunter-foraging ways, were able to rapidly and successfully incorporate new resources into their system.

As already noted elsewhere,[96] goats from the Western Desert may have rapidly moved northwest towards Cyrenaica (Abu Tamsa Site, Sample Pa2467: 7275 ± 40/5746 ± 184 cal BC, and Haua Fteah Sample OxA-18673: 6917 ± 31/5803 ± 74 cal BC)[97] and, at the same time, south towards the Nabta Playa area. The coast may have been a way of further transmission of the goat to the west, now appearing in Libya as well as in Tunisia (Doukanet el-Khoutifa)[98] and Algeria (Gueldaman Cave).[99]

In the light of current knowledge, always subject to revisions, there is no evidence that caprines initially travelled with cattle. Current evidence for northern Egypt indicates the oldest site where goats appear associated with cattle is Faiyum QSIX/81, dated to ca. 5350 cal BC.[100] As such, there is a real territorial

86 Arz et al. 2003; Fahmy 2014.
87 Zeder 2011, S231.
88 Madella et al. 2014.
89 Rowland 2015; Rowland and Bertini 2016, 164.
90 Madella et al. 2014.
91 B. D. Smith 2001.
92 Vermeersch, Van Peer, Moeyerson, et al. 1994; Vermeersch, Van Peer, Moeyersons, et al. 1996; Vermeersch, Linseele, et al. 2015; Close 2002; Barich 2014; Barich 2016.
93 Vermeersch, Linseele, et al. 2015, 499; Barich and Lucarini 2014; Gautier 2014.
94 Rosen 2015; Rosen 2016.
95 Rosen 2015.
96 Barich 2016 and references therein.
97 Faucamberge 2014, 22; Barker, Antoniadou, Barton, et al. 2009.
98 Aouadi and Dridi 2012; Aouadi, Dridi, and Ben Dhia 2014; Aouadi and Dridi 2012.
99 Kherbouche et al. 2014; Merzoug et al. 2016.
100 Linseele 2015.

and chronological gap compared to the relatively well-documented and large area of Nubia. As is well-known from this area, some examples of cattle that were maybe not completely domestic ('putative domestic *Bos*' according to Gautier's definition),[101] but show signs of management in progress. Marshall and Weissbrod notice that the 8th millennium cal BC domestication attempts represent experiments of control over a limited number of animals to get a reliable source of food in times of environmental stress.[102] From their original territory, the first cattle herds spread rapidly through the central Sahara (Tibesti, Acacus, Tassili) probably due to pasture and water requirements. They may have been re-crossed later, in the 5th millennium cal BC, with fully domestic cattle arriving then from the Levant.[103] This should not affect the recognition of an original center of domestication in Nubia as has been the case until now; failure to recognize this has now become a purely ideological position.

In the Faiyum, after the first occurrence of both cattle and sheep/goat in the 6th millennium cal BC, the complete Neolithic package appears only in the following millennium, at the two famous sites of Kom K and Kom W.[104] Plentiful domestic crops – emmer wheat (*Triticum dicoccum*) and barley (*Hordeum hexastichum, H.vulgare, H. distichum*) – are documented at Kom K and the K-Pits from 4600 cal BC onwards (i.e. 6495–6410 and 6380–6320 cal BP).[105] Slightly more recent are the findings from Merimde (ca. 5000 to 4000 cal BC)[106] where we can reconstruct a picture of an agropastoral Neolithic community well-established in the area, also confirmed by the latest research at the site.[107]

The areas of origin of these domesticates have been tracked down mostly by focusing on and comparing the remarkable similarities found in the material culture.[108] Bifacial products, particularly a number of arrowheads (Helwan, Haparsah, Nizzanim, Herzliya), alongside knives, daggers, and flaked axes are the types that allow more analytical comparisons to take place. The majority of these products can be found in the Pottery Neolithic contexts of Jordan and Israel dated between 6500 and 5900 or 5600 cal BC.[109] In several publications Shirai has stressed the strong similarities between the products of those environments (particularly the Lodian Culture) with flaked axes, sickle blades, daggers, and arrowheads present in the Faiyum and Merimde.[110]

Tracing the movement of the Neolithic package southwestward from the Levant to the adjacent territory of Egypt is not too difficult, and was presumably by land and entailed privileged contacts. Out of all the North African data, Egypt's prehistory is the one that offers the most objective comparisons (as regard artefacts, climate, chronology, and bioarchaeological data) to the situations documented in the Near East. However, trying to reconstruct the itinerary that the Levantine components followed along the North African coast represents a much more difficult task. This is due to the gaps in the archaeological records of the various territories and to the fragmented nature of the findings. Some parallels can be drawn between the Holocene sequences of Lower Egypt with those of the two main areas of Libya: Cyrenaica[111] and Jebel Gharbi.[112] Other data about the presence of domestic species – mainly ovicaprines and a few cattle – are emerging from ongoing projects in Tunisia[113] and Algeria[114] and are contributing to the reconstruction of a highly heterogeneous mosaic of case studies.

At the westernmost end of North Africa, a significant amount of data on the Neolithisation process began to emerge in Morocco several years ago.[115] The most recent research has focused on the Alboran coast: a sea stretch in the westernmost Maghreb where the Moroccan coast is very close to that of Spain. In this area alone a dozen sites, all dated to the Mid-Holocene, are clustered not far from each other.[116] The most important of

101 Gautier 1987a, 177,
102 Marshall and Weissbrod 2011, S401.
103 This possibility is also supported by Brass 2013.
104 See Linseele, Van Neer, et al. 2014; Linseele, Holdaway, and Wendrich 2016; Phillipps et al. 2016; Shirai 2016.
105 Wendrich, Taylor, and Southon 2010.
106 Eiwanger 1984.
107 Rowland and Tassie 2014; Rowland and Bertini 2016; Phillipps et al. 2016.
108 A. B. Smith 1989; McDonald 2013; Shirai 2006.
109 Gopher 1994.
110 Shirai 2006; Shirai 2010; Shirai 2011.
111 Barker, Hunt, et al. 2007; Barker, Basell, et al. 2008; Barker, Antoniadou, Barton, et al. 2009; Barker, Antoniadou, Armitage, et al. 2010; Barker, Bennett, et al. 2012; Farr et al. 2014; Rabett et al. 2013.
112 Barich 2014; Barich, Lucarini, and Mutri 2015.
113 Mulazzani et al. 2016.
114 Kherbouche et al. 2014; Merzoug et al. 2016.
115 Ballouche and Marinval 2003; Daugas et al. 2008; Linstädter 2010; Linstädter et al. 2012.
116 Linstädter et al. 2012.

these sites, Ifri Oudadane, yielded rich evidence of a full Neolithic complex mainly based on domestic crops. Remains of domestic lentil (*Lens culinaris*) collected from the Early Holocene base of the deposit have been directly dated to 5600 cal BC (7611 ± 37 cal BP/5661 ± 37 cal BC). The presence of cereals is slightly later: *Triticum* sp. (7063 ± 73 cal BP/5113 ± 73 cal BC), *Hordeum vulgare* (6823 ± 54 cal BP/4873 ± 54 cal BC), and *Triticum aestivum* (6370 ± 39 cal BP/4420 ± 39 cal BC).[117] In this same Alboran territory but more to the west, other important finds concerning domestication had already been noted at the site of Kaf Taht el-Ghar.[118] Here the remains of *Triticum* sp. have been directly dated to ca. 5300 cal BC (7286 ± 85 cal BP/5336 ± 85 cal BC). The site has also yielded *Triticum dicoccum*, *T. aestivum*, *Hordeum vulgare*, and *Vicia faba*; these remains were also found in association with those of goats and cattle.

In light of these data we can state that from ca. 5400 cal BC the Maghrebian region had access to the whole package of Neolithic resources, to which elaborate pottery was also added. The fauna includes domestic ovicaprines, pigs, and to a lesser extent, cattle, the latter probably being slightly later than sheep/goats. The study of the faunal sample from Kaf Taht el-Ghar[119]explicitly associated cattle to level E, which according to the general chronology of the site, suggests a date between 5221 and 4675 cal BC.[120]

The source of this Neolithic influence and its spread to Morocco has long been debated. Ultimately the hypothesis that it could be related to the diffusion of the Cardial complex throughout the Mediterranean prevailed. The presence of domesticated crops in the main sites of the Alboran stretch is in accordance with the chronology that Morales and his colleagues suggest for the spread of agriculture all around the Mediterranean.[121] Some authors indicate an itinerary mediated by the Spanish Cardial[122] or suggest a spread involving both Iberian and Moroccan shores of the Mediterranean at the same time.[123] Lastly, others suggest a typically North African influence in the decorations and pottery styles.[124] As a matter of fact, the Moroccan chronology is consistent with that of the Mediterranean 'Impressed Ceramics' complex of the late 7th and 6th millennia cal BC. In particular, the site of El Barranquet (Sample Beta-221431: 6510 ± 50 bp, i.e. 7414 ± 50 cal BP/ 5464 ± 50 cal BC) on the Spanish southeastern coast, not far from the Alboran region, seems to be the most plausible candidate for the nearest transit region. It is clear, however, that even in this case the adoption of the exotic resources happened through active participation and cultural inter-exchange with the local Epipalaeolithic groups.

6 Conclusion

The high variability of the documented contexts hampers the construction of a general model for the Neolithic process in North Africa. In any case, all of the above mentioned points have prompted a significant reconsideration of what was initially believed in terms of North Africa's links with the Near East. Although it is assumed that the primary locations of the new resources can be found within this region, the new acquisitions are seen only as a part of a gradual transformation process on the part of already low-level food producer groups. These people were already living in semi-residential settlements and taking part in a series of activities that also made it possible for them to successfully acquire exotic products.

The road travelled from the Near and Middle East was not unique, and the events were manifold. For Morocco, the available data suggest a Mediterranean provenance, with subsequent redistributions by land, based on long distance routes, all of which are very difficult to reconstruct. In Egypt, despite its proximity to the southwestern Levantine territories, which allowed for more direct paths through the Negev and Sinai to be traced, the transformation towards a full agropastoral system took longer, with subsequent influences from the Levant. Egypt's late adoption of domesticated crops, which remains a matter of debate,[125] shows that the change

117 Morales, Pérez-Jordà, et al. 2013, Table 2.
118 Tarradell 1955; Tarradell 1958; Ballouche and Marinval 2003; Ramos et al. 2008.
119 Ouchaou and Amani 1997.
120 Daugas et al. 2008, Fig.2.
121 Morales, Pérez-Jordà, et al. 2013, 2660, Fig. 1.
122 'Cardial Neolithic': Ballouche and Marinval 2003; Zilhão 2015.
123 Linstädter et al. 2012.
124 Manen, Marchand, and Carvalho 2007.
125 Phillipps et al. 2016; Rowland and Bertini 2016.

from low-level food producers to farmers was fulfilled only when farming was regarded as a more effective practice by these groups, replacing the less labor-intensive management of spontaneous African plants (while not excluding the existence of non-systematic cases like those reported from Nubia).

When studying the initial stages of food production it is important to review the relationships between North Africa and the Levant, two regions that form a continuous bridge overlooking the Mediterranean, and each independently taking separate routes from the end of the Pleistocene. A critical review of the available data shows that the Neolithic (a stage of full-food production and of social, religious, and ideological evolution), had local roots everywhere, beginning with the intermediate 'middle ground' phase[126] found between the hunter-gatherer and agriculturalist ways of life. The complex forms of interaction between local groups and immigrants bearing the new resources, which were capable of transforming these initial low-level food producing cultures into true farming ones, definitely needs to be explored further.

126 B. D. Smith 2001.

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Last Post-Glacial Global Warming and Agricultural Origins in the Near East – A Transformability Theory

Summary

This contribution provides an integrated model of social-ecological transformations to explain the shift in the Near East from a subsistence economy to food production in the context of the last post-glacial warming. Caught in the grip of climate change, local societies in different habitats coped with recurrent climatic fluctuations through a variety of innovations, including intensive use of wild cereal grasses. By ca. 12 500–12 000 years ago, social arrangements, cosmologies, beliefs, and accumulated knowledge of habitats paved the way to overcome food shortages by cultivating wild cereals as a compliment to foraging. Subsequent developments depended on the perpetuation of social values, norms, and beliefs reinforcing relatively large group sizes and longer residence in settlements.

Keywords: agriculture; climate change; Holocene; Neolithic; social-ecological

Dieser Beitrag liefert ein integriertes Modell sozio-ökologischer Transformationen, um im Kontext der letzten Nacheiszeit-Erwärmung die Verschiebung im Nahen Osten von einer Ökonomie des reinen Auskommens zur Nahrungsmittelproduktion zu erklären. Im herrschenden Klimawandel meisterten Gemeinschaften wiederkehrende Schwankungen durch vielerlei Innovationen, so auch den intensiven Konsum von wildem Getreide-Gras. Vor etwa 12 500/12 000 Jahren ebneten soziale Arrangements, Kosmologien, Vorstellungen und gesammeltes Wissen zu Lebensräumen den Weg, um Vorratsmangel zu überwinden durch den Anbau von wildem Getreide-Gras als Ergänzung zur Nahrungssuche. Folgeentwicklungen hingen ab von der Bewahrung sozialer Werte, Normen, Vorstellungen, was größere Gruppen und längere Aufenthalte in Siedlungen verstärkte.

Keywords: Landwirtschaft; Klimawandel; Holozän; neolithisch; sozio-ökologisch

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1 Introduction

For almost a century, the emergence of agriculture has become a subject of great interest and controversy in archaeological circles. Labelled as a 'revolution' because of its tremendous and lasting impact on humanity, it has proved to be an intractable topic mainly because of the vagaries of the archaeological record and the problem of how to explain such a complex phenomenon.[1] However, much more data are now available that cannot be accommodated by previous explanatory models. I provide below a social-ecological systems model recognizing the efforts by human groups situated in vulnerable biogeographical/ecological settings to cope with stresses and take advantage of environmental opportunities precipitated by different scales of climatic fluctuations during the last post-glacial global warming. In some situations, social contingencies stimulated and fostered a sequence of technological and social innovations that led eventually, over hundreds of generations, to transform the social-ecological system and set it for further dramatic transformations.

2 Theories, models, and data

Earlier models of agricultural origins invoked 'prime movers' that included climate change, cultural pre-adaptation, population pressure, and religion.[2] More recent models focus on evolutionary ecological models and theories such as 'Optimal Foraging Model' and 'Niche Construction Theory'. Such approaches have a useful, but partial significance at certain times in the cultural trajectory from foraging to farming.[3] However, a more pertinent approach, akin to the current model, is Rosen and Rivera-Collazo[4] using 'Resilience Theory'. Without closely adhering to formal concepts of adaptation and adaptive cycles, the aim here is to elucidate the potential of emphasizing not only resilience, but also transformability, which is better suited to dealing with how human groups interact with their habitats and provides a better way of linking the past societies with present concerns with regard to the impact of climate change. At the core of the resilience/transformability theory is the concept of social-ecological systems (SESs). Such systems behave in a nonlinear ways, exhibiting marked thresholds in their dynamics.[5]

Resilience is attracting attention nowadays as humanity faces the scepter of climate change as our ancestors did during the post-global warming event from 17 000 to 11 500 years ago.[6] What is emerging is not just how to foster resilience to be able to recover from shocks, but also how to cultivate preparedness, to seek potential transformative opportunities, which emerge from, change. However, emphasis should be placed on the conceptual shift from 'adaptability' and 'resilience' to transformability[7] because of its paramount value in dealing with the emergence of new systems and regime shifts[8] through learning and creativity.[9] SESs deal with people-place connections, values and beliefs, knowledge and learning, social networks, collaborative governance, economic diversification, infrastructure, leadership, and outlook as an integral dimension.[10]

SESs are predicated on the moderation of the relationships among individuals who interact with each other for mutual interests. A system can be small consisting of bands of peripatetic foragers or large, composed of regional groups or societal segments. Moderation develops through formal or informal organizational structures based on mutual consent or coercion. Such structures are constantly rehearsed and challenged as each generation depending on the intensity of socialization adheres to traditional modalities, but experiments with new ideas, practices or modes of communication that may be imitated by others, and may eventually become socially acceptable as norms.

Knowledge of, and interaction with, the habitat for food, shelter or raw materials depends on the mode of life and the perceptual and explanatory schemata prevalent in a society. Recognition of climate change hence is limited to its impact on the habitats of communities that influence their livelihood. It is also limited by the short

1 Barker 2006; Larson et al. 2014; Price and Bar-Yosef 2011; Zeder 2011.
2 Price and Bar-Yosef 2011.
3 Mohlenhoff, Coltrain, and Codding 2015.
4 Rosen and Rivera-Collazo 2012.
5 Holling, Gunderson, and Ludwig 2002; Davoudi, Brooks, and Mehmood 2013.
6 Desjardins et al. 2015.
7 Walker and Salt 2012.
8 Folke et al. 2004.
9 Capra and Luisi 2014.
10 Berkes and Ross 2013.

generational scale of human memory, especially in the absence of writing and archives[11] that may only recall events that are on a decadal scale covering the span of a few generations. Therefore, climatic events at a centennial or millennial scale are not likely to be recalled, except perhaps in myths. However, they may be encoded in ideas and practices that moderates the relationship with the environment.

3 Resilience and adaptability (17 000–14 500 cal BP)

The Near East was particularly suited for the cultural developments that eventually led to farming and herding, not the least because of the presence of the wild stands of wheat and barley and wild goats, sheep and cattle. Situated where climate systems (North Atlantic/ITCZ) interact and influence climate at millennial scale,[12] the mountain-edge and semi-arid ecotones (Fig. 1) were particularly susceptible to decadal and centennial temporal and spatial hydrological variability.

Recurring climatic fluctuations at centennial scale, superimposed on millennial oscillations had local manifestations[13] of global climatic events[14] that influenced inter-annual and decadal variability in the quality, distribution, density, spatial pattern, diversity and seasonality of plants and wild game. The record reveals pronounced transitions in archaeological entities correlated with the changes that occurred in the climate during the Last Glacial Maximum and the more turbulent climate during the post-glacial global warming, starting ca. 16 800 cal BP concomitant with the Heinrich 1 event (Tab. 1).[15]

One of the main ecological consequences was the establishment of a Mediterranean climate with very dry summers – more seasonal than any today – in the Levant at the end of the Pleistocene, which was favorable for annual species of cereals and legumes.[16] Innovations in food getting technologies and social arrangements were already underway over several millennia, beginning ca. 21 000 years ago (correlated with the Kebaran archaeological unit) when colder and drier conditions prevailed. During that time, human groups took certain measures to alleviate the impact of food shortages due to inter-annual unreliability and spatial unpredictability of rainfall. Such measures included use of low-rank foods and broadening of the diet, preserving and storing of foodstuff, and extracting portions that were more edible. This was achieved through several technological innovations such as grinding stones and microliths.[17] The use of microliths for bows and arrows, for example, could have doubled the yield from birds and small game.[18]

Within a matter of 5–10 generations, it would have become clear that conditions of vegetation and fauna were getting better, especially after 17 000 cal BP. However, frequent climatic oscillations on a decadal scale

11 Hassan 2000, 121–140.
12 Vidal et al. 2012, 13012.
13 Holling, Gunderson, and Ludwig 2002; Van Zeist, Baruch, and Bottema 2009; Robinson et al. 2011, 71; Bar-Matthews, Ayalon, and Kaufman 1997; Wright and Thorpe 2014, 49–62; Yasuda, Kitagawa, and Nakagawa 2000; Migowski et al. 2006; Weninger et al. 2009.
14 Köhler, Knorr, and Bard 2014, 25; Parrenin et al. 2013, 1060–1063; Lorius et al. 2012, 235; Larsen et al. 2015, 291–294; Johnsen et al. 2001; Rohling and Pälike 2005, 975–979; Chen et al. 2006; Rasmussen et al. 2007; Björck et al. 2001.
15 Steven A Rosen (written communication) provided the following comments explaining some key differences between the Mediterranean and the arid southern Levant/Negev/Sinai.: 1) It is perhaps important to distinguish between the arid zones and the Mediterranean zones – the Mushabian never penetrates the Mediterranean zone (except that in some form it perhaps transforms/syncretizes into the Natufian). The Geometric Kebaran seems to penetrate the arid zone, perhaps precisely because of the climatic amelioration. The tail end of the Mushabian transforms into another industry/culture which has gone by the following names: Negev Kebaran, Terminal Mushabian, and Ramonian. This industry can actually be subdivided chronologically according to clear lithic trends (especially increasing use of Helwan retouch with time); 2) There is virtually no early Natufian in the Negev/Sinai, but Goring-Morris suggests that the Terminal Ramonian, of which there are a few sites, is contemporary with at least part of the Early Natufian; and 3) The units you list here are actually chronologically and geographically ordered. The Harifian is found only the Negev and Sinai and clearly develops straight out of the Late Natufian. It is probably contemporary with the Khiamian. The Sultanian follows the Khiamian. Both of these units (Khiamian and Sutlanian) comprise the PPNA.The Mureybetian is another facies of PPNA, 4) Everyone divides the PPNB into three stages, Early, Middle, and Late (EPPNB, MPPNB, LPPNB), followed by the PPNC. Without entering the details of the internal chronologies, note the following: The megasites are Late PPNB, the second half of the 8th mill. Cal BCE and the beginning of the 7th mill. Cal BCE. The PPNB collapse occurs ca. 6700, followed by the PPNC which is a transition to Pottery Neolithic lifeways (changes in technology, architecture, site size, settlement patterns, etc.). The PN (Yarmukian begins ca. 8.2/8.0) Yarmukian is very much considered part of the Pottery Neolithic (Andrew Moore referred to it as the Early Pottery Neolithic, and the later PN as Late Pottery Neolithic).
16 McCorriston and Hole 1991.
17 Hassan 1977; Hassan 1981; Hassan 2009.
18 Bettinger 2013, 118–123.

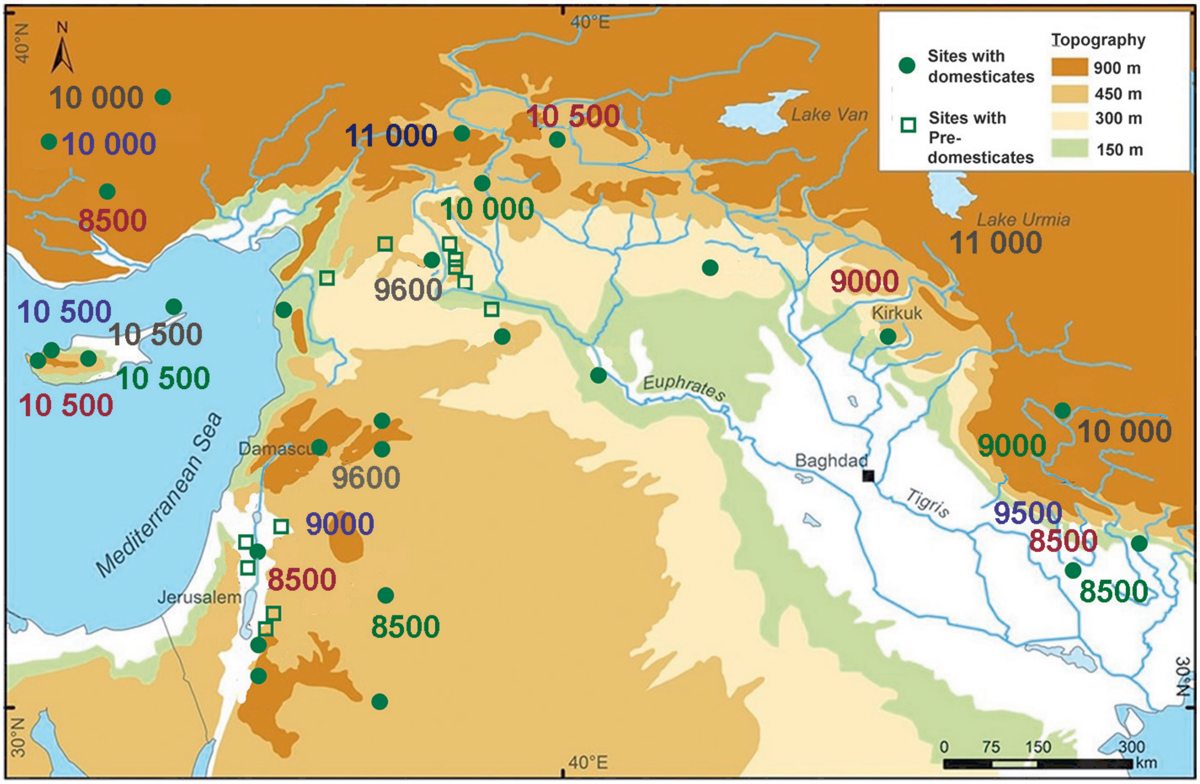

Fig. 1 Topographic map of the Near East showing location of sites containing pre-domesticated plants (green squares) and domesticated plants (solid green circles) after Fuller, Willcox, and Allaby (2011), and dates as calibrated years before present of sites with oldest remains of domesticated animals: pigs (purple), cattle (green), sheep (blue), and goats (black) after Zeder (2011). The sites of both domesticated animals and pre-domesticated plants are situated at the ecotones bordering mountain ranges at the periphery of the 'fertile crescent of ancient civilizations'. The earliest domesticated animals are restricted to the southern slopes of the Taurus and Zagros mountains from where they appear to have spread westwards and southwards during the climatic optimum of the early Holocene after 10 000 years ago, with a further spread farther southwards after 9500 years ago.

called for a conservative subsistence strategy and minimum regret decisions. Any groups that experimented with large congregations, fully sedentary residence or specialization would have failed.

The change in subsistence was apparently associated with a growing sense of place and ancestry, as groups began to repeatedly frequent the same favorable locales. This seems to be suggested by the cemetery of the 'Uyun al-Hammam Site (17 250–16 350 to 15 000–14 200 cal BP), which includes a human-fox burial. This indicates that joint human-animal mortuary practices known from later periods appeared earlier during the Geometric Kebaran.[19]

4 Seeds of transformation (14 500 to 13 000 cal BP)

The rapid increase in precipitation that marked the beginning of the wetter, warmer period known as the Bølling-Allerød (14 500 to 13 000 cal BP) was decisive in providing opportunities to consolidate, expand and intensify pre-existing economic strategies that included intensive utilization of wild cereal grasses.[20] The improvement in climatic conditions permitted population expansion.[21] This period coincides with the Early Natufian characterized by small, sedentary villages and hamlets, ritual burials, artworks, and animal figurines.[22] The subsistence economy was broad-based consisting

19 Maher et al. 2011.
20 Hassan 1981.
21 Wright and Thorpe 2014, 49–62.
22 Goring-Morris and Belfer-Cohen 2008.

Archaeological Units	Chronology (30, 42) in thousands of calibrated years before present (kyr cal BP)	Climatic and environmental conditions in the Levant	Global Climate
Kebaran	21–17	Cold and dry, expansion of forests, hilly coastal areas and forests have winter precipitation, annual rainfall of 300–450 mm, Temp. 12°–16°C.	Initial phase of the transition from the Ice Age to a post-glacial warming with CO_2 deglacial at 18 kyr cal BP.
Geometric Kebaran/Mushabian	17–14.6	Precipitation slowly increases, warming by 2°–3°C, Expansion of C3 vegetation.	Heinrich 1 Event (16.8 kyr cal BP)
Early Natufian	14.9/14.7–13.2/13	More rapid increase in precipitation, with a peak in precipitation following a short cold, dry pulse.	Bølling-Allerød (14.5–13/12.7 kyr cal BP) Wetter climate followed by dry conditions towards the end of the Bølling–Allerød interstadial.
Late Natufian, Harifian, Murebetian/Sultanian/Khiamian,	13/12.8–11.5	Cold an dry, retraction of favorable Mediterranean vegetation, with prevalence of dry Chenopod Artemisia steppe	Younger Dryas (13–11.5 kyr cal BP): onset of the Younger Dryas at 129 kyr cal BP, highly variable sea ice conditions from ca 11.9 to 11.5 kyr cal BP, with an extremely short interval of permanent or near-permanent sea ice at ca 11.7 kyr cal BP.
Pre-Pottery Neolithic A (PPNA)	11.7/11.5/11.1–10.5	Return of pluvial conditions, very wet in northern Levant and Anatolia with a re-advance of forests, with less precipitation in central and southern Levant where parkland vegetation prevails.	Climate warmer after 12 ka BP (Pre-Boreal Oscillation 11.4–11.5), but vegetation remained in disequilibrium with climate until 10 ka BP,
Pre-pottery Neolithic B (PPNB)	10.5–8.2	Warmer and wetter than present day but progressively decreasing, and more unstable, increased soil erosion and runoff. A major wet phase in the Dead Sea ~ 10–8.6 kyr cal BP. An arid event at 8.6 in the Dead Sea. ~ 5.6–3.5 cal kyr BP) and multiple abrupt arid events during the Holocene. The arid events in the Holocene Dead Sea appear to coincide with major breaks in the Near East cultural evolution (at ~ 8.6, 8.2, 4.2, 3.5 cal kyr BP).	A climatic optimum with drier cold anomalies at 10.4–10.2, 9.9–9.2, 8.8-8.3.
Reorganizational phase	8.2 kyr cal BP	A abrupt arid event in the Dead Sea at 8.2 kyr cal BP.	Abrupt 8.2 kyr cal BP Cold event
Post-PPNB (Yarmukian)	8.2–7.5	Sudden cooling and significant decrease in rainfall recalling the Younger Dryas. Drastic drop in level of Dead Sea recovering slightly at 7.5 kyr cal BP.	Holocene thermal maximum (8–5 cal. kyr BP, with a change in variability patterns at 7–6 kyr cal BP.
Pottery Neolithic (PN)	7.5–6.8	Unstable climate with a shift from forest to maquis vegetation in northern Levant and more olives in southern Levant. Relatively low levels are maintained until 5.6 kyr cal BP.	Holocene thermal maximum (8–5 cal. kyr BP, with a change in variability patterns at 7–6 kyr cal BP.

Tab. 1 Chronology of the archaeological units of the Levant correlated with climatic and environmental conditions.

of game animals, birds, reptiles, fish, cereals and other plant foods.

The rapid increase in precipitation at 14 500 cal BP and the prevalence of greater, localized food resources for 1500 years or 75 generations (coincident with the Early Natufian, Tab. 1) provided sufficient time and conditions conducive to try and realize that large, sedentary villages can be sustained.[23] This would have entailed

23 Cf. Goring-Morris and Belfer-Cohen 2008.

the adoption of social mechanisms to strengthen social ties to diffuse conflicts resulting from living together for a longer time than usual, enable sustainability of large corporate groups, and maintain 'territorial' claims. This would explain evidence of ritual and intentional secondary burial practices, including the removal and reburial of skulls and other mortuary rituals as a means of social integration.[24]

The Early Natufian was a time for consolidating the cohesion of relatively large, co-residential groups through rituals, communal gatherings and festivities. In a different context, Birch's[25] investigation of settlement aggregation and social integration in Iroquoian Ontario illustrates how people constructed, inhabited, and negotiated domestic and public spaces in the new community aggregates. Detailed analyses of the occupational histories of village sites point to the creation of new community-based identities, corporate decision-making structures, and increasing social integration over time. This provides an insight into the social aspects of village formation during the Natufian and later during Pre-Pottery Neolithic A (see below).

While it is not unlikely that beer brewing was practiced by Natufian communities,[26] beer consumption and 'feasting' could have been one of the mechanism of social cohesion. Feasting apparently continued during the Late Natufian as indicated by Munro and Grosman[27] at a burial cave in Israel dating to 12 000 cal BP. It indicates the continuity of cereal-based traditions that might have played a role in the cultivation of wild cereals and pulses during such stressful times. However, Kuijt[28] finds no compelling evidence for feasting before agriculture in the Near East.

Feasting among foragers is a means, by which they can share an occasional or seasonal availability of a food resource, e.g., harvesting wild cereals, capture of a big game animals, or abundance of various fruits at a certain time. It is based on reciprocity rather than competition under foraging conditions of scarcity, occasional windfalls, lack of effective preservation and storage. By contrast, feasting in advanced agrarian societies is also a mechanism to maneuver to gain a high position in a status-conscious society, when status can provide opportunities for commanding gifts, labor, and obedience. It appears that the Natufian economy, while providing occasional prosperity and reliable livelihood, did not seem to have allowed the emergence of wealth-based hereditary social inequality[29] as in agrarian societies.

5 The Younger Dryas crisis

By 13 000 cal BP, the advent of the Younger Dryas[30] placed existing systems characterized by large group size, reduced mobility and sedentary settlements at risk.[31] Sea-ice diatom proxy provides an unambiguous measure of seasonal sea ice and thus the onset of the Younger Dryas at 12 900 cal BP, and for the next ca 1400 years prevalence of seasonal sea ice. Conditions changed significantly from stable to highly variable sea ice conditions from ca 11 900 cal BP to 11 500, during which an extremely short interval of permanent or near-permanent sea ice at ca 11 750 cal BP. At ca. 11 500 cal BP ice-free conditions signified the beginning of the Holocene.[32]

Pollen data also indicate that the distribution of cereal grasses was not reduced, but that the Younger Dryas led to a reduction of the productivity of floral resources of the Mediterranean Woodlands.[33] The impact of the Younger Dryas – as with any other global climatic event – had different manifestations and intensities in different regions of the Near East, with areas that may suffer or prosper more or less than other areas depending on location and local topographic and hydrological conditions. The impact also varied depending on the pre-existing states of the social systems. Archaeological data reveal that responses, where the stress was most pronounced, was to descale and re-organize groups, relocate to more favorable habitats, or become more mobile as indicated by the Late Natufian and Harifian sites.[34] It is also highly probable that cultivation of wild cereals and management of wild game were probably attempted at

24 Byrd 2005; Nadel et al. 2013, 11774–11778.
25 Birch 2012.
26 Hayden, Canuel, and Shanse 2013.
27 Munro and Grosman 2010.
28 Kuijt 2009.
29 Bettinger 2013, 118–123.
30 Hajar, Khater, and Cheddadi 2008; Cabedo-Sanz et al. 2013.
31 Makarewicz 2012; Bar-Yosef 2011.
32 Cabedo-Sanz et al. 2013.
33 Makarewicz 2012.
34 Bar-Yosef 2011.

that time.[35] This hypothesis is strengthened by the time required to witness morphological changes in plants (see below). Henry[36] provides a detailed discussion of the relationship between the Natufian and the Younger Dryas.

Munroe[37] examined faunal assemblages spanning the agricultural transition and dating to the Early and Late Natufian and Pre-Pottery Neolithic periods (ca. 14 500 to 11 000 cal BP), and found no evidence for intensified resource use or food stress in the Late Natufian, at least in comparison to the Early Natufian phase. Although, she assumes that this finding does not support the view that the Younger Dryas played a causal role in the adoption of agricultural economies, she misses the point of differentiating between agriculture and cultivation of wild plants and that the economic strategy during the Early Natufian was already intensified and further intensification would not have been possible without driving fragile, scarce resources to extinction. It may also be noted, as she remarks, that site occupation reached an unprecedented high level during the Early Natufian, but quickly reverted to pre-Natufian levels with the onset of the Younger Dryas. Maintenance of an adequate standard of living would have also been due to depopulation and fertility dampening measures. There is also the problem of lack of sufficient quantities of plant remains. In addition, Munroe's Late Natufian collections predate the Younger Dryas (Donald Henry, personal communication).

By decreasing site occupation intensity and increasing mobility, the Late Natufian communities implemented effective strategies to cope with changing resource distributions and at the same time clinging to the social and ritual practices that emerged over at least a millennium during the Early Natufian, which would have been the driver to increase cereal production through cultivation to ensure at least seasonal aggregation of groups.

The stressful situation during the Late Natufian may have also contributed to the use of shamanistic practices and elaborate interment rituals, as indicated by the 12 000-year burial of a shaman that could have served to continue social networking that would have contributed to the social matrix of sedentary villages during the next episode. The grave belonged to a petite, elderly, and disabled woman, who was accompanied by 50 complete tortoise shells and select parts of a wild boar, an eagle, a cow, a leopard, and two martens, as well as a complete human foot.[38]

6 Early Holocene foragers and farmers (11 500 to 8200 cal BP)

Analysis of ice from Dye-3, Greenland, has demonstrated that the transition between the Younger Dryas and Holocene wetter and warmer climate occurred rapidly over a 40-year period. A near annually resolved, multi-parameter record of the transition recorded in the GISP2 core from Summit, Greenland, shows that most of the transition occurred in a series of steps with durations of about 5 years.[39] This means that Late Natufian communities were within a couple of generations suddenly faced with better opportunities to stabilize their food gains.

The return of wetter, warmer conditions during the early Holocene (11 500 cal BP) favored greater dependence on the cultivation of reliable wild cereals and selection of well-watered springs and small and medium river valleys to cultivate wild cereals, pulses and to keep livestock.[40] These developments characterize the Pre-Pottery Neolithic A (PPNA) in the Levant. Clusters of large villages up to 2.5 ha in size, with at least 150–200 people appeared with a mixed economy of hunting, gathering wild plants, harvesting fruits, and cultivation of rye, oats, einkorn, emmer wheat, barley, peas, grass peas, bitter vetch and common vetch. The villages were almost invariably situated next to bountiful springs or along riverbanks.[41] This was a strategic move that represents the solution to locational problems allowing the PPNA communities to combine growing cereals with pulses and keeping animal game to overcome the nutritional problems associated with a predominantly cereal diet.[42]

35 Bar-Yosef 2011; Willcox 2012.
36 Henry 2013.
37 Munro 2003.
38 Grosman, Munro, and Belfer-Cohen 2008.
39 Taylor et al. 1997.
40 Fuller, Willcox, and Allaby 2011.
41 Bar-Yosef 2011.
42 Hassan 1976.

The transition to the stage where domesticated cereals and pulses are recognized in the archaeological record is attested between 10 400 and 9800 cal BP in several areas in the Near East during the Pre-Pottery Neolithic B (PPNB) phase (Fig. 1). The oldest evidence is at about 10 400 cal BP (domesticated lentil and Cicer at Tell Aswad in the Southern Levant, and at the same time at Tell el-Kerk in the Northern Levant/Anatolia region (Cicer), and in southern Turkey at Nevali Cori at 10 300 cal BP. Domesticated wheat, barley, and lentil are documented at Cafer Höyük in southern Turkey together with lentil 10 100 cal BP; domesticated barely at Ganj Dareh in the eastern Fertile Crescent at 10 100, and in the same region domesticated wheat, barley and lentil are found at Tell Abdul Hosein at 10 000 cal BP. The full combination of wheat, barley, lentil and peas are found at Yaftehel in the Southern Levant at 9800 cal BP.[43] The domestication of sheep, goats, cattle and pigs appears at ca. 10 500–9500 cal BP.[44]

Fuller, Willcox, and Allaby[45] and Zeder[46] also suggest that plant and animal domestication occurred at roughly the same time. In addition, Fuller, Willcox, and Allaby[47] conclude that morphological indicators of domestication in crops were preceded by a long period of increasingly intensive human management that can be as much as 2000 years. This places the putative timing of cultivating wild cereals close to ca. 12 400 cal BP at the time of the Late Natufian during the Younger Dryas.

Farming communities of this period became progressively larger and sedentary at an unprecedented level.[48] In addition to private dwellings, Goring-Morris and Belfer-Cohen[49] note that there were occasional appearances of substantial communal architectural endeavors in the PPNA villages. They include the tower at Jericho, which probably played a ritual and community role. Communal structures were more frequent during the Pre-Pottery Neolithic B, with the identification of ritual buildings at Beidha, 'Ain Ghazal, and Netiv Hagdud.[50]

7 Final remarks

The transition from foraging to the cultivation of domesticated cereals over the span of more than 300 generations was as a socially induced multi-stage process by social systems closely coupled to climate changes during the last post-glacial warming. Privileging the role of 'rapid' climatic fluctuations at the time of the emergence of agriculture[51] ignores the long sequence of events that preceded and led to the cultivation of domesticated plants at the beginning of the 11th millennium cal BP.[52] The 10 200 cal BP event[53] is not precisely timed and shows worldwide variability from 9950 to 10 400 cal BP.[54] Its effect might have been to cement the belief in the reliability of cereals as an indispensable food and reinforce the continuation of cultivating wild plants that began two millennia earlier in more favorable habitats.

Early agrarian societies faced their own impact on local resources as population density as well as the size of villages expanded after 10 500 cal BP.[55] They persisted for about 100 generations during which they managed to overcome drier and colder climatic fluctuations at about 9300 cal BP[56] and 8800–8500 year cal BP.[57] However, the severe cold, dry 8200 cal BP event apparently stimulated the dispersal of some Near Eastern groups into North Africa and Europe[58] thus bringing the fruits, the toil as well as the great transformational potential of agricultural production to the rest of the Old World.

The striking correspondence between prominent global climatic events and independently formulated archaeological units beginning with the Last Glacial Maximum makes it impossible to ignore climatic exigencies in an area characterized by its vulnerable ecotones, ecological diversity and domesticable plants and animals. Nevertheless, it would be a grave shortcoming to ignore the ingenuity in developing new subsistence technologies for capturing and managing a broad spectrum of plants and animals, processing, preserving, and storing

43 Byrd and Monahan 1995.
44 Zeder 2011.
45 Fuller, Willcox, and Allaby 2011.
46 Zeder 2011.
47 Fuller, Willcox, and Allaby 2011, 637.
48 Simmons 2007.
49 Goring-Morris and Belfer-Cohen 2008.
50 Finlayson et al. 2011.
51 Borrell, Junno, and Barceló 2015.
52 Chen et al. 2006; Rasmussen et al. 2007; Björck et al. 2001.
53 Weninger et al. 2009.
54 Chen et al. 2006; Rasmussen et al. 2007; Björck et al. 2001.
55 Simmons 2007.
56 Rasmussen et al. 2007.
57 McCorriston and Hole 1991; Weninger et al. 2009.
58 Hassan 2009.

their food products, maneuvering residential mobility, as well as group size and demographics to recover from environmental shocks and take advantage of windfalls. This apparent resilience led after more than five millennia to the propagation of certain social and subsistence innovations that allowed the Ecological-Social System (ESS) to break through to a new order. Agriculture is indebted to human ingenuity and the inherent transformability of ESSs.

No ecological explanation of agricultural origins that does not consider the proactive role of human ingenuity and the contingencies of social structures, as well as the role of values, supernatural beliefs, rituals, and cognitive styles in constraining or provoking human actions can hope to succeed.[59] There is, indeed, evidence of ritual activities and death-life related beliefs that go back to the Kebaran and perhaps earlier due to the trauma of the Last Glacial Maximum.[60] The new cosmologies, religious beliefs, and symbolism preceded agriculture by a very long time, providing an ideational realm that buttressed social bonding and the sacred association between life-giving forces and cereal grasses as a reliable life-support food item.[61]

The floral grave lining from 13 700–11 700 years old Natufian burials at Raqefet Cave, Mt. Carmel, Israel,[62] at a time when death and famine menaced life and threatened the ability of human groups to survive, send us a reminder of the will to overcome death and to celebrate life.

59 Cannon 2014.
60 Cauvin 2002.
61 Cauvin 2002.
62 Nadel et al. 2013, 11774–11778.

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Illustration and table credits

ILLUSTRATIONS: **1** Topographic map, Fuller, Willcox, and Allaby 2011; information on oldest remains of domesticated animals, Zeder 2011; F. Hassan. **TABLES:** **1** F. Hassan.

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Early Livestock in Egypt: Archaeozoological Evidence

Summary

This contribution presents the archaeozoological evidence for early domesticated animals in Egypt, used as a starting point to address the key issues of the Revolutions Workshop in 2014. In the late 7th and 6th millennium cal BC the earliest undisputed evidence for domesticates appeared, but skeletal remains are rare until the 5th millennium cal BC. This lack of evidence limits the possibilities for reconstructing diffusion routes, reasons for adaptation, use of specific species, etc. On the other hand, the lack of data is in itself informative about the form that early food production took, leaving only few archaeological traces. All major domesticated food animals probably found their way to Egypt from Southwest Asia, where they were initially domesticated.

Keywords: Egypt; Fayum; archaeozoology; early food production; introductions; archaeological visibility

Dieser Beitrag präsentiert die archäozoologischen Belege für frühe domestizierte Tiere in Ägypten, die als Ausgangspunkt genutzt werden, um Schlüsselthemen des Revolutions-Workshop aus dem Jahr 2014 anzusprechen. Im späten 7. und im 6. Jahrtausend v. Chr. liegt die früheste unbestrittene Evidenz für Nutztiere vor, wobei Skelettfunde sehr rar sind bis zum 5. Jahrtausend. Dieser Mangel an Evidenz schränkt die Möglichkeiten der Rekonstruktion von Verbreitungsrouten, Anpassungsgründen, der Nutzung von Tierarten etc. ein. Andererseits ist der Mangel an Daten selbst aufschlussreich für die frühe Nahrungsproduktion, die nur wenige archäologische Spuren hinterließ. Alle wichtigen Nutztiere, die in Ägypten als Nahrung dienten, kamen wahrscheinlich von Südwestafrika, wo sie zuerst domestiziert wurden.

Keywords: Ägypten; Fayum; Archäozoologie; frühe Nahrungsproduktion; Einführungen; archäologische Sichtbarkeit

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1 Introduction

The overarching theme of the workshop was the transition to food production in countries bordering the Mediterranean. The present contribution focuses on one aspect of food production, livestock keeping, in the area within the borders of modern Egypt. This country is part of the Mediterranean but also of Africa, and has in fact been of major importance in the spread of livestock over the African continent. It served as an overland corridor through which domestic animals spread to Saharan and sub-Saharan Africa.[1] Egypt owes much of its key role to its proximity to Southwest Asia, one of the core areas in the world where major food animals as well as plants were domesticated.[2] The focus of this paper is on the physical evidence for early domestic livestock from Egypt and will from there address some specific issues of the workshop.

1.1 Bone evidence for early livestock in Egypt

I have published a detailed review of the state of archaeozoological evidence for early livestock in Egypt elsewhere and here I give a summary of the major points.[3] There is insufficient evidence to allow for fine diachronic reconstructions and, therefore, the chronological subdivisions in this paper are necessarily very broad. Emphasis will be on the Fayum Oasis, as this has been the focus of my own research recently and because I believe some interesting lessons are to be learnt from this area.

1.2 Ca. 6200–5000 cal BC

From ca. 6200 cal BC there is undisputed evidence for domestic animals in Egypt.[4] However, for the entire 6th millennium cal BC, records of animal domesticates remain extremely scarce, found at very few sites and usually with not more than a handful of bones at each site (Fig. 1, Tab. 1). The scantiness of data was already pointed out three decades ago,[5] and although data have been added since, the evidence for the earliest stage of stock keeping remains rare. Bone remains of early domesticated livestock come mainly from the Egyptian deserts (Tab. 1), where people with apparently mobile lifestyles had caprines (*Ovis aries* and *Capra hircus*) and some cattle (*Bos taurus*). Caprines have no local wild ancestors and originated from Southwest Asia. Cattle probably also arrived from Asia at this point, although wild cattle (*Bos primigenius*) occurred locally in Egypt (see below on a possible local domestication).[6] Key sites and areas of the late 7th and 6th millennium cal BC are Nabta Playa/Bir Kiseiba[7] and Hidden Valley Village[8] site in the Farafra Oasis for the Western Desert, and Sodmein[9] for the Eastern Desert. In fact, from the latter site, only goat was identified. Both for Hidden Valley and Sodmein, the oldest date associated with domesticates is ca. 6200 cal BC. However, at Sodmein it is to be regarded as a *terminus ante quem*, since the dated sample is from a hearth above the find location of a caprine bone. During the 6th millennium cal BC there is no evidence from Egypt for the cultivation of crops.

Also in the Fayum Oasis, domestic animals were known in the 6th millennium cal BC. At site QSXI/81, dated to ca. 5400 cal BC, five caprine bones have been found.[10] A slightly more recent site in the same area, QSIX/81, dated ca. 5350 cal BC, yielded a larger sample of caprine bones, as well as some cattle remains. The domestic status of the cattle is clear from their small size.[11] In fact, together with cattle from Nabta Playa/Bir Kiseiba, these cattle are the only ones that are published for the 6th millennium cal BC in Egypt. Both QSXI/81 and QSIX/81 are not always included in overviews of early domesticates or models of spread of livestock to Egypt, presumably in part due the fact that they are not well contextualized.[12] Five caprine bones, among which one of sheep and two of goat have now been identified from the area at, and around, locality E29H1 in the Fayum,[13] with extensive but shallow deposits of archaeological material initially reported as 'Epipalaeolithic'.[14] The sheep bone has been directly dated to ca. 5600 cal

1 Blench and MacDonald 2000.
2 Larson and Fuller 2014.
3 Linseele, Van Neer, et al. 2014.
4 Linseele, Van Neer, et al. 2014.
5 Gautier 1987; see also Gautier 2002.
6 Linseele 2004, 9.
7 Gautier 2001.
8 Gautier 2014.
9 Vermeersch, Linseele, et al. 2015.
10 von den Driesch 1986.
11 von den Driesch 1986.
12 E.g. Close 2002; Barich 2014.
13 Linseele, Holdaway, and Wendrich 2016.
14 Caton-Thompson and Gardner 1934; Wendorf and Schild 1976, 182.

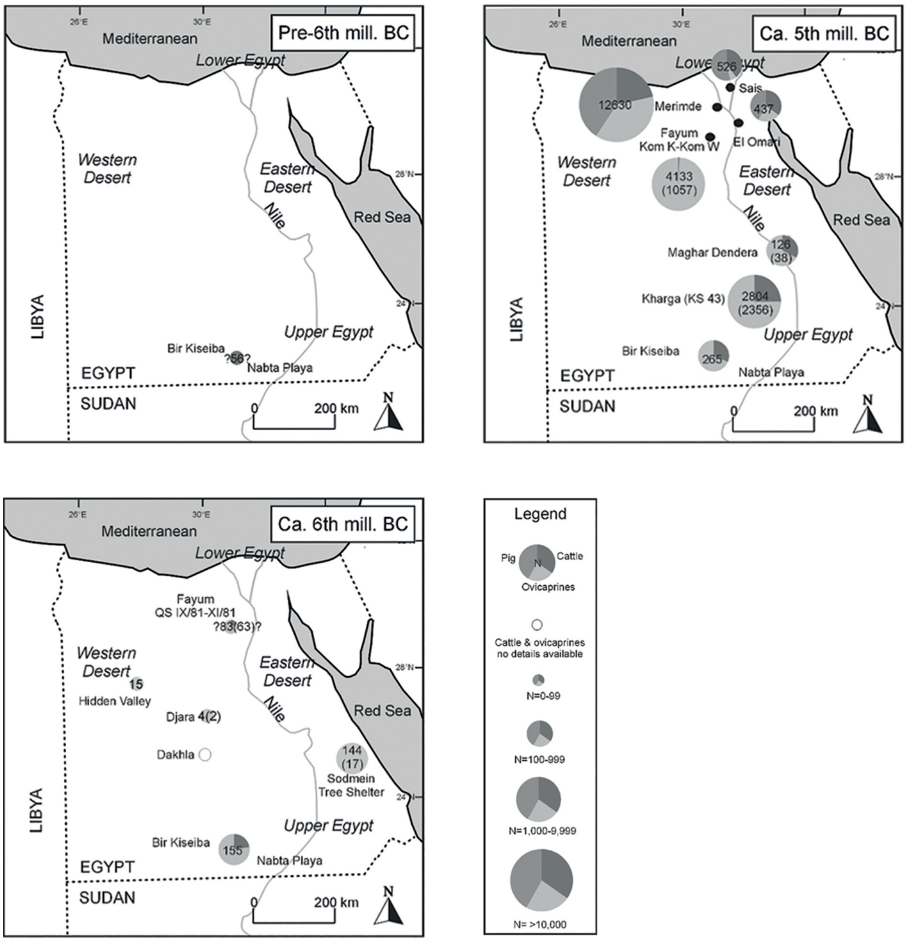

Fig. 1 Overview of bone finds of domestic animals in Egypt by broad chronological phase. Numbers between brackets exclude specimens from the imprecisely identified categories small and large bovids. Number with question marks refers to disputed identifications; site with question mark is poorly contextualized.

BC and is consistent with the younger range of radiocarbon dates recently obtained from areas to the east of E29H1.[15] It is the oldest date for domestic animals hitherto known from the Fayum.

1.3 Ca. 5000–4000 cal BC

From the 5th millennium cal BC, Egyptian sites with domestic animals significantly increase in numbers and also appear in the Nile Valley (Fig. 1). From this time onwards, not only cattle and caprines, but also pigs (*Sus domesticus*) appears in the archaeological record. Cultivated crops from Southwest Asia, including emmer wheat (*Triticum turgidum* ssp. dicoccon) and hulled six-row barley (*Hordeum vulgare* ssp. vulgare) are now also known from Egypt.[16] Evidence for pigs and crops seems to concur. Where it appears, the presence of human groups with a less mobile lifestyle, presumably sedentary farmers, or at least contacts with such groups, can be supposed. Apart from occasional grains obtained through contacts with the Nile Valley,[17] both cultivated crops and pigs are missing from the deserts, as might be expected due to environmental conditions.

While domestic species start to appear in the Fayum from at least 5600 cal BC, most evidence for domestic animals in the Fayum is much more recent, dated to ca. 4500 cal BC, and comes mainly from the sites Kom K and Kom W.[18] Dogs (*Canis familiaris*), caprines, and cattle, as well as pigs have been identified. However, there is no stage in the Early and Middle Holocene of the Fayum where the available evidence sustains the idea of domestic livestock as the most prominent source of

15 Holdaway and Wendrich 2017.
16 See summary in Linseele, Van Neer, et al. 2014.
17 E.g. Briois et al. 2012.
18 Linseele, Van Neer, et al. 2014.

Site	Approximate date (cal BC)	Cattle	Sheep/ goat	of which sheep	of which goat	References
E29H1	5600	–	5	1	2	Linseele, Holdaway, and Wendrich 2016
QS XI/81	5400	–	5	1	–	von den Driesch 1986
QS IX/81	5350	10	46	7	1	von den Driesch 1986
Hidden Valley	6200–5500	–	15	min. 1	min. 4	Gautier 2014
Djara	6500–5900 + 4900	–	1? + 1	1?	–	Kindermann et al. 2006
Dakhla Oasis	6500–5600/5400	x	x			McDonald 1998; McDonald 2013; Churcher et al. 2008
Nabta Playa/Bir Kiseiba	6100–5400	35	120	—— mainly sheep	——	Gautier 2001
Sodmein	6200–3700	–	10	–	1	Vermeersch, Linseele, et al. 2015

Tab. 1 Egyptian sites dating to the 6th millennium cal BC with numbers of bones of domesticated animals recorded. X = present but numbers not reported.

animal proteins. Fish are numerically most important in the fauna from all known localities of this period in the Fayum.[19] Cultivated crops in the Fayum are first evidenced around the middle of the 5th millennium cal BC.[20] No remains of more permanent dwellings have been found in the Fayum and the lithics indicate mobility, although within a restricted area.[21] This is not incompatible with the presence of pigs, which are actually represented by very few bones.

1.4 Management of local wild species?

Before the appearance of Southwest Asian domesticates, there was a phase with possible management of local wild species in Northern Africa. This has especially been argued for wild cattle/aurochs at Nabta Playa/Bir Kiseiba (late 9th/8th millennium cal BC) and has resulted in the hypothesis that cattle were also locally domesticated.[22] A local domestication of cattle in Africa is at present not supported by independent evidence from other sites or by genetic data on modern cattle.[23] However, this does not exclude some type of cattle management at Nabta Playa/Bir Kiseiba. In the Acacus in Libya, management of Barbary sheep (*Ammotragus lervia*) at ca. 6000 cal BC has been hypothesized.[24] This has been much less debated than for the African aurochs, because the Barbary sheep was never domesticated.

1.5 Concluding remarks

In Southwest Asia, the major livestock animals were domesticated from about the middle of the 9th millennium cal BC[25] and by the 5th millennium cal BC farming economies had also reached the western borders of continental Europe.[26] Considering its proximity to Southwest Asia, domesticates from this area thus appear comparatively late in Egypt and this remains one of the key issues in the archaeology of Holocene Northern Africa.

The sites at which the earliest domestic animals appear in the late 7th–5th millennium cal BC in Egypt show variation in a number of characteristics: the relative importance of domestic animals in general, and of cattle and pigs in particular; the relative importance of wild game and of fish; the evidence for cultivated crops; and the mobility pattern of the human population, as

19 Linseele, Van Neer, et al. 2014.
20 Wendrich and Cappers 2005; Holdaway and Wendrich 2017.
21 Phillipps and Holdaway 2015.
22 Gautier 1984; Gautier 2002.
23 Linseele, Van Neer, et al. 2014.
24 di Lernia 2001.
25 Vigne 2011.
26 Crombé and Robinson 2014.

documented from the archaeological data.[27] This variation in the shape of early food production took in Egypt, can be mostly connected to local environmental conditions. In Fayum and also in the Nile Valley there is a continued use of aquatic resources, while hunting seems to have become an opportunistic activity and of minor economic importance from about when domestics appear and onward.[28]

2 The key-issues of the workshop in the light of the evidence for early stock keeping in Egypt

2.1 The reasons and pace of change to food producing societies

The earliest domestic animals appear in Egypt at ca. 6200 cal BC about simultaneously in the Eastern and Western Desert (Tab. 1). At ca. 5750 cal BC, the first domestic cattle has been recorded from northern Sudan.[29] From this evidence, there is thus an impression of rapid dispersal of domestic animals over Northeastern Africa.[30] The data also suggest that there may have been groups of people with and without domesticates living in Egypt's Western Desert around the same time.[31] However, what cannot be emphasized too much for the earliest phase of the appearance of livestock in Egypt (pre-5th millennium cal BC) is the paucity of physical evidence. It seems, therefore, premature to move on to the stage of trying to understand the reasons for their appearance. Theories have been amply formulated,[32] but we should probably first of all concentrate on finding more data.

The poor indications for food production in Egypt prior to the 5th millennium cal BC may be due to problems of visibility of archaeological remains. Part of the problem can be connected to the Nile and the burial of Early and Middle Holocene sites underneath alluvial deposits.[33] However, the new data from E29H1 in the Fayum suggest that it may also be a question of looking at the wrong 'sites'.[34] Outside of the Nile Valley, human occupation before the 5th millennium cal BC is not found in stratified sites, but rather in shallow, though sometimes spatially extensive deposits, which is suggestive of very different lifestyles than the later sedentary farmers of the Nile Valley. Perhaps up to now we have been looking for early domesticates in the wrong places by concentrating only on the relatively sparse stratified deposits. Dating the earliest evidence for the appearance of domestic animals actually means dating the earliest evidence for these species that is present, preserved, and recovered for analyses, not necessarily, and probably unlikely, their first use. Thus, we cannot conclude that because we have not found domestic animals at a certain place and time that they were not there.

2.2 The extent to which indigenous changes in technology, storage, and sedentism during the Epipalaeolithic to Neolithic eased the transition to food production and the potential interaction with immigrant farmers

In Egypt and further west into the Sahara, food production was first known among mobile human groups and this has been identified as an important distinguishing feature from Southwest Asia, where food production first appeared among sedentary groups.[35] However, recent evidence from Egypt shows that mobility patterns were much more complex than a simple dichotomy between sedentary and mobile.[36] What is perhaps more important for this contribution on early livestock, is that domestic animals appeared in Egypt before farming, while stock keeping has been described as a more difficult transition to make than agriculture, because domestic stock needs continuous attention.[37] This apparent paradox has been explained by the fact that, as can be seen in arid Northern Africa today, domestic animals are a more stable source of food than cultivated crops and less sensitive to droughts.[38] It is possible that the taming

27 Linseele, Van Neer, et al. 2014.
28 Linseele and Van Neer 2010.
29 Chaix and Honegger 2015.
30 See also Riemer 2007.
31 Pöllath 2010.
32 For an overview see Brass 2018.
33 Vermeersch, Paulissen, et al. 1992.
34 Linseele, Holdaway, and Wendrich 2016.
35 Garcea 2004.
36 Holdaway, Wendrich, and Phillipps 2010.
37 Marshall 2000.
38 di Lernia 2002.

of local wild animals somehow prepared the minds of people to adopt domestic animals from Southwest Asia.

At sites of the 6th as well as the 5th millennium cal BC, apart from domestic livestock, there is also evidence for wild animals that were being exploited. In the Fayum Oasis for example, fish were particularly important, representing ca. 90% of the identified fauna.[39] The term 'low-level food production society' has been applied, referring to the fact that domestic species added to, rather than replaced, existing subsistence strategies dependent on wild food.[40] The main advantage of keeping domestic animals over pure hunting and gathering may have been their predictable availability, serving as a kind of food reserve on the hoof.[41] Also after 4000 cal BC during the Predynastic period, most sites in Egypt show a continued use of wild resources, and particularly of fish.[42] (Faunal) evidence from the period immediately preceding the introduction of food production is scarce for Egypt. Data from the Fayum Oasis mainly suggest continuity in subsistence strategies, and more particularly the emphasis on fish.[43]

2.3 The impact of environmental change upon the emergence of food producing cultures

The oldest evidence for domestic livestock in Egypt at ca. 6200 cal BC is contemporaneous with that of southeastern Europe, where the appearance of farming and stock keeping around that time was connected with a period of rapid climatic change.[44] The appearance of pigs and cultivated crops, as well as the increase in the numbers of sites in the 5th millennium cal BC, are probably also to be correlated with climatic shifts: aridification after the Early and Mid-Holocene climatic optimum, which opened up the Nile Valley for human occupation, as well as changes in intensity of the Mediterranean winter rainfall.[45]

To understand events on a local scale, the local impact of climatic change also needs to be known.[46] In the Fayum, environmental changes, with an increasing aridification, are thought ultimately to have led to a period of abandonment after ca. 4200 cal BC. The exact impact of such changes on farming and stock keeping are not clear – sheep and goat are the most flexible livestock species, while cattle and pig are more tied to specific conditions. However, considering the importance of fish in the Fayum, the consequences of environmental change for fishing activities could have been more important.[47] In particular, shallow water habitats, where fishing is particularly easy in certain parts of the year, may have disappeared.

Local environmental conditions seem to have played a role in the species and numbers of domesticates kept at a given place and time.[48] In the deserts, numbers of bones of domesticates are low throughout all sites and phases. The only exception is KS43 in Kharga Oasis (4800–4400 cal BC) where the archaeofaunal assemblage is predominantly composed of remains of domestic animals.[49] This is connected to the site's special local environmental conditions, with the presence of artesian springs in which wells could be dug. In the Fayum Oasis, the focus on aquatic resources can be connected to the presence of a large lake. In the actual Nile Valley, domesticates represent large proportions of the total faunal samples, once they start to appear. After the Early and Mid-Holocene moist phase, the Nile Valley must have become a favorable area for stock keeping, with much easier access to fodder and drinking water than in the deserts.

2.4 The directionality of movement of human groups and animals within these contexts

The paucity of remains of domestic animals in early stages of food production should be emphasized for Egypt. This means that any reconstruction of routes of dispersal should be made with caution. The archaeozoological evidence suggests that caprines first spread independently from pigs and crops, and possibly also from cattle. How the earliest domestic livestock reached Egypt from Southwest Asia also has a poor evidence base. Overland across the Sinai and/or over sea, via the

39 Linseele, Van Neer, et al. 2014.
40 Smith 2001; Holdaway, Wendrich, and Phillipps 2010.
41 Marshall and Hildebrand 2002.
42 Linseele, Van Neer, and Friedman 2009.
43 Linseele, Holdaway, and Wendrich 2016.
44 Weninger et al. 2014.
45 Kuper and Kröpelin 2006, 803–807; Phillipps, Holdaway, et al. 2012, 64–76.
46 Phillipps, Holdaway, et al. 2012.
47 Holdaway, Phillipps, et al. 2016.
48 Linseele, Van Neer, et al. 2014.
49 Briois et al. 2012.

Gulf of Suez are two routes that have been suggested.[50] Data from the Southern Levant, through which domesticates must have passed before reaching Egypt,[51] regardless of which of the aforementioned routes is correct, suggest that we should not expect to find domesticates from Southwest Asia much earlier than 6200 cal BC. In other parts of the Mediterranean, farming and stock keeping seem to have spread by boat at an early date.[52] The geographical position of Egypt may not have been favorable for such an early spread via the Mediterranean, because of the prevailing directions of summer winds and currents.[53] The evidence suggests that farming and stock keeping reached the west of North Africa (Morocco) at the same time or earlier than the eastern parts of North Africa (modern day Egypt), pointing to independent routes of dispersal.[54] Ancient DNA analyses could contribute to the reconstruction of the origins and the routes of dispersal of domesticates in Egypt, and whether or not there were multiple introductions. Such analyses have as yet not been possible, mainly due to the Egyptian legislation that very much restricts the export of archaeological remains for any kind of analyses and the lack of local facilities.

3 Summary and conclusions

Before the 6th millennium cal BC, local wild cattle and/or Barbary sheep may have been managed in Northern Africa. Although it has been argued that this resulted in domestication for cattle, the evidence indicates that this is not likely. However, local experiments may have been advantageous for the adaptation of domesticates from Southwest Asia. The fact that early stock keeping in Egypt is mainly a story of introductions from elsewhere, instead of local domestications, makes the questions and methods to be applied very different from those in the core areas of domestication in Southwest Asia. From ca. 6200 cal BC, caprines and, slightly later, also cattle are attested in Egypt. The date fits with a climatic event and the knowledge on the presence of domesticates in southeast Europe and the Southern Levant. This suggest that the lack of domestic animal remains older than 6200 cal BC is not a due to poor archaeological visibility. The routes of arrival and further dispersal of early domesticates in Egypt remain highly speculative in view of the paucity of physical evidence. The scarcity of remains is in part probably indicative of (mobile) lifestyles. Presumably domesticates were more widely spread than is found in the archaeological record. From the 5th millennium cal BC, the amount of evidence significantly increases, with remains found throughout Egypt. This development also coincides with periods of climatic change. In addition, the local impact of climatic change needs to be considered and local environmental circumstances certainly explain much of the variety in early food production.[55] The earliest phase of appearance of domesticated species does not seem to have brought significant changes in lifestyles. These appeared only from the 5th millennium BC, with the arrival of sedentary farming in the Nile Valley.

50 Close 2002.
51 Rosen, this volume.
52 Zeder 2008; Barich 2014.
53 Lambrou-Philipson 1991.
54 Barich 2014; Barich, this volume.
55 For more details on the variety see Linseele, Van Neer, et al. 2014.

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Giulio Lucarini and Anita Radini

A Disregarded Nobility: The Role and Exploitation of Wild Plants in North Africa during the Holocene, Analyzed through an Integrated Functional Analysis on Non-Knapped Stone Tools

Summary

The two case study areas presented in this paper – the Haua Fteah cave of Cyrenaica, Libya and the Farafra Oasis in the Egyptian Western Desert – have so far produced archaeobotanical assemblages exclusively made up of wild plants, among which several species of grasses are included. They have also yielded a number of grinding tools. The general assumption of a direct link between grinding tools and plant exploitation was tested, adopting an integrated approach of use-wear and plant micro-residue analysis of the stone tools. Results of this analysis confirmed that a variety of wild plants were processed in the two regions during the Mid-Holocene, showing how these local species represented a primary source of food even after Levantine domesticated animals and plants were introduced into North Africa.

Keywords: Farafra Oasis; Haua Fteah; Mid-Holocene; wild grasses; ground tools; use-wear analysis; starch analysis

Die Fundstellen der beiden hier vorgestellten Fallstudien – die Höhle Haua Fteah in der Kyrenaika, Libyen, und die Oase Farafra in der Westlichen Wüste, Ägypten – haben bislang archäobotanische Assemblagen ausschließlich aus Wildpflanzen erbracht, darunter mehrere Gräserarten. Darüber hinaus wurden etliche Schleifwerkzeuge gefunden. Die allgemeine Annahme eines direkten Zusammenhangs zwischen Mahlwerkzeugen und Pflanzennutzung wurde überprüft, indem in einem integrierten Ansatz Gebrauchsspuren und pflanzliche Mikroreste an den Steinwerkzeugen analysiert wurden. Die Ergebnisse dieser Analyse bestätigten, dass während des Mittelholozäns in beiden Regionen eine Vielzahl von Wildpflanzen verarbeitet wurde. Das zeigt, dass diese lokalen Arten auch nach der Einführung domestizierter Tiere und Pflanzen aus der Levante in Nordafrika eine primäre Nahrungsquelle darstellten.

Keywords: Oase Farafra; Höhle Haua Fteah; Mittelholozän; Wildgräser; Mahlwerkzeuge; Gebrauchsspurenanalyse; Stärkeanalyse

The archaeological materials analyzed in this paper were excavated in the framework of the Farafra Oasis Archaeological Project, co-directed by G. Lucarini and B. E. Barich, and the Cyrenaican Prehistory Project, directed by G. Barker. This research is one of the outcomes of the MSCA Project FP7-People-2012-IEF 'AGRINA'. G. Lucarini carried out the excavation of the archaeological materials, the sampling for the plant residue analysis, and the use-wear analysis. Anita Radini undertook the plant residue analysis.

1 Introduction

North Africa's potential contribution to the understanding of the food production process has often been considered limited, and the earliest occurrences of food production on the continent have been regarded as mainly derivative.[1] Scholars often put strong emphasis on the lack of a local process of plant and animal domestication; this approach has resulted in a paradigm of Africa's supposed cultural delay with respect to the Levantine regions where crops were first domesticated ca. 10 500 years ago.[2] The appropriateness of the term 'Neolithic' for North African Holocene contexts has long been questioned,[3] but recent research has contributed to shifting this debate by adding a more nuanced understanding of this process in the Eastern Sahara and the southern Mediterranean littoral.[4]

The earliest evidence for exploitation of domestic crops in North Africa can be dated to the 6th millennium BC. The Mid-Holocene contexts of the Egyptian and Sudanese Nile Valley and the northern coast of Morocco are the sole source from which remains of domestic crops have been retrieved so far. In the Faiyum Depression, charred macro-remains belonging to emmer wheat *(Triticum dicoccum)*, two-row (*Hordeum vulgare* ssp. *distichon*), and six-row (*Hordeum vulgare* ssp. *vulgare*) have been dated to ca. 4700–4400 BC.[5] The site of Merimde, located on the western edge of the Nile Delta, has also yielded evidence of domestic wheat and barley dated to ca. 5000–4500 BC.[6] Einkorn/emmer (*Triticum monococcum/dicoccum*), free threshing wheat (*Triticum aestivum/durum*), and barley (*Hordeum vulgare*) macro-remains have been found in the Early Neolithic layers (ca. 5500–4700 BC) of the Moroccan sites of Kaf That el-Ghar, Khil, and Ifri Oudadane.[7] Domestic *Triticum* sp. and/or *Hordeum* sp. phytoliths and starches also come from the two Neolithic cemeteries of Ghaba and R12 in Sudan; these have been dated from ca. 5600 to 4500 BC.[8] A rapid diffusion of farming activities, evidenced by an increase in the size of the settlements and number of storage features, occurred at the end of the 5th millennium BC along the Nile Valley.[9] Differently, direct evidence for a dispersion of farming along the North African littoral remains substantially scarce before the 1st millennium BC.[10]

The Early and Mid-Holocene contexts of the North African littoral east of the Gulf of Sirte and the Eastern Sahara yielded strong evidence of an intensive exploitation of wild plants, mainly grasses and domestic caprines, but no macro-remains belonging to domestic crops have been identified so far.[11] The data coming from these regions are essential in order to understand how domestic animals and plants from the Levant diffused across the North African littoral and the Sahara, and how their use was added into a broad-spectrum economy, which still remained based primarily on the exploitation of wild resources.

This paper discusses the results of our previous work[12] on selected non-knapped stone tools from the Mid-Holocene deposits of the Haua Fteah Cave in Cyrenaica, Libya and Hidden Valley Village, Farafra Oasis, Egypt (Fig. 1) in order to provide new information on the role that wild taxa may have played in the ancient economy of the two regions. The data that has recently emerged from the analysis of macro and micro-wear analysis, combined with residue analysis, is here discussed and reviewed in a wider Northern African context.

2 Materials and methods

The Haua Fteah is a huge limestone karstic concavity located 10 km east of the ancient city of Apollonia, ca.20 km north of Cyrene and less than a kilometer from the Mediterranean shore. The site was first explored in the 50's by the University of Cambridge.[13] The same

1 A. B. Smith 1989.
2 Zohari, Hopf, and Weiss 2012.
3 Barich 1980; Barich 1984; Bishop and Clark 1967; Sinclair, Shaw, and Andah 1993.
4 Barich and Lucarini 2014; Barich, Lucarini, et al. 2014; Lucarini 2013; Lucarini, Radini, et al. 2016; Wendorf, Schild, and Associates 2001.
5 Wendrich, Taylor, and Southon 2010.
6 Hawass, Hassan, and Gautier 1988.
7 Morales, Pérez-Jordà, et al. 2013; Morales, Pérez Jordà, et al. 2016.
8 Madella, García-Granero, et al. 2014.
9 Wetterstrom 1993, 167.
10 Lucarini 2016; Broodbank and Lucarini 2019.
11 Barakat and Fahmy 1999; Barker, Antoniadou, Brooks, et al. 2009; Fahmy 2001; Fahmy 2014; Lucarini, Radini, et al. 2016; Thanheiser 2011; Wasylikowa 2001.
12 Lucarini, Radini, et al. 2016; Lucarini and Radini 2020.
13 McBurney 1967.

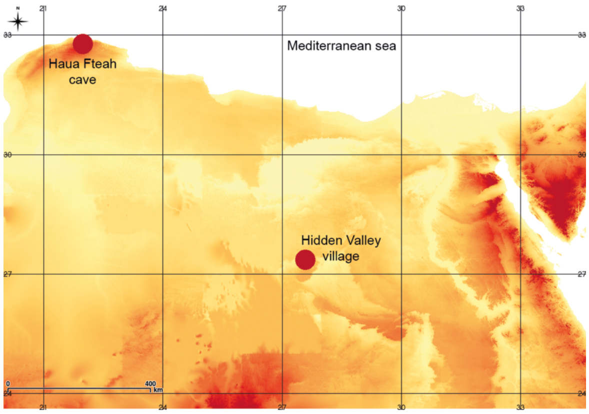

Fig. 1 Map with the location of the two sites mentioned in the text.

Fig. 2 The Haua Fteah cave, Cyrenaica, Libya.

university resumed the investigation of the site between 2007 and 2015 in the framework of the 'Cyrenaican Prehistory Project', which aimed to investigate the relationships between cultural and environmental change over the past ca. 200 000 years along the Libyan littoral (Fig. 2).[14]

The eleven dates for the Neolithic layers of the Upper Trench span approximately between ca. 5700 and 3500 BC.[15] The palaeobotanical analysis carried out from the Haua Fteah sample column by Morales and van der Veen[16] testifies to the presence of only wild species in the Neolithic layers – including Mediterranean shrubs or trees like myrtle (*Myrtus communis*), as well as grasses (the Poaceae family), and vetches (the *Vicia* genus). The groups populating the cave during the Holocene were practicing a mixed economy, combining an intensive exploitation of marine and terrestrial gastropods,[17] wild grasses consumption, associated with herding domestic caprines and, at a lower scale, cattle.[18] The Haua Fteah non-knapped tools assemblage is made up of 79 informal stone implements coming from the Neolithic levels of the cave. The artefacts were usually not manufactured; limestone pebbles, naturally available in the vicinity of the cave, were exploited as handstones. In the assemblages, only two handstones have been found that have proven to have been specifically manufactured. Only upper elements were found in the cave, which did not yield any lower items (e.g. saddle querns or palettes) (Fig. 3).

Considering this absence, we can assume that lower items may be still buried in the unexcavated deposit of the cave or that bedrock outcrops were utilized as the base-stones for grinding activities. Of the 79 implements found in the Haua Fteah Cave, only six handstones showed morphological characteristics that are consistent with a possible use as grinders. These tools were selected and underwent a combined use-wear and residue analysis.

Hidden Valley is a slab structure site located along the course of the Wadi el-Obeiyid, a large valley that opens between the Northern Limestone Plateau and the Quss Abu Said Plateau north of the Farafra Oasis (Fig. 4). The site, located on the shore of an ephemeral pool, was seasonally occupied from ca. 6600 to 5200 BC by human groups practicing a multi-spectrum exploitation of the environment; this included an intensive use of wild plants, hunting activities, exploitation of ostriches, and, starting from ca. 6100 BC, caprine herding.[19] The results from excavation of the site have highlighted the importance of wild grass exploitation for the Mid-Holocene groups settled in the region.[20] This site yielded a very rich assemblage of plant macro-remains that were analyzed by A.G. Fahmy;[21] among these, wild *Sorghum* and other species of grasses are prevalent. The Hidden Valley non-knapped tool assemblage consists of

14 Barker, Antoniadou, Brooks, et al. 2009, 90.
15 Barker, Antoniadou, Brooks, et al. 2009, 90; Douka et al. 2014, 46.
16 Barker, Brooks, et al. 2008; Barker, Antoniadou, Brooks, et al. 2009; Barker, Antoniadou, Armitage, et al. 2010.
17 Hill et al. 2015.
18 Stimpson, pers. comm. 2015.
19 Gautier 2014.
20 Lucarini 2014.
21 Fahmy 2001; Fahmy 2014.

Fig. 3 Haua Fteah Cave. Upper grinders from the Neolithic layers of the cave (a: HFT 1955/7 - HFT 399.00-55, Layer VI-VIII); b: HFT 1955/9 - HFT 160.02.2005, Layer VIII; c: HFT 1955/3 (1) - HFT 192.09, Layer VI; and d: HFT 1955/5 - HFT 193.14.2005, Layer VI-VII-IX-X.

37 items, including ground upper grinders and lower querns (Figs. 5 and 6). Use-wear and residue analyses were carried out on a sample of artefacts coming from the different stratigraphic layers of the site. The items found scattered on the surface within the gridded area of the site were not analyzed.

The presence of possible residues was observed on both assemblages as a first step, by means of a Leica M250C incident-light stereomicroscope at magnifications between 8x and 160x.

Once locations of interest had been identified, these were 'spot sampled' following established protocols for the extraction of microfossils.[22] Microfossils extracted from the samples were mounted on slides.[23] All slides were examined at magnifications of 200x, 400x, and 630x (oil immersion) using Olympus and Zeiss compound microscopes. Lighting conditions included brightfield and cross-polarized light. The extraction and mounting were conducted under controlled conditions in a clean lab.

22 Torrence and Barton 2006.

23 Lucarini, Radini, et al. 2016, 85.

As pointed out in our previous work,[24] due to the complex vegetation history of North Africa, which comprises species of both Mediterranean and tropical origin during the Holocene, the identification was conducted using a large reference collection made up of: 1) species of plants already identified among the macro remains by Morales and Van der Veen in Haua Fteah[25] and by Fahmy in Farafra[26]; 2) a wider variety of domesticated and wild plants known to produce starch granules that were collected by the authors during fieldwork in Egypt, Italy, Libya, and Sudan; and 3) published assemblages of starch granules and phytoliths were also considered as reference samples.[27]

After the residues were extracted, the artefacts were washed with water and washing-up liquid, before undergoing use-wear analysis. The identification and characterization of the use-wear was carried out both at low and high power observation. The low power approach was performed on both assemblages using the same Leica M250C stereomicroscope at magnifications between 8x and 160x. Features such as levelled (flattened) areas, fractures, edge rounding, and polish were recorded following the protocol developed by Adams and colleagues.[28] The high power approach was performed only on the Hidden Valley assemblage, using a Leica DM2700 free-arm metallographic microscope at magnifications between 50x and 200x. The micro-wears detected on the tool surfaces were compared with those present on modern examples produced via experiments, which are part of the reference collection of the Laboratory for Artefact Studies, University of Leiden.

3 Results

Tools from Haua Fteah that have been interpreted as grinders often show a flat irregular surface topography, which is levelled and polished.[29] Levelling affects high and low topographic points, creating a flat morphology and a smooth texture (Fig. 7a). A highly reflective polish is often spread all over the surface, affecting both high

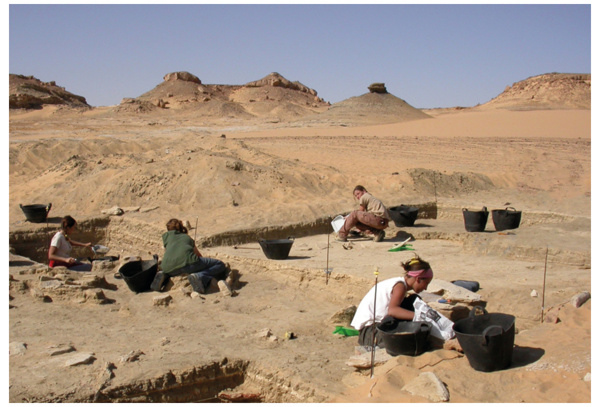

Fig. 4 Hidden Valley Village, Farafra Oasis, Egypt. Excavation of the site.

points and interstices. In the turtle-shell type grinders, a heavy polish is also present on the central area of the convex surface (Fig. 7c). Tools' grinding surfaces often show fractured or extracted quartz grains, possibly caused by rejuvenation activities such as repecking (Fig. 7b). In a few cases, siliceous fibrous plant residues were detected and visible inside the small cavities on the tool's surfaces (Fig. 8).[30]

At a lower power of observation, upper grinders from Hidden Valley showed two grinding surfaces characterized by an irregularly flat micro-topography. The surfaces show very pronounced levelled areas (Fig. 9a). These were caused by a prolonged use of the tools, which lead to the smoothing of the rough surfaces and to the formation of a polish on the artefact's grinding surface. The most levelled areas are often associated with a very developed polish. Both quartz grain fracturing and extraction, sometimes quite deep, are also present, especially on the central area of the tools' surfaces (Fig. 9b). These were the effect of surface repecking. At the high power observation, polish appears granular and quite reflective. It is present in patches all over the tools' surfaces; it affects not only the high microtopography but also the grain's intermediate areas. It develops on the quartz grains' crests in an elongated way, in correspondence to a quite pronounced rounding of the grain's

24 Lucarini, Radini, et al. 2016, 86–87.
25 Barker, Brooks, et al. 2008; Barker, Antoniadou, Brooks, et al. 2009; Barker, Antoniadou, Armitage, et al. 2010.
26 Fahmy 2001; Fahmy 2014.
27 Henry, Hudson, and Piperno 2009; Leonard et al. 2015; Madella, Lancellotti, and García-Granero 2016; Tao et al. 2015; Torrence and Barton 2006; Wang et al. 2016; Yang, Zhang, et al. 2012; Yang, Ma, et al. 2014.
28 Adams et al. 2009.
29 Lucarini, Radini, et al. 2016, 81–82.
30 Lucarini, Radini, et al. 2016, 84.

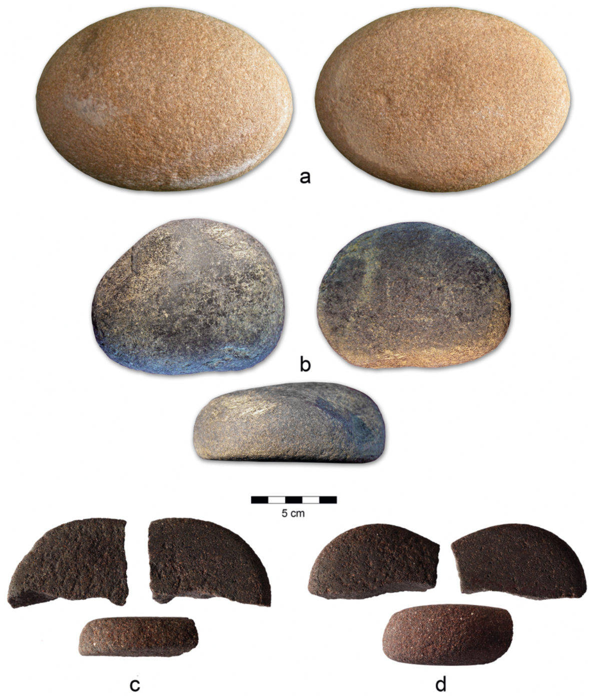

Fig. 5 Hidden Valley Village. Upper grinders from the site (a: Square I/3, Layer IIa; b: Square A/4b, Layer II; c: Square A/1b, Layer IIa, Feature 9; and d: Square G/4d1, Layer III).

Fig. 6 Hidden Valley Village. Fragment of lower quern (Square F/1, Layer II, Feature 48) from the site.

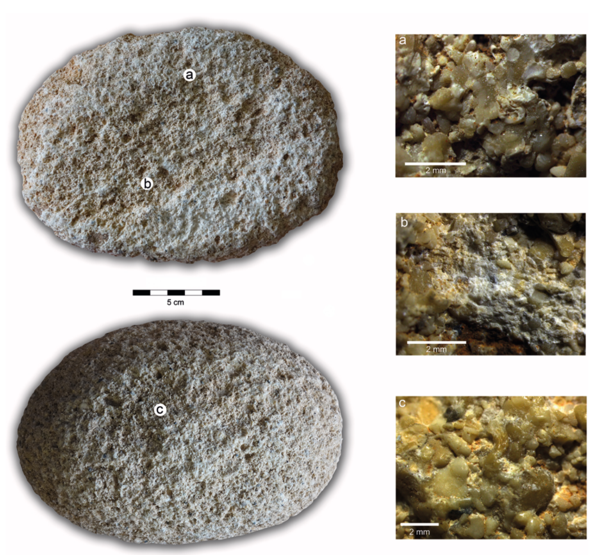

Fig. 7 Haua Fteah Cave. Ground turtle shell-type upper grinder HFT 1955/7 - HFT 399.00-55, Layer VI-VIII (a: levelled areas and slightly reflective polish; b: white crust-like areas resulting from grain fracturing; and c: highly reflective polish).

Fig. 8 Haua Fteah Cave. Turtle shell-type upper grinder HFT 1955/9 - HFT 160.02.2005, Layer VIII. Crevice containing fibrous plant residues.

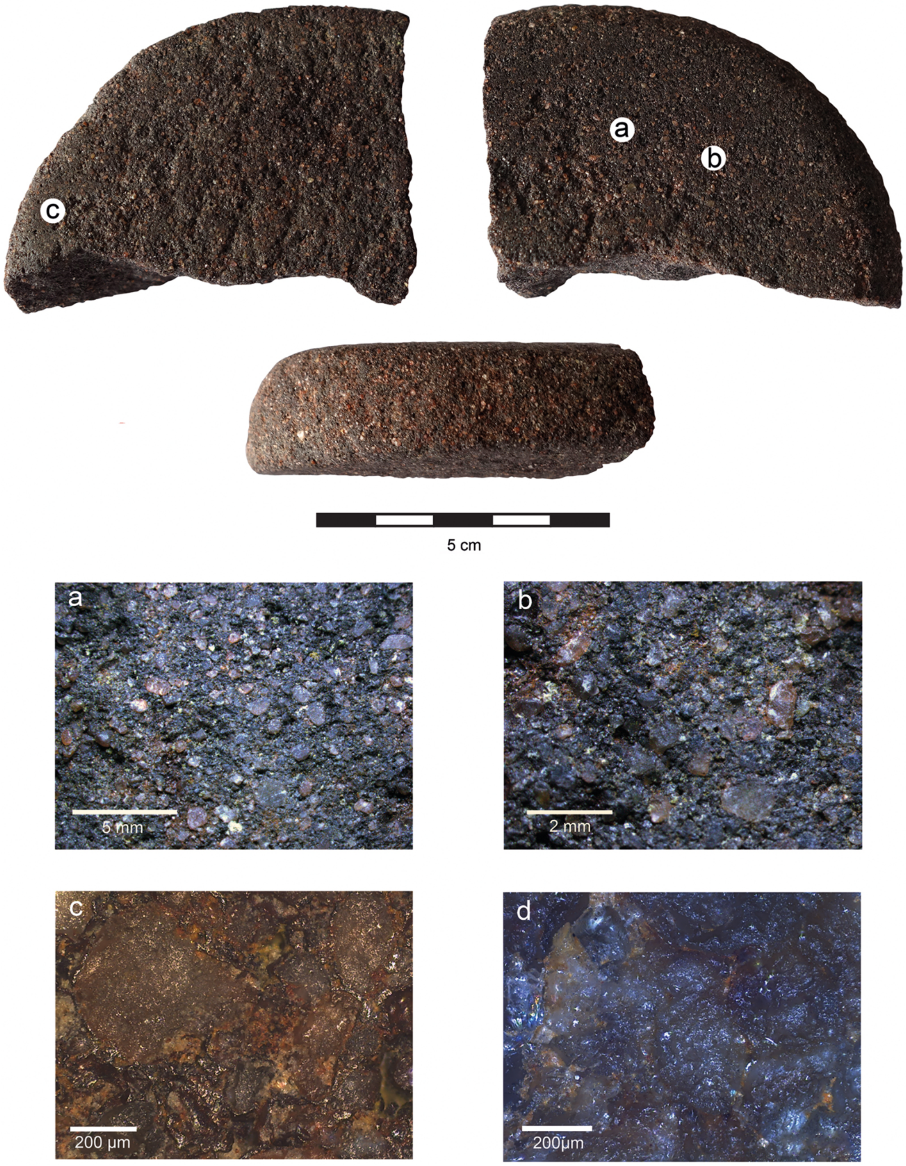

Fig. 9 Hidden Valley Village. Fragment of the upper grinder from Square A/1b, Layer IIa, Feature 9 (a: levelled areas; b: fractured and extracted grains; c: granular reflective polish resulting from plant processing; and d: granular reflective polish on experimental tool used for grinding dry einkorn wheat).

working edge. When the upper part of the quartz grain is levelled, the polish is spread not only on it, but also extends to the peripheral areas of the grain that are not levelled and lower in topography. Moreover, it also affects the surface of the small interstices and cavities that are present on top of the quartz grain's surface, thus confirming the very high degree of its development (Fig. 9c). The polish directionality varies from patch to patch; this is not surprising if we consider that the circular or sub-circular shape of the analyzed grinders could allow their use not only along one axis.[31]

The results of starch analysis at the two locations produced important results regarding the use of wild grasses (Tab. 1). At Hidden Valley, starch granules were retrieved in large numbers, often above 100 granules/sample. This is thought to be due to the presence of calcium carbonate sealing the remains from the surrounding deposit, thus protecting them from deterioration. Both Haua Fteah and Hidden Valley had remains of starch granules sufficiently preserved to be identified at least at the tribe level, but in some cases suggestions of sub-tribe or even genus were proposed based upon

31 Lucarini and Radini 2020.

Site	Sample	Tool	Context / Layer	Extraction point	St 1	St 2	St 3	St 4	St 5	OrSt
Hidden Valley village	F1	HV1	2001 A/4b Layer II	Surface 1	70		3	36	12	x
Hidden Valley village	F2	HV2	2001 A/4d Layer II	Surface 1	15					x
Hidden Valley village	F3	HV3	1999 A/1b Layer IIa feature 9	Surface 1	48	12	2	60	46	x
Hidden Valley village	F4	HV3	1999 A/1b Layer IIa feature 9	Surface 2	45	40	2			x
Hidden Valley village	F5	HV5	1999 F/3a Layer IIa	Surface 1	11	28	3	11	40	x
Hidden Valley village	F7	HV7	1999 I/2d Layer IIa feature 67	Surface 1	79	35	21		40	x
Hidden Valley village	F8	HV8	1998 I/3 Layer IIa Hearth feature 64	Surface 1	34		20	23	60	x
Hidden Valley village	F9	HV9	1998 I/3 Layer IIa	Surface 1	230	13	5		11	x
Hidden Valley village	F10	HV10	1998 I/3 Layer IIa Hearth feature 64	Surface 1	90		12		23	x
Hidden Valley village	F2015	HV2015	1998 G/4d1 Layer III	Surface 1	24		24	20	42	x
Hidden Valley village	F2016/1	HV2016	HV-VG96 E/4 II	Surface 1	34	23	45	12	32	x
Hidden Valley village	F2016/2	HV2016	HV-VG96 E/4 II	Surface 2		13	32		12	x
Haua Fteah cave	A6E6	HF6	AE6	Surface 1				8		x
Haua Fteah cave	A6E2	HF6	AE6	Surface 2				1		x

Tab. 1 Summary table of the starch granules retrieved from the Hidden Valley Village and Haua Fteah Cave grinding tools (St 1: Eragrostideae; St 2: Digitariineae; St 3: Andropogoneae; St 4: Cenchrineae; St 5: Setariineae; Or St: Other unidentified starch granules; x: present).

size and morphology. Starch granules of overall polyhedral shapes with a clear extinction cross were found at both sites, and it was possible to assign them to different sub-tribes of Paniceae based upon morphology. In Haua Fteah, intact starch granules are large, around and above 20 µm; sub-round to polyhedral in shape; and show a central fissured hilum with a high number of thin fissures radiating from it. Such fissures expand over almost the entire granule surface, giving the granules a distinctive stellate aspect and a very glossy appearance. The large granules retrieved were thought likely to be those of the sub-tribe Cenchrineae. Overall, the starch granules found have an extraordinary resemblance to species belonging to the genus *Cenchrus*, such as *Cenchrus biflorus* (Fig. 10 d2), which have starch granules sub-round to polyhedral and the sub-round granules show a high number of fissures radiating from the hilum.[32] Starch granules possibly belonging to the sub-tribe Cenchrineae have also been found in Hidden Valley (Fig. 10 d1); the presence of seeds belonging to the *Cenchrus* type was already reported in the macro-botanical assemblage.[33] Hidden Valley also yielded another type of starch granule belonging to the tribe Paniceae; these were found to be smaller and more angular than the others and likely consistent with those belonging to the sub-tribe Setariineae (Fig. 10 c1). *Setaria verticillata* (Fig. 10 c2) is one of the species found in the Hidden Valley macro-botanical assemblage. *Brachiaria* and *Urochloa*, which are both present in the Hidden Valley macro-botanical assemblage, also belong to the sub-tribe Setariineae, but considering the size of their starch granules, much larger than our archaeological micro-remains, they have been excluded.[34]

The large data set from Hidden Valley also allowed for the retrieval of starch granules of 3 tribes other than the Paniceae:[35]

32 Lucarini, Radini, et al. 2016, 88.
33 Fahmy 2014.
34 Lucarini and Radini 2020, 79.
35 Lucarini and Radini 2020, 76–79.

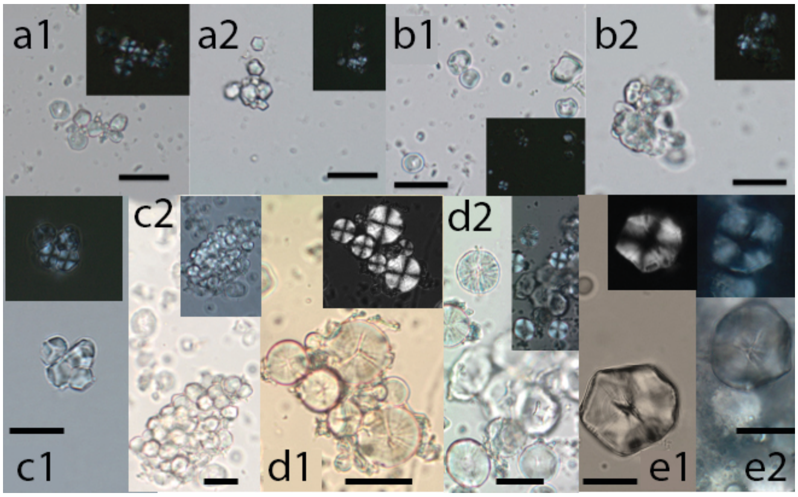

Fig. 10 Starch granules from archaeological tools compared with modern reference collection (a1: Eragrostidae from tool HV3; a2: Modern *Eragrostis cilianensis* from Egypt; b1: Digitariineae from tool HV9; b2: Modern *Digitaria sanguinalis* from Egypt; c1: Paniceae, sub-tribe Setariineae from tool HV1; c2: Modern *Setaria verticillata* from Italy; d1: Paniceae, sub-tribe Cenchrineae from tool HV1; d2: Modern *Cenchrus biflorus* from Niger; e1: Andropogoneae from tool HV3; and e2: Modern *Sorghum bicolor* from Libya. *All scale bars: 20 μm*).

- Tribe Eragrostideae (Fig. 10 a1): Polyhedral starch granules with angular and sharp facets and a hilum that is central and often sunken and fissured, ranging from 5 to 10 μm. Such starch granules are found in the tribe of Eragrostideae, sub-tribe Eleusininae, of which the species *Dactyloctenium aegyptium* and species of the genus *Eragrostis* spp. are widely represented in many North African macro-botanical assemblages. The starch granules in our analysis are very similar to those belonging to the genus *Eragrostis* (Fig. 10 a2), which was not found in the plant macro-remains assemblage.

- Tribe Digitariineae (Fig. 10 b1): Starch granules showing a more irregular but still polyhedral shape. Extinction cross is less sharp and appears somewhat smaller than the one belonging to the tribe Eragrostideae starch granules. In our reference collection, such starch granules are found in the tribe Digitariineae, of which *Digitaria sanguinalis* (Fig. 10 b2) has the closest similarity, and it has been found in the plant macro-remains record.

- Tribe Andropogoneae (Fig. 10 e1): Starch granules larger than the others, still polyhedral, often with a central, fissured, or stellate hilum, which appear very similarly to those of the tribe Andropogoneae, species *Sorghum bicolor* (Fig. 10 e2), and very likely belong to *Sorghum arundinaceum* as this dominates the archaeobotanical record.

None of the locations produced any starch granule consistent with barley or wheat or any of their wild ancestors, which are known to have starch granules characterized by a bimodal distribution of small round starch granules and large sub-oval ones. [36]

4 Discussion

At a lower power of observation, the upper grinders from Haua Fteah and Hidden Valley show traces of intensive use, evidenced by the presence of levelled areas and edge roundings often associated with developed polish. Various stages of tool use can be also detected from the clear evidence for rejuvenation activities, noted on the grinders' surfaces, such as repecking. An analysis of the micro wear on experimental grinders used to grind dry einkorn wheat showed their polish to be granular in appearance and similar to the granular/spider-web like appearance of the archaeological tools from Hidden Valley (Fig. 9 c–d). This similarity, together with the incidence of the polish on both high and low microtopography, its high reflectivity and patchy development in both the modern and archaeological samples, confirms that the Hidden Valley grinders must have been used to process plants at some point.

In terms of species composition, the results obtained from the plant micro-remains analysis at Hidden Valley are mainly consistent with the ones from the macro-

36 Henry, Hudson, and Piperno 2009; Yang, Zhang, et al. 2012.

remains assemblage. However, from both locations, some types of starch granules provided new data and did not match any of the species present among the macrobotanical remains: at Hidden Valley starch granules from the tribe Eragrostideae, likely the sub-tribe Eleusininae and very similar to the starch granules belonging to the genus Eragrostis,[37] and at Haua Fteah, starch granules from the Paniceae tribe, sub-tribe Cenchrineae, whose species are also not present in the macro-remain assemblage.[38] Species of the sub-tribe Cenchrineae that are common in the desert are those belonging to the genus *Cenchrus* and *Pennisetum*, both of which would need the bristles removed. Overall, the analysis of the starch granules extracted from the Hidden Valley and Haua Fteah tools has confirmed the absence of domesticated crops and their relatives at both these sites.

Both in Hidden Valley and Haua Fteah, the lack of farming activities is also consistent with a lack of harvesting tools, such as sickle blades. Only two small gloss-banded blades, interpreted as possible sickle elements, were found during the 1950s excavations of Haua Fteah.[39] All this considered, the idea that wild plants may have been gathered with peoples' bare hands or using unhafted and unretouched tools, which may have been used as opportunistic knives/sickles, cannot be ruled out, as already evidenced by the findings from Farafra.[40]

Although the majority of North African archaeological contexts have yielded clear evidence of an intense exploitation of wild resources during the Mid-Holocene, the role of these non-domesticated taxa has often been underestimated. The general assumption is that when domesticates were first imported into the region, the legacy represented by thousands of years' worth of wild resource exploitation fell into oblivion. Although it is already clear that this model is not appropriate to understand the Mid-Holocene sites of the Eastern Sahara and the Cyrenaican coast, can it be used in the study of the North African littoral and other regions along the Nile Valley? In light of recent research, it is clear that even for the contexts that yielded the earliest evidence of domesticated crop processing in Egypt (e.g. Faiyum and the early Merimdian occupation at Merimde), cultivation of domestic crops was only a marginal component of a mixed economy based on the combined exploitation of wild and domestic resources.[41] The marginal use of domesticated plants is also attested in the Moroccan region where they represent only a very small part of the palaeobotanical assemblage, for example, at the site of Ifri Oudadane. They range from 0.2% in the Early Neolithic A (5600–5300 BC) through to 0.9% in the Early Neolithic B (5100–4700 BC), to 1.7% in the Early Neolithic C (4600–4400 BC).[42] A much stronger reliance on domestic plants is, on the contrary, attested from the Early Neolithic layers of Kaf That el-Ghar (5500–5200 BC) and Khil (5300–5000 BC) in the Tangier region.[43]

Given the capacity of wild plants to adapt easily to adverse environmental conditions, North African groups relied on wild resources, mainly plants, to face food shortages. The exploitation of wild plants is a low cost and easily reversible strategy requiring little productive capacity on the part of human groups. It, therefore, tends to represent the most immediate response to a food shortage.[44] It was under this framework that the human-plant relationship became stronger, with the wild species gaining more and more importance for the human groups settled in the Sahara and along the North African coast during this period. During times of severe food shortages, a number of these plant species may have been chosen based on their nutritional properties, even if they were inefficient in terms of the time and energy required to process them. Take, for example, the case of *Cenchrus biflorus*. Its grains are found in a 'spiny' envelope comprised of modified leaves; this thorny package, therefore, makes gathering and processing this particular species quite time consuming. This is why *Cenchrus*, despite its high nutritional yield, is at present only made use of during times of extreme famine, as noted in studies on the Tuaregh and Zagawa communities.[45] Other studies have also shown that when food shortages are recurrent, human diets begin to rely more heavily on wild foods, to the point that these continue to be a primary

37 Fahmy 2001; Fahmy 2014.
38 Barker, Brooks, et al. 2008; Barker, Antoniadou, Brooks, et al. 2009; Barker, Antoniadou, Armitage, et al. 2010.
39 McBurney 1967, 298.
40 Lucarini 2014.
41 Holdaway, Wendrich, and Phillipps 2010; Tassie 2014, 204–205.
42 Morales, Pérez-Jordà, et al. 2013; Morales, Pérez Jordà, et al. 2016.
43 Morales, Pérez Jordà, et al. 2016.
44 Watts 1983; Watts 1988.
45 M.-J. Tubiana and J. Tubiana 1977.

component even when food supplies return to normal and environmental conditions improve.[46] Studies carried out by Harlan have confirmed that even today more than 60 wild grass species continue to be collected and used in many parts of Africa.[47] Although these are generally only employed during periods of food shortages or extreme famines, some of them are a primary food source for a number of modern African groups. For example, collecting a range of wild grains for consumption is still today observed in a number of areas in the Saharan, Sahelian, and Near Eastern regions. *Kasha/kréb*, a mixture of about 12 different kinds of wild grasses that grow in the savannah and ripen at the same time, is at present one of the most important food sources of the Sahelian regions.[48] It is, therefore, not surprising to find that the species comprising the modern *kréb* – *Panicum, Eragrostis, Digitaria, Dactyloctenium aegyptiacum, Brachiaria deflexa, Latipes senegalensis,* and others – have also been identified among the residues extracted from the grinding equipment recovered from the Hidden Valley.

5 Conclusions

The importance of wild plants in the economy of North African prehistoric groups has often been underestimated, especially after the Levantine domesticated crops, the so-called 'noble grains', were imported into North Africa. Data from the archaeological contexts investigated here showed, on the contrary, how North African wild plants represented a primary source of food for people during the Neolithic. Despite being located in two different eco-zones and being characterized by contrasting past environments, the Holocene deposits of the Haua Fteah Cave (Cyrenaica), Libya, and Hidden Valley, Farafra Oasis (Egyptian Western Desert), have so far produced archaeobotanical assemblages exclusively made up of wild plants, among which are several species of grasses.[49] The situation presented by the other North African regions during the Early and Mid-Holocene is also a complex one, showing a high degree of variability due to different ecosystems, giving rise to different adaptations, but all with a common feature: their heavy reliance on wild resources.[50] The economies of North African groups at this time entailed low-risk subsistence strategies centered around the hunting, gathering, and fishing of wild resources. Local wild foods, however, were not replaced with the introduction of domestic species from the Levant around 6200 BC; they instead, supplemented these wild resource-centered strategies, providing a greater degree of predictability, but not necessarily increased productivity.

Wild grasses, especially *Sorghum*, were heavily exploited and the only evidence of domestic wheat and barley during the 6th and 5th millennia available so far (dated between ca. 5600 and 4400 BC) is from the Nile Valley and the northern coast of Morocco;[51] even in these contexts, the exploitation of domesticated crops was undertaken alongside foraging activities, and it was only after some time, and along the Nile only, that these groups became more fully committed to agriculture. For these reasons, the use of definitions such as 'low-level food producers' today seems much more appropriate as a way to describe this kind of adaptation to the environment.[52] Investigating and better characterizing the 'middle ground', as defined by Smith,[53] seems today the only way to better understand the role played by wild resources in the process of North African Neolithisation and to give wild plants back the noble status they so richly deserve and which has been disregarded for far too long.

46 Huss-Ashmore and Johnston 1994, 63.
47 Harlan 1989, 79.
48 Harlan 1992, 23.
49 Barker, Antoniadou, Armitage, et al. 2010; Fahmy 2001; Fahmy 2014.
50 Lucarini, Radini, et al. 2016.
51 Hawass, Hassan, and Gautier 1988; Madella, García-Granero, et al. 2014; Morales, Pérez Jordà, et al. 2016; Wendrich, Taylor, and Southon 2010.
52 Holdaway, Wendrich, and Phillipps 2010; B. D. Smith 2001.
53 B. D. Smith 2001.

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Caught in the Current: Maritime Connectivity, Insularity, and the Spread of the Neolithic

Summary

The earliest permanent settlement of the Mediterranean islands is largely a Neolithic phenomenon, but recent discoveries point to earlier forms of colonization. These discoveries raise questions regarding the process of Neolithisation, as well as the relationship between Neolithic colonists and Mesolithic populations. Just how reliable are the patterns we see in the archaeological record in terms of highlighting potential maritime routes of Neolithic expansion? This paper draws on data from 147 islands to discuss which factors may have contributed to observed patterns in the colonization and abandonment of islands during the Neolithic, and to reflect on the meaning we give to terms such as colonization, connectivity, and insularity.

Keywords: island colonization; rates of maritime spread; Mesolithic-Neolithic interaction; abandonment; early seafaring

Die früheste permanente Besiedlung von Mittelmeerinseln ist vor allem ein neolithisches Phänomen, aber jüngste Entdeckungen weisen auf frühere Formen der Kolonisierung hin. Diese Entdeckungen werfen Fragen auf zum Prozess der Neolithisierung sowie zum Verhältnis zwischen neolithischen Siedlern und mesolithischer Bevölkerung. Wir verlässlich sind die Muster, die wir im archäologischen Befund sehen hinsichtlich potenzieller Seerouten der neolithischen Expansion? Dieser Beitrag nutzt Daten von 147 Inseln, um zu untersuchen, welche Faktoren zu den beobachteten Mustern beigetragen haben dürften bei Kolonisierung und Verlassen von Inseln im Neolithikum, und zu reflektieren, welche Bedeutung wir Begriffen wie ‚Kolonisierung', ‚Konnektivität' und ‚Inselcharakter' beimessen.

Keywords: Inselkolonisation; Grad der maritimen Ausbreitung; mesolithisch-neolithische Interaktion; Verlassen; frühe Seefahrt

The questions I attempt to develop in this paper were first presented at the AIA annual meeting in New Orleans in 2015 at the invitation of Tristan Carter, and elaborated further as part of the 'Revolutions' workshop later in the same year. I am thankful for the feedback I received from the anonymous reviewers and the Topoi editorial team, who helped me clarify the scope of the paper considerably. The volume editors, Joanne Rowland and Giulio Lucarini, have shown tremendous strength in bringing this volume to completion after the untimely death of Geoffrey Tassie (Tass), a friend to us all. This paper is written in his memory.

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Verba volant, scripta manent

For Tass

1 Introduction

Island colonization in the Mediterranean has long been a synonym for Neolithic settlement, although recent archaeological investigations point to earlier forms of island occupation.[1] These discoveries are filling existing gaps in the archaeological record, but inevitably raising more questions. Is there a relation between the emerging horizon of Mesolithic human presence on some of the islands and the subsequent maritime spread of the Neolithic? How reliable are the patterns we see in the islands' archaeological record in terms of highlighting potential maritime routes of Neolithic expansion? When attempting to understand overall patterns of island colonization, biogeography remains a useful explanatory framework for the earlier periods. Following the Neolithic, an island's size and distance affected colonization less and less, as communities were more able to overcome geographical constraints and sustain long-term population through the establishment of farming, more regular exchange of goods, and increased social interaction.

Generally, it has been difficult to prove continuity between different colonization horizons or phases on individual islands, especially for the earlier periods. This is partly because our data are mostly derived from surface finds from field surveys and partly to do with gaps in stratigraphic sequences, which may represent either actual occupation gaps or taphonomic disturbances if not a lack of investigation. As a result, we are still far from having a clear picture of the degree of overlap and admixture between subsequent lifestyles on the Mediterranean islands; thus, islands are generally considered to have undergone multiple colonization, abandonment, and re-colonization events. Despite these challenges, this paper draws on data from 147 islands, from Cyprus to the Balearics,[2] to discuss a range of environmental, climatic, and socio-cultural factors that may have contributed to observed patterns in the colonization and abandonment of islands during the Neolithic, and use these to reflect on the meaning we give to terms such as 'colonization', 'connectivity', and 'insularity'.

The Neolithic was a new way of life.[3] Although the exact mechanisms of diffusion are still debated, recent archaeological and genetic studies point to a demic diffusion model with areas of interaction with local hunter-gatherers. Migration is generally accepted for the Early Neolithic of the Balkans, the rapid spread of Linearbandkeramik or LBK pottery following the main river valleys across continental Europe, and Impressed/Cardial Ware across the central and western Mediterranean coastal zones. While coexistence and adoption of Neolithic traits is associated with "outlying and interstitial areas", i.e. the Alps, Central Iberia, the Atlantic coast of France, Belgium, the Netherlands, Scandinavia, Britain, and Ireland.[4] In the areas where migration is attested, the traditional 'wave of advance'[5] model has been superseded by an 'arrhythmic model' based on 'jump dispersal' or 'leap frogging'.[6]

This paper begins by asking if the archaeological evidence fits a model of 'maritime pioneer colonization',[7] i.e. a rapid and purposeful spread of people via the Mediterranean islands during the Neolithic. In this process, Neolithic colonists may have used islands as stepping-stones or targeted them in their own right, potentially allowing us to follow their routes across the Mediterranean. Finally, the paper considers the implications of earlier (Epipalaeolithic/Mesolithic) island occupation for our understanding of the spread of the Neolithic.

1 The meaning of colonization is time- and context-specific and not limited to permanent settlement (for different definitions, see Dawson 2011).

2 The data are reviewed in detail in Dawson 2014, 147–49, Tables 6.1 and 6.2.

3 Robb and Miracle 2007; Robb 2013.

4 Robb and Miracle 2007, 101.

5 The 'wave of advance' model postulated a gradual movement by Neolithic colonists averaging a rate of about 1 km per year, spurred by population growth caused by sedentism; Ammerman and Cavalli Sforza 1971.

6 These models all envisage alternating periods of rapid and targeted population expansion and periods of prolonged stasis. See Anthony 1997; Fiedel and Anthony 2003; Guilaine 2001; Guilaine 2013.

7 Zilhão 2001.

2 Island colonization in the Mediterranean

The earliest permanent settlement of the Mediterranean islands is largely a Neolithic phenomenon, but recent archaeological investigations point to earlier forms of colonization. Prior to the Neolithic, island colonization is usually associated with temporary and/or seasonal occupation, which has left ephemeral traces in the archaeological record. Such pre-Neolithic colonization involved the largest islands both in the western and eastern Mediterranean (Sicily, Sardinia, Corsica, Crete, and Cyprus), as well as an increasing number of smaller islands in the Aegean, where geographical configuration was conducive to early maritime exploration.[8] To date, the Mesolithic horizon emerging in the Aegean has no equivalent in the smaller central and western Mediterranean islands. As we will see in the following sections, apart from the larger islands already mentioned, in the western Mediterranean only the Dalmatian islands have evidence that clearly predates the Neolithic; however, this was a coastal rather than insular phenomenon given the extremely short distances involved.[9]

Although the picture is gradually changing, based on current knowledge, the majority of islands in the Mediterranean were first settled by incoming groups during the Neolithic (7th to early-/mid-3rd millennium BC) with the deliberate transfer of domesticated plants, animals (sometimes also wild species), pottery, and polished stone tool technologies to the islands (the so-called Neolithic package, whether in its entirety or elements thereof).[10]

Where an earlier Mesolithic horizon is attested, there is usually evidence for a lengthy gap, often in the order of ca. 1000 years, likely indicating abandonment and recolonization with the Neolithic. Rarely do we see evidence of continuity, which (as we will see below) may indicate local adoption of Neolithic traits by a preexisting population. The archaeological data should be interpreted against a changing environmental backdrop following the Last Glacial Maximum ca. 20 000 BP. After this time, warmer mean annual temperatures caused sea levels to rise and the submergence of existing land surfaces, depleting terrestrial resources but also creating islands and new opportunities in the process. Sea levels continued to rise until ca. 6000 BP when the Mediterranean reached its current configuration.[11]

3 Eastern Mediterranean and Aegean islands

The earliest accepted evidence for island colonization involving long-distance water crossing is currently placed in the 11th millennium cal BC and comes from Cyprus (see Fig. 1).[12] Taking into account changes in sea levels, this crossing entailed distances in the order of 80–90 km, from the southern coast of Anatolia (from where the island is visible), very likely via a now-submerged stepping-stone island.[13] Radiocarbon dates from the rock-shelter site of Akrotiri-*Aetokremnos* span the whole 11th millennium cal BC.[14] Controversy still surrounds the nature of the huge faunal assemblage of pygmy hippopotamus and dwarf elephants at the site, as it is unclear if the island's first human inhabitants hunted the species to extinction or simply used the bones as fuel.[15] Field surveys and excavations in the early 2000s led to the discovery of possible open air camp-sites, located on former sand-dunes and at river mouths, which on typological grounds could be considered contemporary to Akrotiri-*Aetokremnos.*[16]

The recent discovery of Initial Aceramic Neolithic sites on Cyprus (equivalent to Pre-Pottery Neolithic A or PPNA on the Levantine mainland) dated to ca. 9000–8500 cal BC has reduced the gap following the Aetokremnos phase of occupation to ca. 1000 years,[17] and it may be that future work on the island will further reduce this gap, though currently abandonment is the most likely explanation for this interruption. At Ayia Varvara-*Asprokremnos*, 93.6% of animal remains were suids and

8 Broodbank 2006.
9 Kaiser and Forenbaher 2016, 147.
10 See Reingruber 2011, 292–295, for a critique of this concept; cf. "transported landscapes": Kirch 1982, 2.
11 Dawson 2014, 27–32, 35–36.
12 Simmons 1999. Claims of earlier (Lower and Middle Palaeolithic) human occupation on Crete (Strasser, Panagopoulou, et al. 2010) are debated (Leppard and Runnels 2017).
13 Simmons 2014, 65; Vigne et al. 2014, 159; Bar-Yosef Mayer et al. 2015.
14 Ammerman 2010; Knapp 2013.
15 Knapp 2010, 85–94.
16 Ammerman 2010.
17 Knapp 2013.

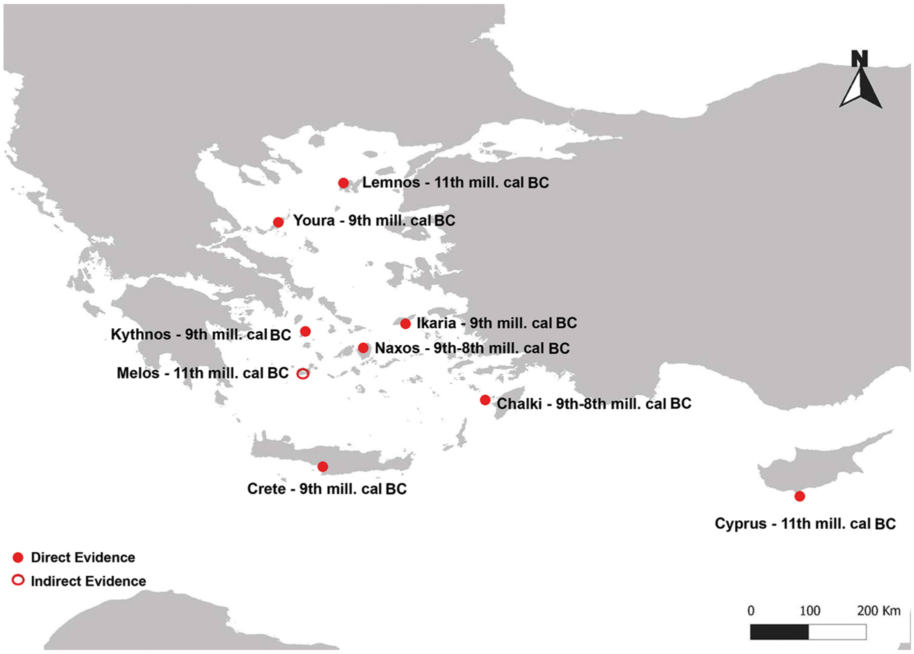

Fig. 1 Pre-neolithic (Holocene) island colonization in the Aegean and eastern Mediterranean.

the ratio was 94.6% at Klimonas.[18] These early villagers also grew wheat. The subsequent Early Aceramic Neolithic sites (Pre-Pottery Neolithic B or PPNB on the Levantine mainland) had suids as well as domestic goats and early domestic cattle (the latter became extinct around 7000–6500 cal BC).[19] Wild species were also introduced to the island for hunting, including fox and fallow deer.[20]

Moving on to the smaller islands, obsidian used at Franchthi Cave on the Greek mainland already in the 11th millennium cal BC has long provided indirect evidence for early seafaring to its source, the Cycladic island of Melos (ca. 130 km away from the Greek mainland, via several stepping-stone islands).[21] The recent evidence found at Ouriakos on Lemnos confirms this early activity. The site, characterized by a chipped stone industry with close links to Anatolia and the Levant, has been dated to the 11th millennium cal BC on typological grounds and a single AMS date (a burnt sample of mammal bone dated 10 390±45 uncal BP/10 437–10 198 cal BC at 2 σ – GrA-53229).[22] It has been estimated that at that time, sea levels were between -60 and -65 m and Lemnos and Imvros formed a single large island some 10 km from the coast.[23]

A Mesolithic horizon has been steadily emerging on the smaller Aegean islands. Finds on Chalki, Corfu, Ikaria, Kythnos, Naxos, and Youra show that they were occupied during the 9th–8th millennia cal BC, when they were already separated from the mainland. At Maroulas on Kythnos, radiocarbon dates for the initial phase of occupation spanned from 8926 to 8406 cal BC (1 σ); the subsequent phase of occupation was dated to the late 7th millennium cal BC.[24] At Cyclops Cave on Youra, occupation lasted from the Mesolithic to the Final Neolithic period (8600–3500 cal BC), although there are stratigraphic gaps before and after the earliest Neolithic: an early phase dated to the beginning of the 6th millennium cal BC was separated by a gap of around 800–1000 years from a later phase around the end of the 6th and the beginning of the 5th millennium cal BC.[25] The presence of human burials in rock-cut tombs and of habitation structures with hearths (as seen at open sites such as Maroulas on Kythnos and Kerame 1 on Ikaria), together with the environmental evidence (from Cyclops Cave on Youra), indicate a degree of stability and a possible inter-island network predating the Neo-

18 Vigne et al. 2014, 163.
19 Vigne et al. 2014, 164.
20 Vigne et al. 2014, 164.
21 Perlès 1979; Broodbank 2006.
22 Efstratiou, Biagi, and Starnini 2014, 3.
23 Chalkioti 2016, 113.
24 Facorellis et al. 2010, 133–134.
25 Quinn et al. 2010, 1043.

lithic, as seen also from similarities in the lithic repertoire (including Melian obsidian) between sites.[26]

Evidence from Cyclops Cave and Maroulas indicate specialized fishing and the keeping of young animals: feral goats at Cyclops Cave and pigs at Maroulas. This evidence suggests that animals were under "human control or management or perhaps in a transitional stage of domestication",[27] 1500 years earlier than in Thessaly. Sampson argues that this could indicate the existence of "multiple centers of Neolithization" as opposed to "one nuclear zone".[28] At Sidari, on Corfu, an Early Neolithic layer was found directly above the earlier Mesolithic shell midden.[29] Sheep, goat, and poorly fired pots are found at Sidari from ca. 6500 cal BC, which Broodbank suggests might represent "a case of Mesolithic adoption"[30] of Neolithic traits, given the apparent continuity in the stratigraphy.

On Crete, the Plakias Survey (2008–2009) identified 28 preceramic sites on the southwestern coast, targeting locations with similar characteristics to those favored by hunter/fisher/foragers on the smaller islands: limestone caves and rock shelters and proximity to coastal wetlands, fresh water perennial streams, and rivers.[31] The sites have been dated on technological and morphological grounds.[32] Twenty sites had artifacts of Mesolithic type, similar to those on the Greek mainland and islands (9th millennium cal BC); the remaining sites had evidence of apparent Lower Palaeolithic occupation (ca. 130 000 BP), a contested dating.[33] A handful of obsidian tools of likely Mesolithic date found at these Cretan sites has been sourced to Melos, providing the earliest known link between Crete and the Cyclades.[34] No Neolithic evidence was found at any of these sites, suggesting that occupation was discontinuous. Ongoing excavations at Stelida on Naxos revealed four buried palaeosols bearing Middle to Lower Paleolithic artefacts, including a Mousterian point, the latter indicating a Neanderthal presence possibly involving short water crossings.[35]

The earliest dated Neolithic occupation on Crete is found at Knossos. The site has produced reasonably consistent radiocarbon dates for the Neolithic; the earliest, pioneer site from aceramic layer X, was established during the first half of the 7th millennium cal BC (6900–6600 cal BC at 95.4% probability) and lasted 200–400 years (95.4% probability).[36] A small village was then founded in the Early Neolithic in the first half of the sixth millennium BC, after a long break that may have lasted 1000–1500 years (probably a phase of abandonment).[37] The small size of Neolithic Knossos led Evans to hypothesize an influx of fewer than 100 individuals migrating to Crete, bringing with them the full Anatolian-Balkan package.[38] Cherry spoke of a dozen families at the most.[39] Broodbank and Strasser also calculated a group of 40 individuals would have been necessary to colonize the island successfully in a single journey, on a flotilla of 10–15 vessels carrying ca. 1–2 tons of cargo each (including grain seeds and animals).[40] Carter recently suggested that Neolithic colonists might have acquired knowledge of the routes from local hunter-gatherers who already engaged in obsidian exchange. So, in fact, multiple journeys to Crete are also a possibility.[41] The dating of the Neolithic layers at Franchthi Cave supports a rapid dispersal of Neolithic traits from Crete to the Greek mainland across the sea, spanning two centuries at most.[42]

Based on current knowledge, both Cyprus and Crete were abandoned by their Epipalaeolithic/Mesolithic occupiers and subsequently recolonized by Neolithic groups, which did not reoccupy any of the earlier known sites. On the smaller islands, Neolithic occupation occurred at a few of the Mesolithic sites already mentioned, often separated by a temporal gap, although a degree of overlap and interaction seems a likely explanation for situations where specific locations were reused (e.g. Sidari on Corfu). Nonetheless, the majority of islands in the Aegean were first colonized

26 Sampson, Kaczanowska, and Kozlowski 2012; see also Reingruber 2011.
27 Galanidou 2014, 23.
28 Sampson 2011, xx.
29 Sordinas 1969.
30 Broodbank 2013, 190.
31 Strasser, Runnels, et al. 2010; Strasser, Panagopoulou, et al. 2010.
32 Strasser, Panagopoulou, et al. 2010, 145, 164.
33 Galanidou 2014; Leppard and Runnels 2017.
34 Carter 2016.
35 Carter et al. 2019.
36 Douka et al. 2017, 309.
37 Douka et al. 2017, 317.
38 Evans 1971, 116; Douka et al. 2017, 314, posit they might have come from Cyprus on the basis of similarities in the archaeological record.
39 Cherry 1985, 24.
40 Broodbank and Strasser 1991, 240.
41 Carter 2016, 19; Douka et al. 2017, 317.
42 Douka et al. 2017, 315; Reingruber 2011, 298, fig. 9.

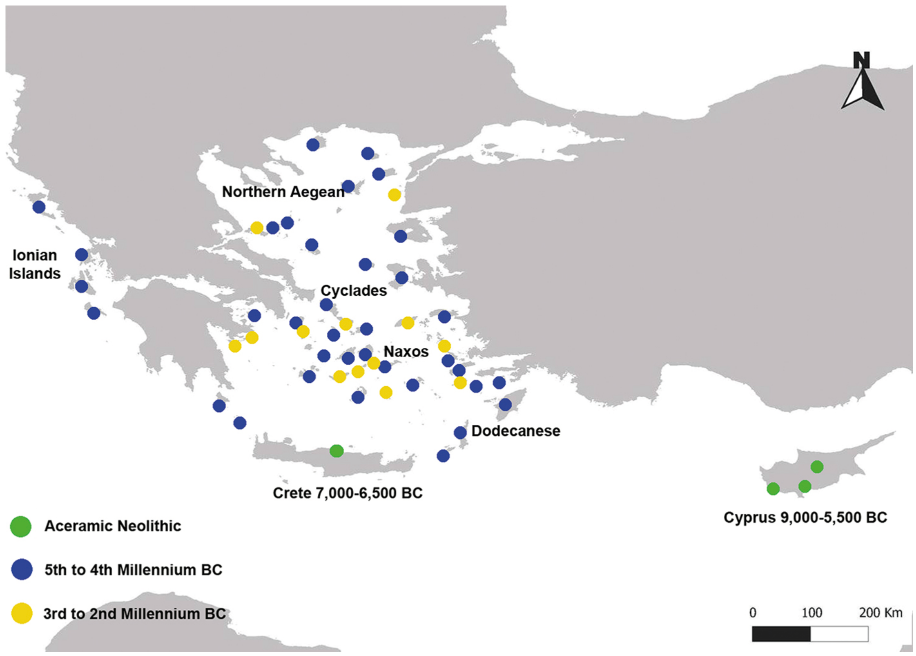

Fig. 2 Neolithic and later island colonization in the eastern Mediterranean.

starting in the Neolithic, with small faraway islands colonized last, mostly in the Bronze Age (Fig. 2).[43]

4 Central and western Mediterranean islands

In the central and western Mediterranean, a similar pattern can be seen (Fig. 3). The first islands to be colonized were the largest: Sicily and Sardinia were certainly inhabited from the Upper Palaeolithic (earlier claims for Sicily have been recently contested[44]) and Corsica from the Mesolithic (mid-9th millennium cal BC). At Uzzo Cave in Sicily the so-called transitional phase between the Mesolithic and Neolithic periods (featuring evidence for hunting, fishing, and early domesticates) is currently dated ca. 7000–6600 cal BC.[45] At Grotta Corbeddu in Sardinia, the start of the Early Neolithic (Layer 1) is also dated ca. 6000 cal BC, and the end of Mesolithic (top of Layer 2) ca. 7000–6500 cal BC.[46] A similar potential 'gap' can be seen at a number of sites in Corsica (e.g. Araguina-Sennola, Strette, Longone, and Monte Leone).[47]

Mesolithic activity can be seen to a minimum extent on the Dalmatian Islands in the eastern Adriatic.[48] As already mentioned, the configuration of Dalmatia is more coastal than insular, thus, quite different from the Aegean. The Dalmatian Islands were presumably already frequented at low sea levels when they were attached to the coast, and their occupation continued following their insularization.[49] Recent investigations support the generalized presence of an occupation gap between the latest Mesolithic (10th–8th millennium cal BC) and the earliest Neolithic levels (ca. 6000 cal BC) along the Dalmatian coast and on the islands.[50] However, Mlekuž points out continuity at specific sites and erosional discontinuities at others, which may have removed evidence of interaction.[51] According to Mlekuž et al., at a number of sites the 2-σ calibrated age ranges of the radiocarbon dates for the latest Mesolithic and earliest Neolithic occupations overlap, so that the existence of a gap is less certain (e.g. evidence for a mixed econ-

43 Dawson 2014, 154–155.
44 See Di Maida et al. 2019.
45 Mannino et al. 2006, 23.
46 Sondaar, Boer, et al. 1984; Sondaar, Sanges, et al. 1986, 19.
47 Dawson 2014, 83–90, on stratigraphic 'gaps' see also Guilaine 2013, 56.
48 Forenbaher, Kaiser, and Miracle 2013.
49 Forenbaher and Kaiser 2011, 99.
50 Forenbaher, Kaiser, and Miracle 2013, 594.
51 Mlekuž 2005.

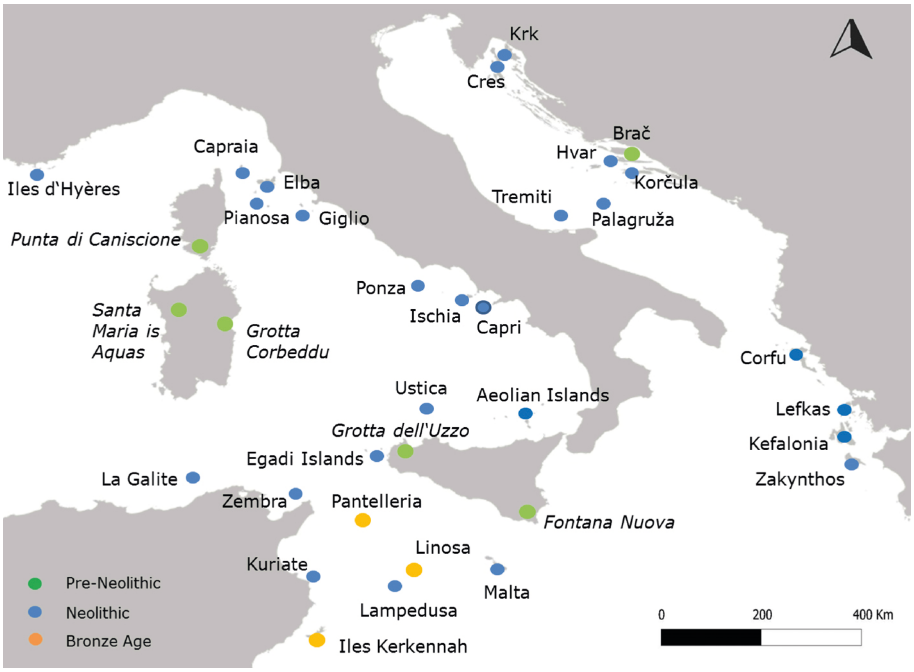

Fig. 3 Island colonization in the central Mediterranean.

omy at Vela Špilja on the island of Korčula in Croatia).[52] They go on to say that gaps observed at different sites are not contemporary, that a number of sites exist with undated Late Mesolithic–Early Neolithic sequences, so that abandonment on a regional scale cannot easily be proven.[53]

Another possible pre-Neolithic site was recently found just off the coast of Pantelleria, an island that is visible both from Sicily (ca. 110 km to the north) and Tunisia (ca. 70 km to the south). An underwater survey identified flint debitage over an area of 1200 m², some 18–21 m below sea level at Cala Tramontana. The authors propose an indirect age for the lithic industry, based on comparison of the palaeo-sea level with the eustatic curve, of 9600–7700 cal BP.[54] However, the dating of the material is not straightforward, given that the lithic artifacts were found in underwater layers mixed with Punic amphorae and Roman tile. Four obsidian fragments were recovered that, if the dating can be confirmed, would be contemporary to Pantelleria obsidian found in Epipalaeolithic contexts in Tunisia.[55]

As in the east, the majority of islands were first colonized in the Neolithic, starting in the 6th millennium with a peak in the 5th millennium cal BC.[56]

Neolithic colonizers travelled to tiny Palagruža in the middle of the Adriatic in the early 6th millennium cal BC, a distance of over 100 km.[57] This journey could have been broken up into two 50 km stretches via intervening islets, each leg approximately a day's line-of-sight navigation in good conditions. Two major marine currents convert on Palagruža, making it virtually impossible to miss; this small island, thus, provided a highly convenient stopover across the Adriatic during the sailing season (April to October).[58] There is evidence for the occupation of the Tremiti Islands in the western Adriatic around the same time. The Tremiti are also very small (in the order of 1 km²) and located some 30 km from southeast Italy and ca. 45 km from Palagruža. The dates for the EN on the Italian and Croatian sides of the Adriatic are similar (ca. 6000 cal BC);[59] however, the coastal spread in a northerly direction was much slower than

52 Mlekuž et al. 2008, 400–401; see also Bass 1998, 46, and Pilaar Birch 2018.
53 Mlekuž et al. 2008, 400–401.
54 Abelli et al. 2014.
55 For the Tunisian material see Mulazzani et al. 2010, although the proposed dating is not without problems (see Mannino 2014, 175).
56 Dawson 2014, 154–155.
57 Forenbaher and Kaiser 2011, 103.
58 Forenbaher and Kaiser 2011, 106, Kaiser and Forenbaher 2016, 148, 155, fig. 5.
59 Kaiser and Forenbaher 2016, 153, fig. 4

the initial east-west crossing, taking some 1000 years to cover ca. 700 km along the Italian peninsula.[60]

The seafaring capabilities of Neolithic farmers are evident. Nonetheless, the colonization of small remote islands in the Adriatic could be considered as an unavoidable necessity in the course of the maritime spread of the Neolithic.[61] In fact, most islands colonized from the 6th millennium lie closer to the nearest mainland (less than 50 km away) and this continues to be true during the 5th millennium, with another exception, Lampedusa (ca. 200 km away and not visible from Sicily).[62] On this island, there is evidence of a short-lived Early Neolithic village at Cala Pisana (6th millennium BC).[63] There is no obvious reason why Neolithic colonists would venture from Sicily to far-away Lampedusa, unless we envisage a network in the south-central Mediterranean connecting North Africa and Sicily at this time, as suggested by some on the basis of the distribution of obsidian.[64]

5 Pattern and process in island colonization

Evans and Cherry[65] both linked island colonization to the 'Neolithisation' of the whole Mediterranean basin following the 'wave of advance' pattern of migration. Two recent aDNA studies lend support to the demic diffusion theory. The first study identified a direct genetic link between Neolithic individuals from Levantine sites and the modern populations of Cyprus and Crete,[66] and the second a direct genetic link between Mediterranean and Central European early farmers and those of Greece and Anatolia.[67] As extracting and analyzing ancient DNA becomes increasingly refined and feasible, it will be possible to identify more closely the route taken by these early farmers along the coasts and islands into the central and western Mediterranean. In the meantime, we must rely primarily on archaeological data to reconstruct their progress, which was apparently less smooth than initially thought.

A review of the available archaeological data from 65 center-west Mediterranean islands shows that islands of all sizes were targeted during the Neolithic and, with the exceptions already mentioned, nearby islands seem to have been favored, whether large or small.[68] Subsequently, most of the remaining faraway islands were colonized. In the third millennium, most islands colonized were very small (smaller than 10 km^2), and far away from the nearest mainland. In this respect, the absence of any evidence for colonization from the Spanish islands before the Bronze Age really stands out.[69] It may be that they were just considered too far: Ibiza is ca. 90 km from Spain and Mallorca ca. 85 km from Ibiza. Although these distances are comparable to crossings to Cyprus and Crete, they were open sea crossings.

In the eastern Mediterranean, considering data from 82 islands, we can say that most large islands (larger than 50 km^2) were colonized between the Neolithic and Bronze Age regardless of distance to the mainland.[70] The Aegean has been described as a 'seafaring nursery',[71] where maritime mobility was facilitated by configuration: distance to the mainland was less significant in the east than in the west because of the more frequent occurrence of stepping-stone islands. This 'stepping stone' effect also helps explain the Mesolithic horizon emerging in the Aegean.

Early maritime activity (pioneering) in the small islands in the Aegean is, to date, simply not paralleled in the central Mediterranean. As Cherry noted, large islands in the west acted as a mainland attracting early occupation,[72] Mesolithic activity in the west thus appears overall to be more coastal (mainland-based or focusing on the largest islands) than insular *sensu strictu*.

Based on the foregoing review, the following observations appear to still be valid:[73]

60 Forenbaher and Kaiser 2011, 108; Biagi, Shennan, and Spataro 2005, 47.
61 Bass 1998; Dawson 2014, 61.
62 Dawson 2014, 156.
63 Radi 1972.
64 Tykot 1996; Mulazzani et al. 2010; contra Zilhão 2014. See also Broodbank and Lucarini 2020, 222 (this extensive review of Mediterranean Africa came to press after I completed this paper and it was not possible to discuss it here in detail).
65 Evans 1977; Cherry 1981.
66 Fernández et al. 2014.
67 Hofmanová et al. 2016.
68 Dawson 2014, 154–155.
69 Ramis et al. 2002; Alcover 2008; Cherry and Leppard 2018b.
70 Dawson 2014, 154–155.
71 Broodbank 2000; Broodbank 2006.
72 Cherry 1981, 63.
73 Dawson 2014, 150 (Fig. 6.1), 152.

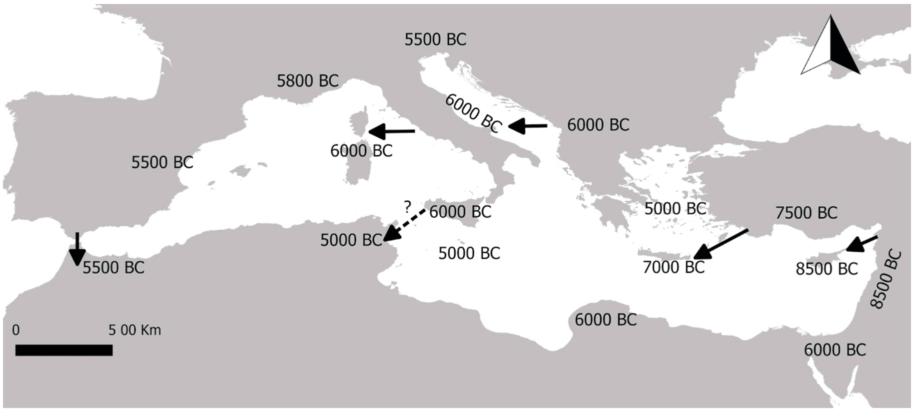

Fig. 4 Approximate dates of Neolithic expansion on the islands and adjacent coasts with main sea crossings.

1) Island colonization dates to before the Neolithic both in the east and west.

2) The pace of colonization picked up momentum with the Neolithic and was very similar in the east and west, supporting the idea of a rapid maritime spread via the islands and coasts.

3) The reduction in both areas in the number of islands colonized in the 7th millennium BC (Mesolithic/Neolithic transition) suggests distinct colonization horizons before and during the Neolithic.

There are a number of potential climatic, environmental, social, and cultural reasons for a decline in island colonization at the Mesolithic–Neolithic transition. Guilaine has proposed that the 8200 cal BP event, featuring a cool dry climate, may be responsible for the under-representation of archaeological sites for 2–3 centuries around 6200 cal BC (which may help explain an apparent lull in island colonization), either as a result of taphonomic processes (erosion) or because of environmental stress on people.[74] Zilhão has suggested that such a gap may mask different degrees of interaction between Mesolithic and Neolithic groups, resulting in a punctuated advance model.[75]

Whatever the reason(s), the archaeological evidence from the islands supports recent modeling of marine expansion resuming ca. 6000–5950 cal BC (Fig. 4).[76] The similar pace of island colonization in both the east and west between the 6th and 3rd millennia cal BC supports the idea of a rapid maritime diffusion once the Neolithic made its appearance. This spread was not continuous, but featured distinct peaks of activity, supporting the punctuated model, as well as temporal and spatial gaps, indicating jump dispersal or leap frogging mobility.

6 Rates of colonization and potential routes

How reliable are the patterns we see in the islands' archaeological record in terms of highlighting potential maritime routes of Neolithic expansion? Are the perceived patterns in fact the product of research bias in the archaeological record? This is not an easy question to answer since the degree of archaeological investigation on the islands varies considerably. At present, rates of colonization[77] support both maritime pioneer colonization and leap frogging. There is evidence for specific islands being targeted because of their resources (e.g. fresh water sources, obsidian, alum, marine shells, salt, ochre, and probably also perishable materials) or attractive size/distance/configuration, but we should also factor in their frequent abandonment.[78] Island colonization did

74 Guilaine 2013.
75 Zilhão 1993, 51–52; Zilhão 2000.
76 Bocquet-Appel et al. 2012, 537.
77 As reviewed by Cherry 1981 and Dawson 2014 and updated here.
78 Dawson 2014, 188–208.

not always entail permanent settlement, and even in the Neolithic islands were often abandoned. Nonetheless, occupation apparently lasted longer than abandonment: on average, occupation lasted ca. 2000 years and abandonment lasted on average ca. 1000 years.[79] This figure is on the upper limit of occupational gaps recorded from Mediterranean regional settlement surveys, gaps that lasted between 500 and 1000 years,[80] suggesting that (as we might expect) islands experienced longer abandonment periods than mainland regions.

Island colonization in the central Mediterranean was more gradual and spread out, while in the Aegean we see distinct peaks.[81] This too supports the view that Neolithic expansion along a maritime route was not a smooth process, but was rather arrhythmic after its inception.[82] The initial spread of the Neolithic from the Near East to Cyprus and its final leg from Italy to the Iberian Peninsula occurred rapidly, while the passage from Crete to Greece and into Italy occurred much more slowly.[83] The abandonment evidence from the smaller islands across the Mediterranean also supports a punctuated pattern, which goes against the model of a smooth wave of advance.

Islands acted as stepping-stones in Neolithic east-to-west expansion, but also as pivots or springboards for localized expansion. This is the case for larger islands within archipelagos, such as Lipari and Naxos. From such 'central' islands, we can envision capillary, as opposed to directional, dispersion. Specific islands, these usually being the largest ones, were targeted first (via colonization 'jumps') and the surrounding smaller islands filled in subsequently. We can attempt to trace movement in the most parsimonious way by fitting dates and sites in a way that shows progressive movement, but in all likelihood these early pioneers followed multiple paths (e.g. both along and across the Adriatic) as well as dead ends (e.g. Lampedusa). Attempts to reconstruct such routes should integrate archaeological data, radiocarbon dates, and genetic data as they become available.

7 Is there a relation between Mesolithic colonization and subsequent Neolithisation?

In the Aegean, given the presence of a distinct Mesolithic horizon, we can assume that there was considerable pre-existing knowledge of the sea and islands by the time of Neolithic colonization. In the west, initially colonizers targeted islands that were close to the mainland. Were they more reluctant seafarers? Was there less interaction? For both Cyprus and Crete, we may currently envisage two, perhaps even three, separate colonization events. On the smaller islands of the Aegean, there may have been a greater degree of continuity and even overlap between Mesolithic and Neolithic occupation at specific sites: in fact, given Mesolithic patterns of mobility and seasonality, we should bear in mind that the idea of abandonment in a Mesolithic context is very different to what occurs in a Neolithic context.

In the central Mediterranean, apart from the Dalmatian Islands, there is still a lack of pre-Neolithic activity on the smaller islands and, consequently, Mesolithic/Neolithic interaction is unlikely. In any case, it is difficult to generalize given the variety of features we subsume under the labels Neolithic and Mesolithic. This has implications in terms of what we define as intentional/accidental, sustainable/unsustainable, long-term/short-term, permanent/periodic, and successful/unsuccessful.[84] Neolithic expansion was ultimately successful despite it being a punctuated process, and we should not consider abandonment necessarily as a failure but as an adaptive strategy in the long-term.[85]

8 Conclusions

What was the role of islands in the spread of the Neolithic across the Mediterranean? Unlike in the Aegean – which is a veritable sea of islands and where island-hopping seems a logical choice for population mobility – in the central and western Mediterranean there was

79 These observations are based on a detailed study of 20 islands, for details see Dawson 2014, 245–259.

80 As measured by Butzer 1996, 46, and discussed in Dawson 2014, 250.

81 Dawson 2014, 153, fig. 6.2

82 Recent modeling of the Neolithic spread in the western Mediterranean supports the idea of a very rapid coastal expansion (300 km per generation) (Isern et al. 2017, 902). For reasons already discussed, the Balearic Islands were not part of this process.

83 Ammerman 2011; Mannino 2014, 177.

84 Dawson 2011, 46–49.

85 Dawson 2014, 185.

in fact no need for Neolithic pioneers to colonize the smaller islands, as only a few provide convenient stopover places. Islands provide a bridge only in a couple of instances, across the Adriatic and in the Sicily Strait. Both were important points of passage (the former more than the latter, based on current knowledge, during the Neolithic). Elsewhere, the smaller islands are located off the coast of larger islands, such as Sicily and Sardinia, or off a mainland. Coastal routes were more convenient, a fact that is well-reflected by the distribution of Cardial impressed pottery,[86] and yet small islands were occasionally targeted by Neolithic people; a few even became prominent places within the broader region, such as Lipari. These places usually had specific resources that made them appealing to Neolithic colonists and worth the extra effort of reaching them.

Overall, the evidence supports rapid maritime spread via the largest islands and intervening coasts. On such islands, Neolithic communities tended to target new areas and may have interacted with existing Mesolithic groups; on the smaller islands of the Aegean, there is also some evidence for interaction with local Mesolithic communities. In the central Mediterranean, the small islands represented an attractive option for incoming farmers in terms of freely available space, which apparently lacked previous occupation.

Pre-Neolithic island colonization is generally explained by climatic and environmental conditions, but it could equally be conceived of as a way of life that suited Mesolithic people's mobility and modes of resource acquisition[87] and by-passed the need for large territories, as long as social interaction was not hindered by excessive distance.[88] In the Neolithic, both environmental and cultural factors provide useful explanations for peaks in island colonization.[89] Ultimately, insularity itself may have represented an attractive option to colonists at all times, since islands are well-defined spaces that are separate from the mainland. An island is a place that can be more easily controlled (physically and mentally) and where communities could establish themselves and create connections more freely than on the mainland.

86 Robb and Farr 2005, 27; Broodbank 2013, 191.

87 Cf. "foraging seascapes" in Barker 2005.

88 Giovas 2016 argues that island size may not be a limitation to settlement *per se*, since humans can interact with limited ecosystems in ways that make settlement possible.

89 Cherry and Leppard 2018a have pointed out that permanent occupation of small remote Mediterranean islands only became possible with the introduction of farming in the Neolithic.

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1–4 H. Dawson.

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By Sail and by Land: Comparing the Inland and Maritime Streams of Neolithisation across the Western Balkans

Summary

This paper reviews the introduction of early farming in the Western Balkans through a comparison of the radiocarbon, zooarchaeological, and archaeobotanical records, both inland and in the Adriatic Basin. Summed calibrated date probability distributions, alongside data on settlement patterns, suggest an overall low Mesolithic presence across the area, sharply contrasting with a much higher density of Neolithic occupations appearing in the area after the end of the 8.2 kyr cal BP climatic event. Faunal and plant data present clear differences between both regions, although they share a common trajectory of increasing cultural diversity through time.

Keywords: Mesolithic; Neolithic; Western Balkans; Adriatic Basin; 8.2 kyr cal BP event; early farming

Dieser Beitrag revidiert die Einführung der frühen Agrarwirtschaft im Westbalkan, indem die Angaben für die Radiocarbondatierung, die zooarchäologischen und die archäobotanischen Angaben verglichen werden, sowohl auf dem Festland als auch im Adriatischen Becken. Die Wahrscheinlichkeitsdichte der Summenkalibration, neben Daten zu Siedlungsmustern, legt eine niedrige mesolithische Präsenz in diesem Gebiet nahe, als scharfen Kontrast zu einer viel höheren Dichte neolithischer Okkupation nach dem Ende des 8.2 event (Misox-Schwankung). Daten zu Fauna und Pflanzen zeigen klare Unterschiede zwischen beiden Regionen, obwohl ein gemeinsamer Verlauf zunehmender kultureller Diversität sie über die Zeit verbindet.

Keywords: Mesolithisch; neolithisch; Westbalkan; Adriatisches Becken; Misox-Schwankung; frühe Agrarwirtschaft

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1 Introduction

The existence of two streams of Neolithisation across the Western Balkans (along the Adriatic coast with the Impresso culture, and across the continent with the Starčevo-Körös-Criş complex) is a well-known trope of European Neolithic studies. Yet, beyond the association of each stream with distinct archaeological complexes, the precise nature of their differences remains elusive. How do we describe and account for this variability? What are the factors at play? Are we, for instance, simply dealing with archaeological reflections of varied landscapes? These many questions are far from anecdotal as, in many respects, the situation in the Western Balkans epitomizes the complexity of the entire Mediterranean. From the domestication process in the Near East, to the introduction of plant and animal domesticates across the confines of the northern Sahara, the archaeological record is rich in diversity and seems to deny the possibility of any all-encompassing interpretation.

The situation is further complicated by the overall quality and quantity of available data. Although admittedly not as problematic as across many parts of Northern Africa for instance, the long-troubled political history of the Western Balkans has been detrimental to the archaeological documentation. Noticeable progress has been made over the past decade or so thanks to the commitment and professionalism of local archaeological communities. Yet the overall state of affairs remains problematic and high-quality data is often confined to a few well-researched sites and micro-regions. All in all, a traditional conundrum emerges, whereby scant data point to numerous exciting research questions, but, at the same time, seem to prevent any attempt to answer them.

The present contribution stems from a five-year research project called EUROFARM, which aims at directly tackling this archaeological conundrum.[1] To this purpose, the project takes two main methodological directions. Firstly, EUROFARM adopts a polythetic definition of archaeological variability[2] and thus aims at separately investigating selected facets of the archaeological record (e.g. radiocarbon chronology, zooarchaeology, archaeobotany, settlement pattern, pottery, and lithic technologies). Comparative analysis only happens at a secondary stage, by resorting to cross-examination of patterning for each element and computational modelling. Secondly, in order to tackle the aforementioned documentation problems, we implement data collection at three distinct levels: survey of the published literature for the Western Balkans (i.e. Bosnia and Herzegovina, Croatia, Macedonia, Montenegro, Slovenia, Serbia, and neighboring areas); analyses of older and new museum collections, in collaboration with local heritage institutions and universities;[3] targeted fieldwork in Bosnia and Herzegovina[4] and Montenegro.[5] The last two dimensions aim at filling documentation gaps and at providing high-quality windows to explore in detail the large-scale patterns detected by the literature survey.

The focus lies here upon the radiocarbon record and farming practices, as reflected by zooarchaeological and archaeobotanical records. Radiocarbon evidence allows the pace and spatial structure of each stream to be compared, characterized by distinct tempos and magnitudes. The emphasis on zooarchaeology and archaeobotany is justified by the wish to avoid any confusion between 'minimal' and 'extended' definitions of the term Neolithic (i.e. Neolithic as farming vs. Neolithic as social and ideological cohesive package). In this sense, the process of Neolithisation referred to in the title should be taken as a descriptive synonym for the diffusion of early farming techniques, regardless of the underlying mechanisms – social, ideological, ecological, etc. – eventually identified through analysis.

2 Radiocarbon

The radiocarbon database covers the core research area, and adjacent regions such as Adriatic Italy, Albania, southern Hungary, western Romania, western Bulgaria, and northern Greece (Tab. 1). From a chronological point of view, collected data cover the period between the Bølling-Allerød interstadial period and the onset of the Middle Holocene (*ca.* 12 000 to 5000 uncal. b.p.). The adoption of such large chronological

1 Vander Linden, Orton, et al. 2013.
2 Clarke 1968.
3 Vander Linden 2011.
4 Vander Linden, Pandžić, and Orton 2014.
5 Pandžic and Vander Linden 2014.

Country	Mesolithic	Neolithic	Total
Albania	4	3	7
Bosnia and Herzegovina	1	116	117
Bulgaria	0	153	153
Croatia	21	205	236
FYROM	0	41	41
Greece	47	209	256
Hungary	0	308	308
Italy	133	292	425
Kosovo	0	2	2
Montenegro	23	11	34
Romania	86	112	198
Serbia	91	296	387
Slovenia	14	97	111
Total Result	**420**	**1856**	**2275**

Tab. 1 Table summarizing the distribution of ^{14}C per country and per period.

brackets enables exploration of the long-term trajectory of Holocene foraging populations or Mesolithic, the introduction of early farming and its local development over more than a thousand years.

As of April 2016, the database holds information on 2275 radiocarbon dates for a total of 423 sites. Despite this relatively large size, it presents numerous quantitative and spatial biases, which must be taken into consideration. Table 1 summarizes the number of radiocarbon determinations available for the project core area as per the main chronological periods (Mesolithic and Neolithic) and countries. Two conclusions stand out: firstly, the number of dates for the Neolithic period outstrips the corresponding information for the Mesolithic by a factor of four, despite the fact that the latter period lasted more than twice as long and secondly, there are marked discrepancies between values per country that cannot be accounted for by differences in total areas. Whilst the implications of this Mesolithic-Neolithic imbalance are explored in the next section, more attention is required to explore the geographical biases at play in the database. Figure 1 presents the geographic distribution of known radiocarbon dates using, on the left, a classical 'dots-on-the-map' representation and, on the right, a technique called hexagonal binning. In the latter, each hexagon is colored according to a given value, here the number of radiocarbon dates present within this area. Together, both maps clearly show the geographic imbalance in the existing record, with several areas totally devoid of any information, and others comparatively over-represented. The local history of research plays a key role in the creation of these patterns, with areas such as the Iron Gates having been long subject to intense scrutiny,[6] or the surroundings of modern-day Belgrade, with the eponymous Late Neolithic tell site of Vinča, which has recently been extensively re-dated.[7]

Without denying the importance of such high-quality records, the scarcity of the available information from a geographic point of view is detrimental to any assessment of the chronological sequences in the region. In this optic, one of the objectives of the EUROFARM project is, in collaboration with local colleagues, to identify suitable collections to be dated in order to fill in some of these gaps. For instance, until the mid-2000s,

6 E.g. recently Borić, French, et al. 2014; Bonsall, Vasić, et al. 2015.

7 Tasić et al. 2015.

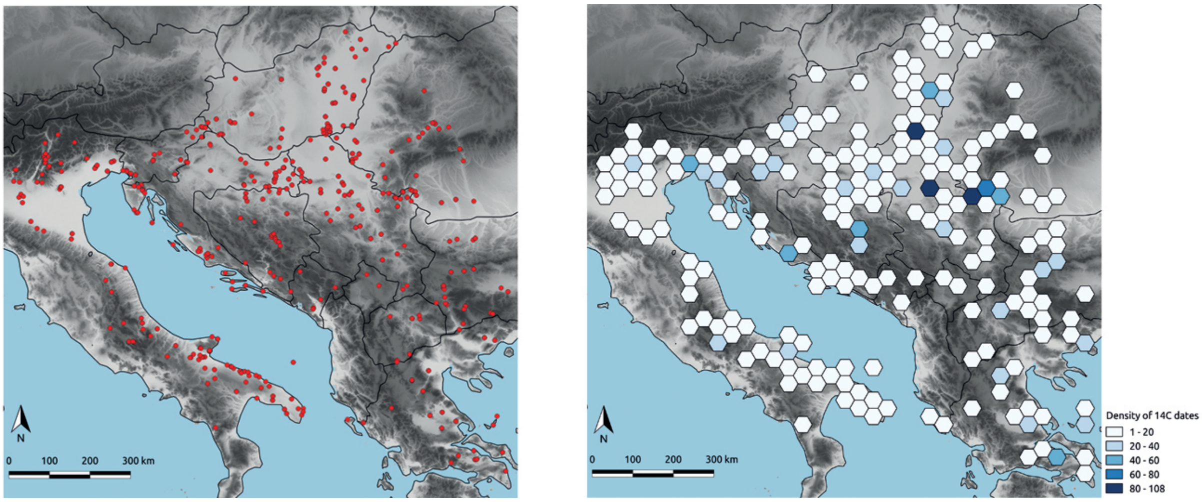

Fig. 1 Left: distribution of radiocarbon dated sites for both Mesolithic and Neolithic periods. Right: density of distribution of radiocarbon dated sites.

radiocarbon dated sites in Bosnia and Herzegovina were confined to Gornja Tuzla in the northeastern part of the country, and a cluster of sites in the central region of Visoko (e.g. Obre I and II,[8] Okolište, and other sites).[9] Since then, we have obtained 34 dates for 11 sites spread to the north along the Sava catchment area and to the south across Herzegovina,[10] whilst further sampling is ongoing across the entire research area.[11]

These limits being kept in mind, the question arises of how to use such a relatively large dataset. To this purpose, we use summed calibrated date probability distributions (hereafter SCDPDs), using the same method as described by Timpson and colleagues (i.e. a comparison of summed data with a null model, and statistically significant differences between both being considered as potentially meaningful).[12] This method, also known as "dates as data",[13] assumes that any regional radiocarbon record reflects the magnitude of past activities, so that fluctuating densities of radiocarbon dates are informative of the intensity of past human behavior, including past demography. As discussed in the original publication, many factors – taphonomic, history of research, etc. – are likely to blur this suggested one-to-one relationship and must be taken into consideration in the interpretation of the radiocarbon distributions.[14] In this sense, the technique works best when the radiocarbon signal is combined with another category of information, such as palaeoenvironmental records.[15] In the near absence of such proxies for our research region, SCDPDs are compared against cartographic information and known trends in settlement patterns.

3 Holocene foragers

As previously noted, the quantity of radiocarbon dates for the Mesolithic period in the research area is comparatively low. This trend is reflected in the SCDPDs, which present a gentle continuous rise from the beginning of the Holocene onwards, with several minor fluctuations (Figs. 2 and 3). Spatially, the distribution of Mesolithic sites in the Western Balkans presents a strong bias towards maritime and riverine environments, such as the Adriatic coast or the Danube Gorges. This situation is sometimes interpreted as the result of the extension of the forest cover during the Holocene, which would have pushed human communities to settle preferentially along major river valleys and seacoasts.[16] The general validity of this argument was recently demonstrated by the discovery, as part of the EUROFARM project, of an Early

8 Gimbutas 1974.
9 Hofmann 2014.
10 See also Vander Linden, Pandžić, and Orton 2014.
11 E.g. Vander Linden, Marriner, et al. 2015.
12 Timpson et al. 2014.
13 Rick 1987.
14 E.g. Williams 2012.
15 E.g. Woodbridge et al. 2014.
16 See recently Gurova and Bonsall 2014.

Mesolithic site along the shores of the Skadar Lake in southeastern Montenegro, an area devoid of previous archaeological investigation, but where the presence of potential Mesolithic sites was expected (cf. lake with cold water and corresponding rich ecosystem).[17]

This scarcity of information is particularly noticeable for the Late Mesolithic. The possibility of flooding events in the Iron Gates has, for instance, been invoked[18] although settlement continuity is obvious.[19] Across the eastern Adriatic, there is a noticeable lack of Mesolithic sites for the last centuries of the 7th millennium cal BC,[20] with the clear exception of Montenegro. For the western Adriatic coast, the pattern provided by radiocarbon data can be supplemented by a recent survey of the latest Mesolithic.[21] The quasi-total absence of sites in the Adriatic Basin is remarkable, most likely reflecting the low productivity of the Mediterranean Sea. By contrast, there is a relative concentration of sites in the Alpine Piedmonts, mirroring a clear preference for a different, richer ecosystem more suited to a foraging economy. Overall, there are numerous arguments to consider that the Mesolithic meta-population across the Western Balkans and the Adriatic Basin was fairly thin[22] and clustered in specific ecological niches by the time early farming techniques were locally introduced.

4 Onset of farming in the European mainland

Until recently, several scholars have questioned the presence of farming communities in Europe during the earlier half of the 7th millennium cal BC. For instance, Weninger and colleagues considered, in an overwhelmingly critical assessment of the evidence, that all dates prior to 6200 cal BC were unreliable and, thus, that the spread of early farming in this part of Europe was a direct consequence of improved climatic conditions after the end of the so-called 8.2 kyr cal BP cooling event.[23] Since, several sites have yielded radiocarbon dates from secure archaeological contexts that demonstrate without doubt that farming was practiced across Turkish Thrace, Greece, and Bulgaria during the second half of the 7th millennium cal BC.[24]

This being said, the role of the 8.2 kyr cal BP event in the European Neolithisation process should not be minimized. Indeed the SCDPDs evidence a sudden rise by 6000 cal BC, which corresponds to the spatial extension of farming across the Adriatic Basin and the Western Balkans (Figs. 2 and 3). The match between the local Neolithic sequence and the end of the 8.2 kyr cal BP event, set at a minimal date of 8045 cal BP based upon published confidence intervals,[25] is impressive and extremely suggestive. Yet, it remains hazardous in the present state of documentation to infer any strict causal link between both events. Indeed, the impact of this global cooling event upon local environmental conditions are changing greatly. Magny and colleagues infer a zonation of hydrological regimes across Europe, with increased aridity and seasonality south of a Valencia-Napoli-Athens line and, by contrast a wetter and cooler climate across the northern Mediterranean and central Europe.[26] For instance, palaeoclimatic proxies for the lakes Maliq and Prespa (Albania), point to slightly cooler – especially during the winter – and drier conditions, with a relative opening of the forest cover.[27] By contrast, Core MD 90-917, located in the southern Adriatic, shows a relative stability of the warm temperate oak forest.[28] All in all, it remains difficult to translate these environmental conditions in terms of potential agricultural stress. The conditions were probably less favorable in numerous parts of Greece, where early farming communities were established, and this could explain to some extent the observed standstill after an initial migratory episode. Nevertheless, in this hypothesis, the reasons why the spread of early farming would have resumed when the local farming conditions became potentially more favorable (i.e. absence of a push factor) remain unclear, and other factors must be sought beyond a simple deterministic environmental scenario.

17 Vander Linden, Orton, et al. 2013; Vander Linden, Marriner, et al. 2015.
18 Bonsall, Macklin, et al. 2002.
19 Borić, French, et al. 2014.
20 Forenbaher, Kaiser, and Miracle 2013, 603.
21 Franco 2011.
22 See also Porčić and Nikolić 2016.
23 Weninger et al. 2006.
24 Lespez et al. 2013; Perlès, Quiles, and Valladas 2013; Karamitrou-Mentessidi et al. 2015.
25 Blockley et al. 2012.
26 Magny et al. 2003; see also Berger and Guilaine 2009.
27 Aufgebauer et al. 2012.
28 Combourieu-Nebout et al. 2013.

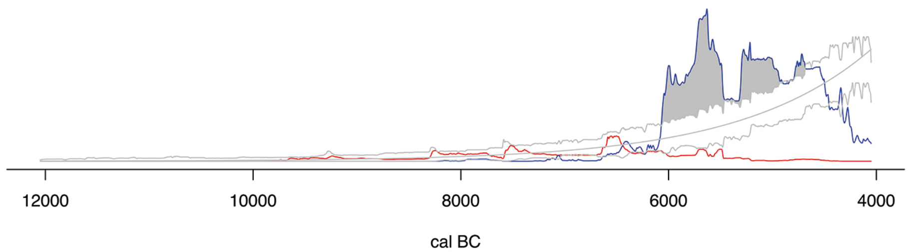

Fig. 2 Summed calibrated date probability distributions for the inland zone. Y-axis: summed radiocarbon dates density. Blue line = Mesolithic dates; red line = Neolithic dates; grey line = null model, and grey area = zone where the difference between date and null model is statistically significant.

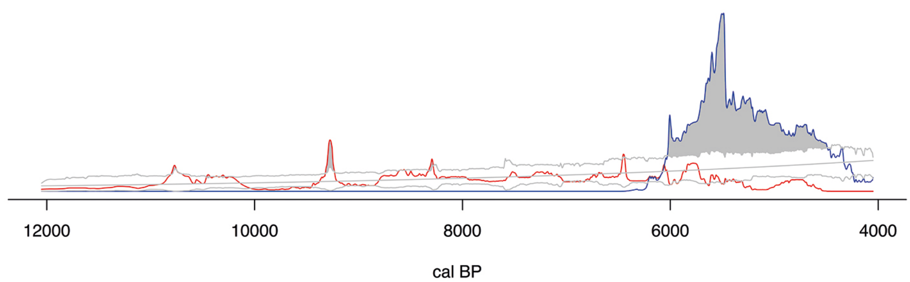

Fig. 3 Summed, calibrated date probability distributions for the Adriatic Basin. Y-axis: summed radiocarbon dates density. Blue line = Mesolithic dates; red line = Neolithic dates; grey line = null model, and grey area = zone where the difference between date and null model is statistically significant.

Regardless of the environmental context within which Neolithisation resumes in the Western Balkans, it is noteworthy that this process concerns both the Adriatic Basin and the inland regions. The rest of the following exposé is structured accordingly, starting with a comparison of the Impresso and Starčevo-Körös-Criş (hereafter SKC) complexes.

The extent of the Impresso complex is noticeable, covering most of the eastern Adriatic and the southern half of the Italian Adriatic side. Nevertheless, in both cases, the distribution remains mostly confined to the coasts, with only limited use of the hinterland prior to 5600 cal BC. As suggested by Forenbaher and Miracle,[29] this pattern is most probably indicative of small communities leap-frogging from one coastal location to the next by boats.

In comparison, the SKC is characterized by a faster and wider diffusion. Indeed, by 5800 cal BC the northern and western limits of its distribution area had been reached, with sites in Hungary and Slavonia (eastern Croatia). If the spatial extent of this spread is noticeable, its exact progression remains elusive, partly because of its high speed, which lies at the limits of the resolution of radiocarbon technique, partly because of the uneven distribution of dates, especially along some possible key corridors such as the Morava Valley in southern Serbia. Ongoing sampling as part of the EUROFARM project, coupled with Bayesian statistical analysis, will hopefully help to resolve these questions.

The spatial extent of this diffusion and the sharp rise in the SCDPDs, together suggest that we are dealing here with an expanding new population experiencing a situation of demographic stress. Recent aDNA studies confirm that the SKC corresponds to an incoming population, which finds its eventual origins in the Near East.[30] Levels of admixture with a putative Mesolithic population remain low and, so far from an aDNA point of view, limited to a single individual from Hungary. Despite having been buried in a Körös cultural context, this individual presents an aDNA signature that falls within the known range for the Mesolithic.[31] As previously noted, the overall Mesolithic presence seems indeed limited to a few enclaves centered upon riverine isolates, such as in the Iron Gates. There, the Mesolithic-Neolithic transition corresponds to a demographic increase, inferred by statistical analysis of the settlement pattern and associated bioarchaeological data.[32] It is, however, unclear to what extent this demographic rise is related to increased fertility and/or lower mortality rates linked to the new economy or to the migration of new people, as documented by Sr isotopes.[33]

29 Forenbaher and Miracle 2005.
30 Szécsényi-Nagy et al. 2015.
31 Gamba et al. 2014.
32 Porčić and Nikolić 2016.
33 Borić and Price 2013.

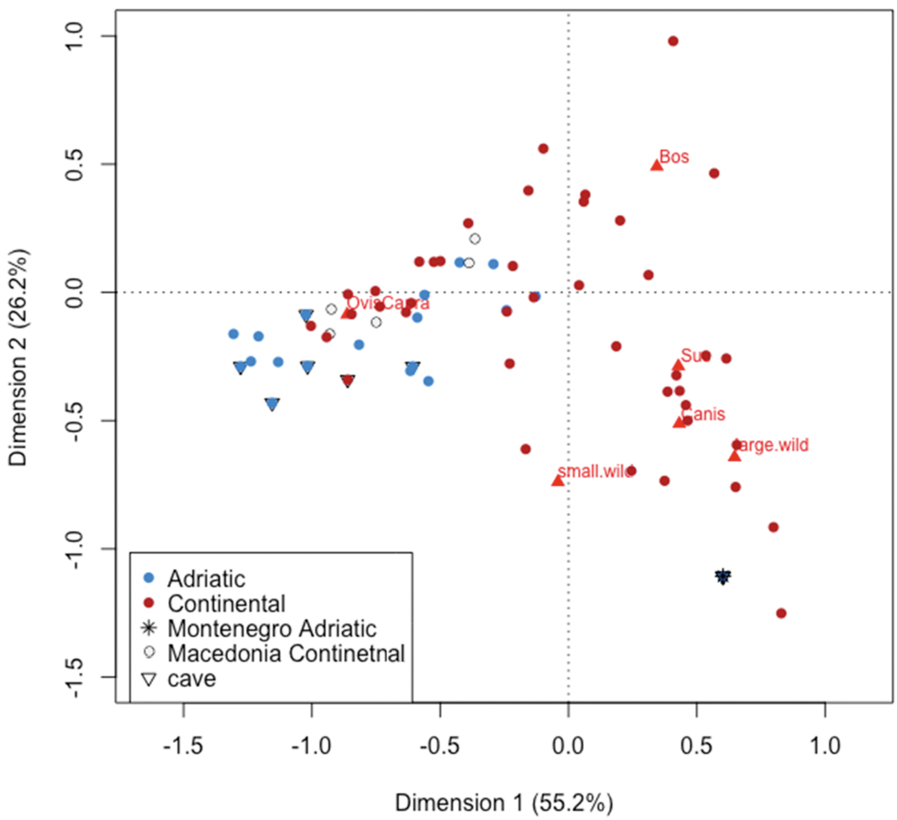

Fig. 4 Comparison of animal exploitation practices from faunal data of early Neolithic sites from continental (SKC complex) and Adriatic (Impresso) streams of Neolithisation.

5 Early Neolithic farming systems

5.1 Zooarchaeology

In order to broaden the comparison between both streams of Neolithisation, we have conducted a full survey of all zooarchaeological records for the period under consideration. The current comparative zooarchaeological dataset comprises 140 assemblages from 125 sites of the Western Balkans and nearby areas. These represent a subset of the available data that meets the minimum sample size of >199 NISP (Number of Identified Specimens) with accurate chronological determination within a period (or periods) of the Neolithic according to our chronological subdivision. This dataset contains 56 assemblages from 49 sites of the Adriatic and 84 assemblages from 76 sites of the continental zone. These data were compared via correspondence analysis both across time and space to determine the changing patterns of hunting and livestock management within and between the coastal and continental regions throughout the Neolithic.

The Early Neolithic sites of the SKC complex in the Western Balkans and neighboring regions provide a relatively large dataset of studied faunal assemblages. The rapid spread of farming through these regions demonstrates at first glance a highly varied pattern of livestock management practices, with a geographical separation between a retention of ovicaprine-focused management in both Macedonia and the Pannonian plain with a transition in central regions towards the increased management of cattle at the expense of ovicaprines (Fig. 4). This overall diversity, in part, masks more rapid chronological changes during the earlier 6th millennium cal BC (i.e. roughly pre-5700 cal BC) from ovicaprine-focused towards cattle-focused livestock management, with this transition occurring more slowly to the north in sites of the Pannonian Plain.[34] The intensity of hunting across SKC sites varies, but appears to increase over time, particularly on sites of the Pannonian Plain. Hunted animals

34 Orton, Gaastra, and Vander Linden 2016.

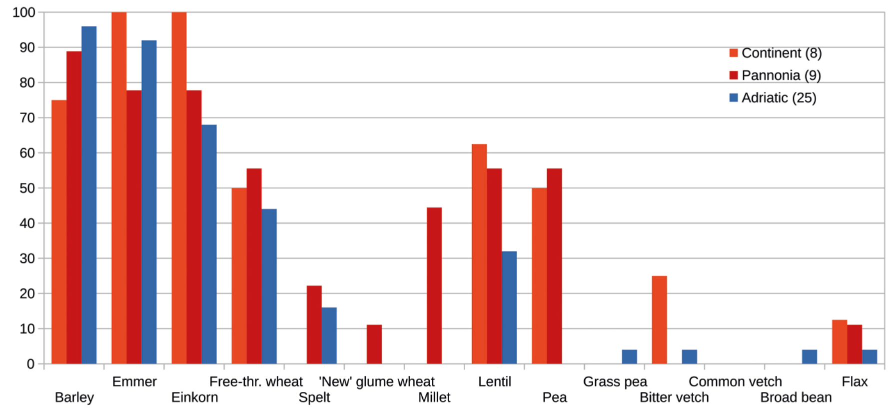

Fig. 5 Ubiquity scores by site of Early Neolithic cereals, pulses and flax.

are mainly represented by larger game at SKC sites (most commonly cervids and boar).

Early Neolithic agro-pastoral practices of the coastal Impresso complex are, by contrast, far more uniform. Both the eastern and western Adriatic coasts show a relatively homogenous focus on ovicaprine management, with low levels of hunting. Between these two coasts, EN faunal assemblages vary only in the intensity of their high-ovicaprine-low-wild focus. In both cases (although particularly along the eastern Adriatic), hunting appears to have been more opportunistic, with a greater representation of small game (relative to continental sites).

5.2 Archaeobotany

Archaeobotanical data was gathered from the Western Balkans and surrounding countries (Italian Adriatic coast, Hungary, Romania, and Republic of North Macedonia). Data was also obtained from Greece and Bulgaria, representing another area not discussed here. Records of grains, seeds, nuts, and fruits recovered charred and as impressions in clay were obtained from 208 sites. Two main problems arose when analyzing the data. Firstly, the published and unpublished archaeobotanical records rarely include methodological details on the recovery and recording of data, which not only vary between countries, but also in time, as archaeological techniques have developed. Secondly, the two forms of preservation are not easily integrated as they have very different taphonomical pathways, providing complimentary but not congruent information.[35] A third of the main crops only occur carbonized and the remainder are under-represented as impressions.

Therefore, in order to make sound comparisons, records from impressions were removed and the remaining data was reduced to a binary format of presence/absence of species. Consequently, this study includes carbonized crops from 125 sites (133 phases), 56% of which are from inland (Pannonian and continental) and 44% from the Adriatic coast. 34% of records are from the Early Neolithic, in which there is a slight geographic imbalance towards coastal sites (60% of sites, 21 sites from Italy but only four from Croatia). The degree of geographic imbalance is reversed for the Middle and Late Neolithic, with inland sites accounting for 63% of records.

The main cereal crops barley *(Hordeum vulgare)*, emmer *(Triticum monococcum)*, and einkorn *(T.dicoccum)* spread across all areas during the Early Neolithic (Fig. 5). Barley is more ubiquitous across coastal sites, whilst emmer and einkorn are slightly more common inland. The latter is reminiscent of the well-established preference for hulled wheats during the Early Linear Pottery Culture (*Linearbandkeramik*, LBK).[36] Despite being less common, free-threshing wheat *(T.aestivum/durum)* is also present throughout the research area. 'New' glume wheat currently has a low and singular distribution, probably due to its relatively recent discovery and formal description.[37] Findings of spelt *(T.spelta)*, though infrequent, are intriguing, as its origins remain contentious.

35 E.g. McClatchie and Fuller 2014.
36 Bogaard 2004; Colledge and Conolly 2007; Kreuz et al. 2005.
37 Jones, Valamoti, and Charles 2000.

European spelt began as a weed from the introgression of emmer with a hexaploid bread wheat[38] and was not a crop *per se* until after the Neolithic.[39] Millet *(Panicum miliaceum)* has been found inland, though only ever as one or two seeds. This crop's presence in the Western Balkans is problematic as it was domesticated in Central Asia and is not thought to have been cultivated in the Balkans before the 5th millennium cal BC.[40]

Of the five Early Neolithic pulses identified, lentil *(Lens culinaris)* and pea *(Pisum sativum)* were by far the most common, particularly inland. The predominance of these two pulses is also evident in Greece, the Iberian Peninsula, and during the LBK.[41] The absence of pea along the Adriatic is therefore unusual. Records of lentils are all from Apulia, though this may simply reflect the low number of Dalmatian sites. Bitter vetch *(Vicia ervilia)* is the only other pulse found inland. Grass pea *(Lathyrus sativus)* was found in Dalmatia and broad bean *(V.faba)* in Apulia. The latter was one of the main pulse crops in Old World agriculture and the most common Early Neolithic pulse in the Iberian Peninsula.[42] Its restricted presence to the Adriatic coast during the Early Neolithic may suggest an early maritime diffusion.

Flax *(Linum usitatissimum)* was part of the crop package introduced from the Near East,[43] and it is present in all three areas. Its ubiquity scores are very low however, which must be partly due to taphonomy as it is unlikely to survive carbonization.[44]

This dataset reveals the presence of several crops, including spelt, 'new' glume wheat, bitter vetch, grass pea, and flax, which had not been recognized in the area in several previous large-scale assessments of the literature.[45] This is important as it suggests that, contrary to general assumptions, the crop package of both SKC and Impresso were not as reduced when compared to the rest of the eastern Mediterranean Basin.

6 Last but not least: secondary Neolithisation at the end of the sixth and beginning of the fifth millennium cal BC

After the marked peak associated with the initial spread of early farming across the Western Balkans, the SCDPDs for the Adriatic Basin and the inland region present a marked drop, followed inland by further fluctuations (Figs. 2 and 3). Although these oscillations do not deviate from the null model in a statistically significant way, they are correlated with other elements in the archaeological record. A similar pattern of rise and drop of the SCDPDs during the first centuries after the local inception of farming has been observed across several western European regions and is interpreted as a demographic 'boom-bust'.[46] In this hypothesis, the 'boom' corresponds to a population increase, enabled by the Neolithic Demographic Transition,[47] while the 'bust' corresponds to a population collapse, for which reasons remain unclear. Following the methodological caution exposed earlier, other factors must be evaluated rather than assuming that a comparable demographic reading is appropriate for the Middle and Late Neolithic of the Western Balkans.

The Adriatic situation is characterized by a progressive rise until the mid-sixth millennium BC, followed by a continuous drop lasting the entire Neolithic sequence.[48] Interestingly, this drop is synchronous with the expansion of early farming across the entire Adriatic Basin, including the Pô Valley to the north, and the hinterland of areas where the Neolithic economy was already present. Beyond the Adriatic Sea, the period also corresponds to the introduction of animal and plant domesticates across vast sways of the western Mediterranean Basin, including northern Maghreb.[49] Rather than a population collapse, it thus seems that the drop observed in the SCDPDs corresponds to a process of spatial dilution. There might well have been across the Adriatic a lower overall population density, but this is

38 Blatter, Jacomet, and Schlumbaum 2004; Zohary, Hopf, and Weiss 2012, 48–50.
39 Filipović 2014; Rösch 1998.
40 Hunt et al. 2008; Motuzaite-Matuzeviciute et al. 2013.
41 Antolín, Jacomet, and Buxó 2015; Colledge, Conolly, and Shennan 2005.
42 Antolín, Jacomet, and Buxó 2015.
43 Zohary, Hopf, and Weiss 2012, 103.
44 Märkle and Rösch 2008.
45 E.g. Coward et al. 2008.
46 Shennan et al. 2013.
47 Bocquet-Appel 2011.
48 See also Fiorentino et al. 2013.
49 Bocquet-Appel et al. 2009; Morales et al. 2013.

rather to be explained as the result of an outgoing migration.

The inland situation is more complicated, with a first drop between 5600 cal BC and 5300 cal BC, then a brief peak at 5200 cal BC, followed by a further drop until a final rise by 4800 cal BC. It is noteworthy that the apparent drop at 5600 cal BC corresponds to the development and diffusion of the Linearbandkeramik culture from the Hungarian plain to the rest of central Europe.[50] As for the Adriatic case, it is likely that the overall meta-population did not experience any drop, but that locally we observe a loss of density related to outgoing migration. The second oscillation in the SCDPDs occurs between 5200 to 4800 cal BC, which corresponds to the development and maximal use of stratified tell sites across the Western Balkans.[51] In this sense, whilst the peak at 5200 cal BC remains difficult to interpret, the successive drop seems to correspond to a process of increased settlement nucleation, rather than variation in the population as such. Conversely, the subsequent rise from 4800 cal BC is probably linked to the gradual abandonment of tell sites from 4800–4700 cal BC onwards in more dispersed settlements.[52] In central Bosnia, the first half of the 5th millennium cal BC corresponds to a gradual shift from centralized sites, such as Obre and Okolište, towards a more dispersed settlement pattern, characterized by smaller sites which tend to be located outside the Bosna River Valley and, in some instances, towards higher topographical positions.[53] At the same time, this period also marks a new expansion of farming into new areas. In the lower Vrbas Valley, for instance, extensive field survey coupled with test excavations show that Neolithic sites only appear in this humid floodplain by 5200–5000 cal BC, whilst by 4800 and 4500 cal BC there is a multiplication of small sites set on small raised, well-drained grounds.[54]

All in all, the fluctuations in SCDPDs for the Middle and Late Neolithic cannot simply be read in absolute demographic terms, but rather require being approached from a more spatial point of view. In both the Adriatic and inland cases, there seems to be a limited drop in the local population related to further outgoing migrations towards surrounding areas (western Mediterranean and central Europe). Locally, there are also numerous changes in settlement patterns, including successive episodes of nucleation and dispersion, as well as the use of a wider range of categories of landscapes by Neolithic communities.

7 Middle and late Neolithic farming systems

7.1 Zooarchaeology

From the mid-6th millennium cal BC, a supra-regional continental pattern of cattle-focused agropastoral practices is extant across all regions, with the exception of Macedonia (Fig. 6). Hunting levels continue to vary, and the focus of hunting continues to be on larger game.

Inland, faunal exploitation patterns, which can be seen initially developing in the Early Neolithic and gradually becoming more uniform during the Middle Neolithic, continue during the Late Neolithic. By then, we observe the near uniform domesticate economic pattern with cattle as the dominant livestock managed, as well as regional patterns in the supremacy of this domesticate and in hunting practices. While cattle are consistently the predominant domesticate on sites, their presence ranges from ca. 50% (Late Vinča Belovode and Late Sopot Kosjerovo) to over 90% (Late Vinča Boljevci) of domesticates. Variation in the intensity of hunting can also be seen both within and between cultural complexes. Far more hunting evidence overall is seen in northern than southern Vinča sites.[55] By contrast, Sopot sites (same environmental zone, different cultural group) just across the Danube display far less hunting than either northern or southern Vinča. Butmir sites in the uplands of central Bosnia demonstrate a heightened focus upon the exploitation of cattle with an even lesser degree of hunting than Vinča or Sopot.

Along the Adriatic coasts, the secondary spread of farming practices from 5600 cal BC onwards into upland sites of Istria and the Trieste karst is paralleled by a

50 Bocquet-Appel et al. 2009.
51 Schier 2014.
52 Link 2006.
53 Furholt 2012; Hofmann 2012.
54 Pandžic and Vander Linden 2014.
55 Orton 2012.

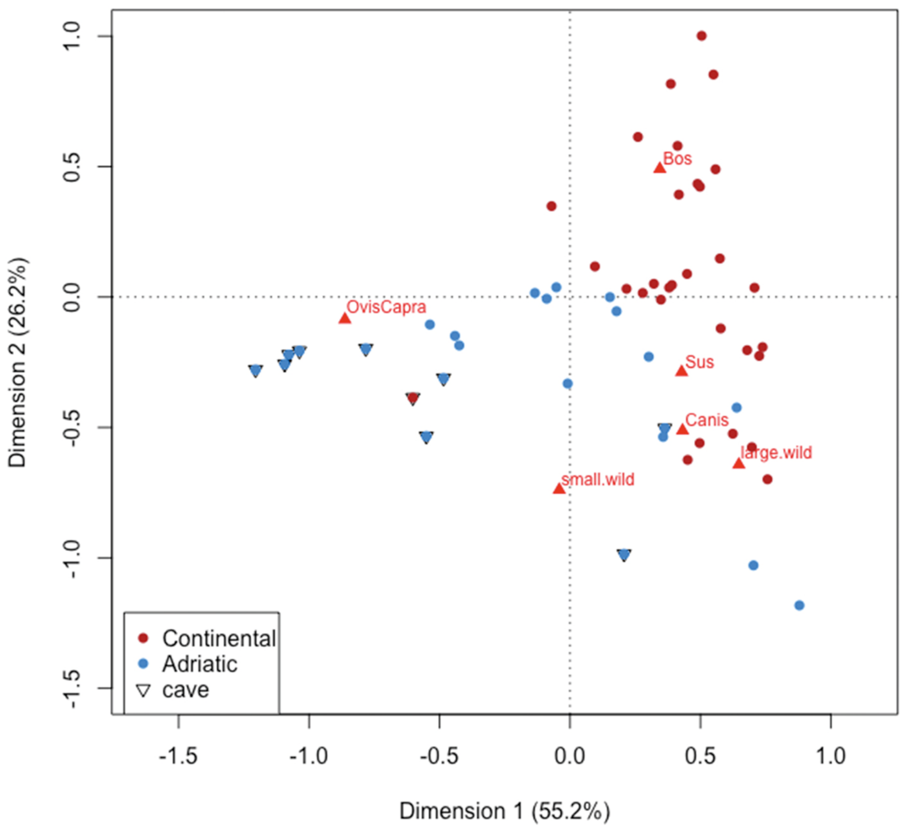

Fig. 6 Comparison of animal exploitation practices from faunal data of late Neolithic sites from inland and Adriatic regions.

high degree of hunting, although the domesticates continue to be dominated by ovicaprines (Fig. 7). Areas with farming already present in the Early Neolithic (southern Italy and most of the eastern Adriatic coast) still display an unchanged high-ovicaprine and low-wild pattern of animal management. Settlements along the coasts of central Italy show a greater level of variation in stock management and hunting, with a less restricted management focus (more pigs and cattle) and higher levels of hunting. This diversity of management strategies is not simply a chronological process, but most probably the outcome of the spread of farming outside of coastal Mediterranean bioregions. While it is difficult to determine precise bioregion zonation for this period, it is noteworthy that the homogenous ovicaprine-focused taxonomic patterns are seen in regions today classified as Mediterranean bioregions. By contrast, domesticate proportions vary considerably for settlements located in modern-day continental bioregions.

Late Neolithic faunal profiles across the Adriatic Basin continue these trends, including the formation of regional taxonomic patterns. Upland sites located in Istria and the Trieste Karst continue in some cases to demonstrate the high level of wild taxa seen in the Middle Neolithic, while other sites demonstrate the high-ovicaprine and low-wild pattern still prevalent along the eastern Adriatic coast and southern Italy. Central and northern Italy also display a continuation of faunal exploitation patterns seen in the Middle Neolithic, notably in the high variability in both domesticate proportions and wild exploitation patterns. Sites from these regions do not demonstrate management practices focused upon a particular domestic taxon (as with ovicaprines in southern Italy or cattle in the continental regions), but instead practice a diverse range of production strategies according to each individual site.

7.2 Archaeobotany

Barley, emmer, and einkorn continue to be well represented in Middle to Late Neolithic archaeobotanical assemblages (Fig. 8). Free-threshing wheat retains a similar score of around 50% for inland sites. It has not been found in large quantities and is not considered to have

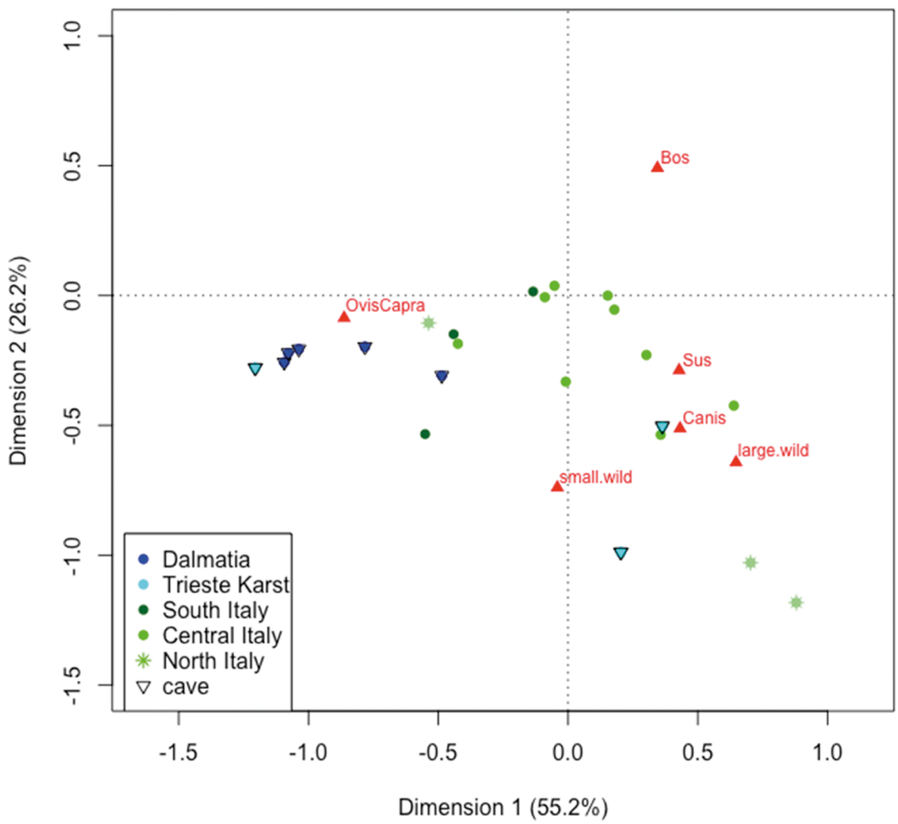

Fig. 7 Regional comparison of animal exploitation practices from faunal data of late Neolithic Adriatic sites.

been specifically cultivated in Europe until the Bronze Age.[56] A different pattern is evident along the Adriatic, where its presence rises from 44% to 74% in the Middle to Late Neolithic. The increasing importance of barley and free-threshing wheat along the Adriatic, especially in Apulia, is comparable to the Iberian signal,[57] in accordance with the maritime spread of crop packages along the Mediterranean.[58] Spelt is a little more common than in the previous phase but could not have been more than a crop contaminant. Finds of millet also increase. Of note are records of millet impressions in Middle Neolithic pottery (5300–4700 cal BC) from two sites in Hungary.[59] Its early presence in southern Europe remains contentious until further dating and analyses can be performed.

Lentil and pea continue to be the dominant pulses. Nevertheless, both pulses become less common in the Pannonian Basin despite increased ubiquity scores along the coast and in the continental zone. Pea is still absent during the Middle and Late Neolithic in Dalmatia (6 sites), despite its growing presence in the continent and along the Italian Adriatic coast. The other four pulses become more common across all three areas. An additional pulse, common vetch *(V.sativa)*, is found for the first time during the Middle to Late Neolithic, mostly along the northern Adriatic coast of Italy.

The sharp rise of flax along the coast and in the continent between Early and Middle to Late Neolithic periods tentatively suggests renewed efforts towards its cultivation. In Hungary, flax retains a low ubiquity score, which is intriguing when viewed in comparison to its mostly western distribution within the LBK.[60] Compared to the previous period, Middle and Late Neolithic assemblages are, thus, characterized by an intensification in the range of crops utilized and a diversification in agricultural regimes between inland and coastal areas. Unlike the zooarchaeological record, it is however difficult

56 Rösch 1998.
57 Antolín, Jacomet, and Buxó 2015.
58 Coward et al. 2008.
59 Gyulai 2010, 479.
60 Bickle and Whittle 2013, 11.

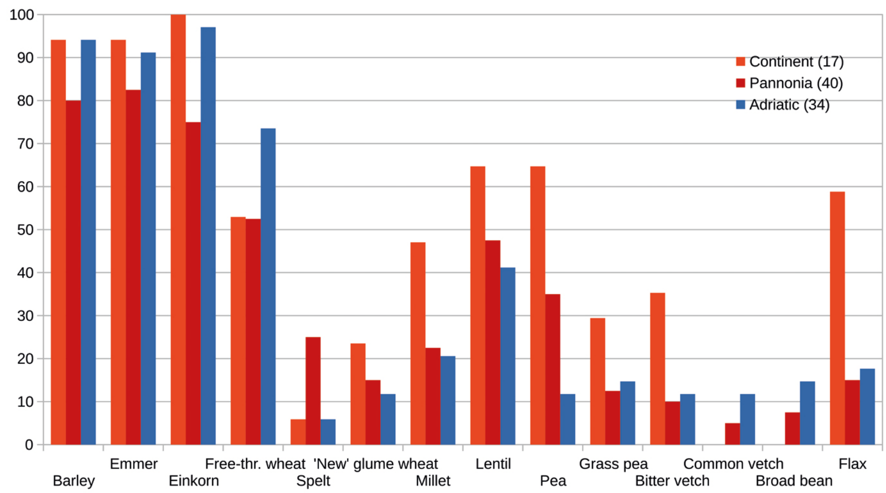

Fig. 8 Ubiquity scores by site of Mid/Late Neolithic cereals, pulses, and flax.

to clearly link this diversification to specific ecological adaptations, though the overall trajectory is undeniable.

8 Conclusion

The Balkans are reputedly the European region for which the archaeological record is the most uneven and sparse. As this contribution demonstrates, there is actually a large wealth of evidence to be unearthed from the literature, which allows the creation of fairly extensive specialized datasets. Arguably, each of these datasets presents specific qualitative and quantitative biases often explained by the history of local archaeological research. Yet, one needs to shy away from any methodologically driven pessimism. Not only is it possible to start filling documentary gaps through targeted fieldwork and careful selection of museum collections, but numerous biases can actually be taken into consideration in interpretations. From this point of view, a comparative agenda is key, by crosscutting signals from different regions, time periods, and categories of evidence to underline the possible existence of trends.

Whilst the local historiography of research is traditionally keen on stressing the role of the Mesolithic substratum in the spread of early farming (the 'Iron Gates effect'), several congruent lines of evidence point rather to an overall low density of the last local foraging populations, especially in view of the extensive imprint of the Early Neolithic. Together with recent aDNA results, it is now undeniable that the spread of early farming in the Western Balkans was closely associated with the arrival of new populations. The timing of this migration and diffusion process is well-known, though the underlying factors remain difficult to assess. For instance, a correlation between the end of the 8.2 kyr cal BP climatic event and the rapid dispersal of early farming across the area is obvious, but the precise identification of the causal forces at play is hampered by the dearth of local high-resolution environmental records.

It must be stressed that the positive identification of a migratory movement does not solve all archaeological problems for the period, as it leaves open, for instance, the question of the variability evidenced by the two large-scale Early Neolithic complexes (SKC inland and Impresso across the Adriatic Basin). Differences between both complexes are clear, as demonstrated by the radiocarbon, zooarchaeological, and archaeobotanical records, but cannot be merely reduced to adaptations to the contrasted ecological settings within which the diffusion occurred. Interestingly enough, whilst further differences can be observed between both sub-regions for the Middle to Late Neolithic, comparable trends can be highlighted. Indeed, from 5400 cal BC, one notes a gradual process of 'infilling,' marked by the expansion of farming communities in new habitats. In both inland and Adriatic cases, this general process is mirrored by changes in settlement patterns and a relative diversification in farming practices. Whilst parts of the zooarchaeological record point to adaptations to new ecological niches, the picture remains blurred for the archaeobotany record.

In conclusion, the comparative agenda advocated here is an essential methodological tool. Not only does it help to bypass some of the limits imposed by biases for specific categories of evidence, but more fundamentally, it forces us to consider the possible existence of larger diachronic and regional trends at play. There seems to be a natural habit by archaeologists to either consider their preferred local case study as the norm, or to dismiss unilaterally the possibility of any synthesis. The present contribution shows, we think, that it is actually possible to reach a satisfactory intermediary analytical and interpretative level, whereby each regional sequence is explained in its own terms, but also compared to others in order to highlight differences and similarities. In this sense, it appears that the entire process of Neolithisation in the Western Balkans, from the arrival of a pioneer migratory front to progressive infilling and extensive use of the landscape, goes in parallel with a gradual loss of uniformity in the material record. We are confident that further work will validate this proposal, and help to explain the factors underlying this pattern.

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The Iberomaurusian Prelude to Farming in Morocco

Summary

The transition to the Neolithic followed a complex pattern in North Africa. Using Taforalt as a major case study, we examine the changes that occurred before farming. Our results suggest that a marked change in the use of the cave occurred around 15 000 cal BP, with the rapid accumulation of massive ashy midden layers known as the 'Grey Series'. Based on a large number of radiocarbon dates, we demonstrate that the beginning of cemetery activity occurred soon after this time. It is also clear that before the middens formed, the nature of occupation was different. Changes in diet; elaborate burials, sometimes of grouped individuals, containing red ochre; and other grave goods confirm the complex social behavior of these hunter-gatherer groups.

Keywords: hunter-gatherer; Iberomaurusian; broad-spectrum; burials; Neolithic

Der Übergang zum Neolithikum verlief nach einem komplexen Muster in Nordafrika. Mit Taforalt als Gegenstand einer großen Fallstudie untersuchen wir Veränderungen, die vor dem Landbau eintraten. Unsere Ergebnisse legen nahe, dass eine Veränderung der Höhlennutzung eintrat um 15 000 cal BP, mit einer raschen Akkumulation massiver aschiger Abfallschichten, den 'Grey Series'. Anhand großer Zahlen von Radiokarbondaten können wir demonstrieren, dass der Beginn von Gräberfeldaktivität bald nach dieser Zeit einsetzt. Auch ist klar, dass vor der Formierung des Abfalls die Natur der Besiedlung anders war. Veränderungen in der Ernährung, aufwändige Bestattungen mit rotem Ocker, teils in Gruppen, und andere Grabbeigaben bestätigen das komplexe Sozialverhalten dieser Jäger und Sammler.

Keywords: Jäger und Sammler; ibéromaurusisch; weites Spektrum; Bestattungen; neolithisch

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1 Introduction

This paper grew out of an invited presentation given to the workshop on Revolutions: 'The Neolithisation of the Mediterranean Basin: The Transition to Food-Producing Economies in North Africa, Southern Europe, and the Levant'. One of the themes discussed at the conference concerned the necessary pre-conditions for the emergence of food production and whether any precocious forms of domestication or other behaviors associated with the emergence of the Neolithic had much deeper roots in hunter-gatherer economies in the same geographical area.[1] For North Africa, and particularly the Maghreb (present-day Morocco, Algeria, Tunisia, and parts of western Libya), the Neolithic seems to have been a relatively late phenomenon in comparison to the eastern end of the Mediterranean. Linstädter et al. have argued that the Neolithic appeared simultaneously in coastal Morocco and southern Iberia ca. 7600–7500 cal BP.[2] This was partly evidenced by the introduction of domesticated cereals, legumes, pottery, and ovicaprids.[3] There was nevertheless some likely acculturation with indigenous hunter-gatherer groups and it has also been proposed that Epipalaeolithic communities in this region had already begun to show broad-spectrum subsistence patterns, economic intensification, and increasing sedentism.[4] In some cases, this was accompanied by probable food storage and the use of locally made ceramics,[5] which in turn might be seen as anticipating a foraging-to-farming transition and the processes of Neolithisation.

In this paper, we would like to develop this theme further by discussing whether some of the changes that prefigure the transition to farming in the Maghreb were not only present in the millennia leading up to the adoption of domesticates, but whether they were, in fact, already in evidence much further back in time in the Iberomaurusian (25 000–11 000 cal BP). One of the most interesting of these developments concerns the Broad Spectrum Revolution (BSR).[6] Much has been written about the BSR in the context of adaptations that occurred in the late Epipalaeolithic in the eastern Mediterranean before the onset of food production.[7] In this region, supporters of a sudden transition suggest that key changes took place in the Natufian (from 15 000 years cal BP) when pressure on the main ungulate resource (mountain gazelle) led to an enforced shift in exploitation patterns, resulting in more restricted culling patterns as well as the hunting of less cost-effective but resilient animals such as lagomorphs, birds, and other lower ranked resources.[8] Proponents of a more gradual transition would prefer to see these changes as beginning earlier in the Epipalaeolithic, but essentially involving the same process of an increased exploitation of smaller game taxa.[9] Developments in parallel would also seem to have included the intensification of plant exploitation with extensive use of wild plants long before domestication in the Neolithic.[10] Thus, the question arises, given broad similarities in Mediterranean ecologies,[11] can we expect any similar changes to have occurred in North Africa before the advent of food production and, if so, how would they have been manifested? Another point that emerges from the eastern Mediterranean studies is the apparently strong link that exists between intensification in subsistence and increasing sedentism. From analysis of Natufian sites, greater permanence of site occupation is seen as a consequence of both intensification and the diversification of resource exploitation.[12] Evidence for increased sedentism is, for example, cited in the occurrence of stone hut structures, large cemeteries, diverse ground stone assemblages, personal ornaments, and art items, amongst others.[13] Again, a question that invites consideration: should we expect similar manifestations in the pre-Neolithic archaeological record of the Maghreb?

1 Cf. Barker 2006.
2 Linstädter, Medved, et al. 2012.
3 Linstädter, Medved, et al. 2012; Linstädter, Wagner, et al. 2015; Morales et al. 2013.
4 Mulazzani, Belhouchet, et al. 2016.
5 Görsdorf and Eiwanger 1998.
6 Flannery 1969.
7 Stiner, Munro, and Surovell 2000; Bar-Oz and Dayan 2002; Stutz, Munro, and Bar-Oz 2009; Yeshrun, Bar-Oz, and Weinstein-Evron 2014.
8 Yeshrun, Bar-Oz, and Weinstein-Evron 2014.
9 Maher, Richter, and Stock 2012.
10 Asouti and Fuller 2012; Maher, Richter, and Stock 2012; Snir et al. 2015.
11 Blondel and Aronson 1999.
12 Bar-Oz 2004; Davis 2005; Munro 2004; Munro 2009; Stutz, Munro, and Bar-Oz 2009.
13 For references see Maher, Richter, and Stock 2012; Yeshrun, Bar-Oz, and Weinstein-Evron 2014.

To examine some of these ideas, we have been conducting long-term excavations at the cave site of Taforalt in eastern Morocco. In 2009 we began a major project entitled 'Cemeteries and Sedentism in the Epipalaeolithic of North Africa' funded by the Leverhulme Trust. The main aim of this multidisciplinary project was to investigate whether the first appearance of cemeteries in North Africa marked an important transitional phase during which hunter-gatherers began to develop more sedentary forms of existence, and whether this could be linked to any changes in the intensification of diet and other subsistence behavior. Taforalt was identified as an important site for examining these questions because it contains one of the longest unbroken records of Iberomaurusian occupation in the Maghreb and includes human burials that date from ca. 15 000 cal BP.[14] The cave is also noteworthy for the occurrence of massive midden-like accumulations, which are not uncommon in other caves, rock shelters, or open-air sites across North Africa. They are often referred to as *escargotières* (because of the abundance of edible snails) or alternatively as *rammadiya*[15] from the Arabic *ramad*, meaning ash, referring to the noticeably high component of burnt ashy deposits. It is unknown whether such deposits are characteristic of a particular period of the Iberomaurusian, so a further line of enquiry of our project was to date the inception of the Taforalt *escargotière* and to determine whether the grey ashy accumulations corresponded with any wider behavioral changes within the Iberomaurusian. The fine-grained quality of the depositional sequence at Taforalt also provided opportunities for dating and environmental studies that are so far unparalleled at any other sites of this age in the Maghreb.

We have recently completed a monograph on the major outcomes of this project. What is offered below, therefore, are some interim observations and questions that are considered in greater detail and are more fully expanded in the final publication.[16]

2 Cultural and chronological background

The Iberomaurusian is a technology characterized by bladelets and microlithic backed tools and represents a cultural stage that first appears in North Africa around 25 000 cal BP (Fig. 1). Despite some evidence for continuity across the Late Pleistocene to Holocene boundary, relatively little is known about the later part of this timespan (11 000–8000 cal BP), which is referred to by some authors as the Epipalaeolithic.[17] The term Iberomaurusian was first coined at the beginning of the 20th century[18] and has remained in use ever since. The term itself derives from the fusion of two elements 'Ibero' (meaning Spanish) and 'Maurusian' (referring to Mauretania tingitana, the name given by the Romans to northern Morocco and western Algeria). Pallary introduced the definition in order to draw attention to similarities between lithic industries in Iberia and Morocco. The implied link with Iberia has since been largely dismissed by many archaeologists, though it remains an open question whether there might have been contacts across the Sicilian Channel involving the Italian Epigravettian and the Iberomaurusian.[19] Even though the chronological evidence for this period in southern Spain and Italy (Sicily) continues to be sparse, the fact remains that the microlithic components in the Iberomaurusian show some similarities with those of the latest Palaeolithic technologies in Italy[20] and southern Spain,[21] and new fieldwork in both regions will undoubtedly shed further light on this question.

The oldest secure occurrence of the Iberomaurusian so far is from the rock shelter of Tamar Hat in Algeria.[22] The site today overlooks the Mediterranean Sea, and this may also have reflected its position in the past to judge from the presence of marine mollusks *(Monodonta turbinata)* in the Iberomaurusian deposits. A recent program of AMS radiocarbon dating has been undertaken on levels excavated by Saxon. This produced eight new dates on modified and unmodified animal bone from the archaeological layers. Near the base of the sequence

14 Humphrey, De Groote, et al. 2014.
15 Balout 1955; Lubell 2001; Lubell, Feathers, and Schwenninger 2009.
16 Barton, Collcutt, et al. 2019.
17 E.g. Linstädter 2008.
18 Pallary 1909.
19 Ferembach 1985.
20 Camps 1974; Roche 2001.
21 Barton pers. obs.; Otte 1997; Straus 2001.
22 Saxon et al. 1974.

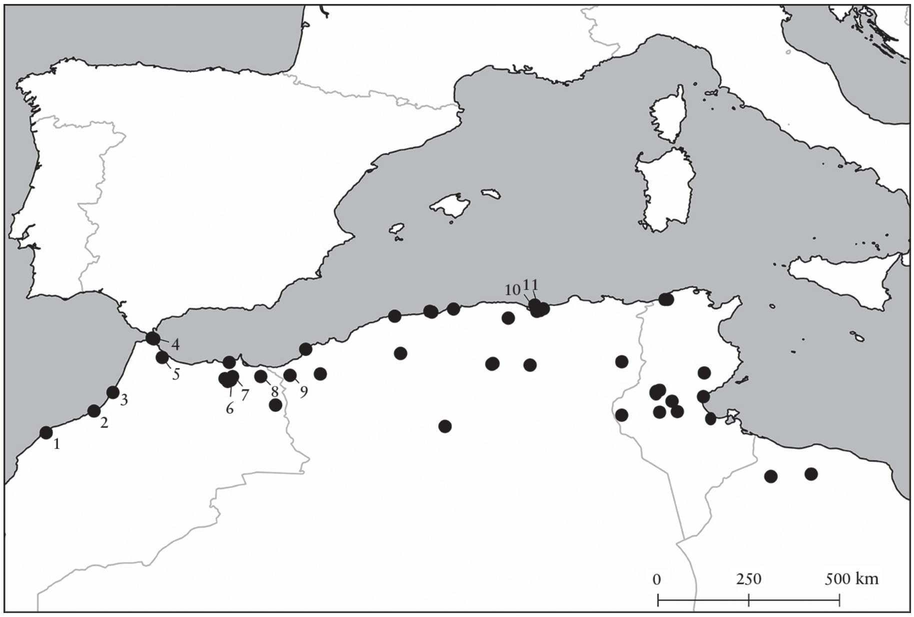

Fig. 1 Distribution of Iberomaurusian sites in the Maghreb. 1. El Khenzira, 2. Contrebandiers, 3. Dar es Soltane I, 4. Ghar Cahal, 5. Kehf el Hammar, 6. Ifri el-Baroud, 7. Ifri n'Ammar, 8. Taforalt, 9. La Mouillah, 10. Tamar Hat, and 11. Afalou Bou Rhummel.

this provided ages of 25 845–25 270 cal BP while some of the youngest dates came from near the top of sequence at around 20 122–19 632 cal BP.[23] The dating indicates a timespan of at least 5000 years for the Iberomaurusian at Tamar Hat and overlaps substantially with other dated occurrences of this culture at the nearby site of Afalou Bou Rhummel and elsewhere in the Maghreb. For example, at Taforalt in eastern Morocco, the AMS dates range in age from the lowermost occupation horizons from 22 292–21 825 cal BP to the youngest at 12 698–12 548 cal BP.[24] The oldest dates from Tamar Hat are thus around 1400 calibrated years earlier than those for Taforalt, although Taforalt itself covers a lengthier timespan of up to 10 000 years. There is still much discussion about the most recent end of the chronology for the Iberomaurusian. It appears to have persisted into the early Holocene as indicated by radiocarbon dates of (Bln-4755) 9677 ± 60 BP (11 223–10 785 cal BP) at Ifri el-Baroud also in eastern Morocco[25] and one from an aceramic level containing backed bladelets with an age of (OxA-11321) 9470 ± 55 BP (11 071–10 573 cal BP) at Ghar Cahal in the Tigitane Peninsula in northern Morocco.[26]

3 Taforalt Cave

A key site for the study of the Iberomaurusian is Grotte des Pigeons at Taforalt (eastern Morocco), which offers one of the most detailed archaeological records for this period in the whole of the Maghreb and, as such, is an excellent case study for examining patterns of cultural change. Taforalt Cave, (34°48' 50" N, 2°24' 14" W) is situated about 500 m east of the village of Tafoughalt in the Eastern Rif near the border with Algeria (Fig. 2). It is a karstic cave formed in steeply folded Permo-Triassic dolomitic limestone.[27] The site lies at an altitude of around 720 m above mean sea level, in an upland area known as the Beni Snassen Mountains. The cave is now situated near an *aïn* or natural spring (a structurally guided feature that may well have functioned more or less in the same place during the cave's occupation) and overlooks a narrow gorge with a rich and varied vegetation that descends northward towards the coastal plain. Its position approximately 40 km inland from the Mediterranean coast has probably not altered much since the last glacial maximum (LGM); even at lower sea levels very little additional coastal shelf would have been exposed.

23 Hogue and Barton 2016.
24 Barton, Bouzouggar, Hogue, et al. 2013, 273.
25 Moser 2003, 100.
26 Bouzouggar, Barton, Blockley, et al. 2008.
27 Bouzouggar, Barton, Vanhaeren, et al. 2007.

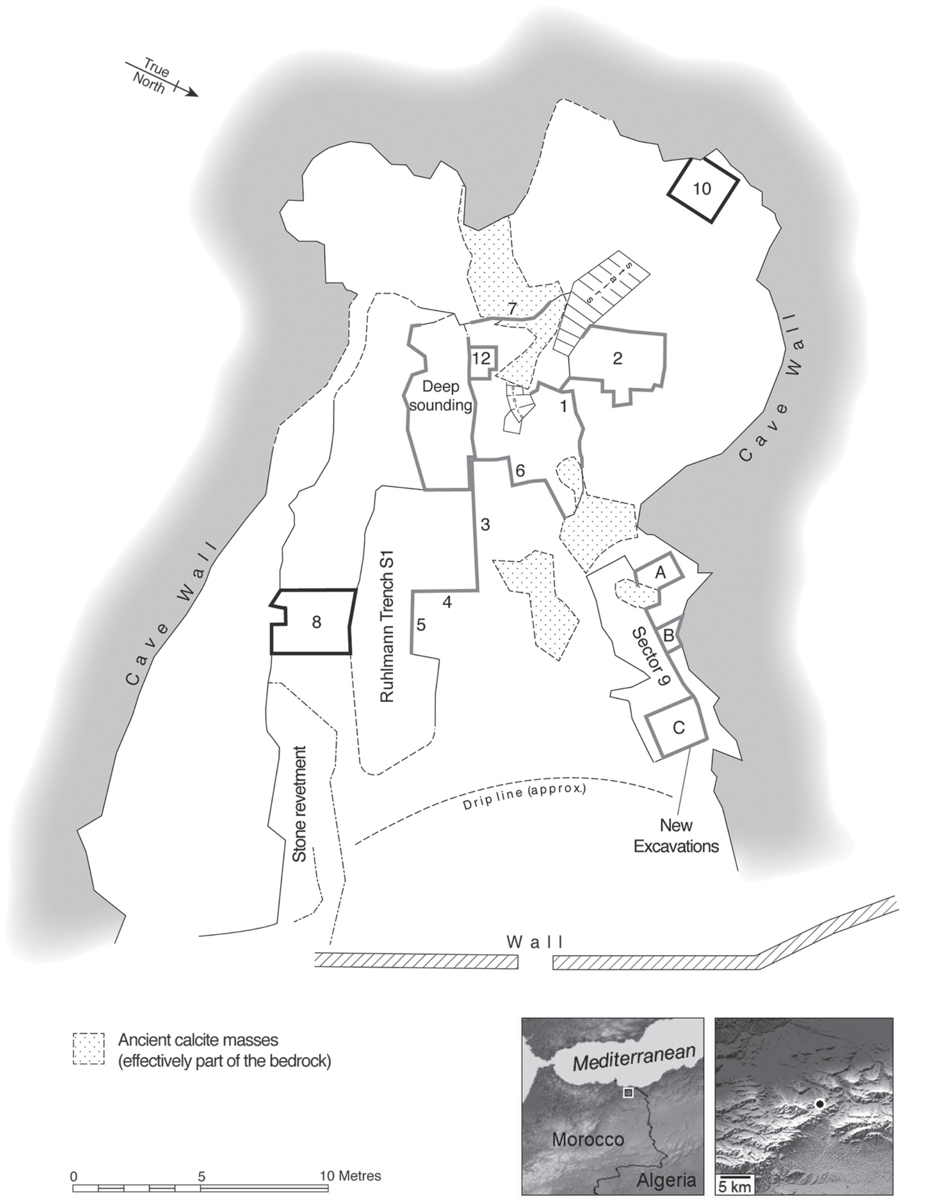

Fig. 2 Plan of Taforalt showing earlier excavations and main sectors including Sector 8 and Sector 10 (burial area) of the recent field campaigns.

The cave was discovered in 1907, but surprisingly was not investigated further for almost 40 years. In 1939, the cave was used as a gun emplacement by the French military and this led to the destruction of deposits at the top of the sequence. After the war in 1944, the site came to the attention of Armand Ruhlmann, then *Directeur des Antiquités Préhistoriques Marocaines*, who conducted excavations there until 1947.[28] This first period of archaeological work, which was never fully reported, was followed by more extensive excavations by Abbé Jean Roche over two periods, between 1951 and 1955 and from 1969–1972. In the first period, evidence of a major 'necropolis' was uncovered towards the back of the cave.[29] During the second period between 1969 and 1972,[30] work also focused on central areas of the cave. In total, the investigations reported a sequence of 17 principal Iberomaurusian layers (*niveaux* I–XVII), underlain by 11 'Palaeolithic' (Aterian) layers (*niveaux* XVIII–

28 Ruhlmann 1945.
29 Roche 1952; Roche 1953; Roche and Souville 1956.
30 Delibrias and Roche 1976; Roche 1973–1975.

XXIX).[31] The nature of the deposits was further elaborated during later excavations in the 1980s[32] before the new phase of excavations was initiated by ourselves in 2003.[33] Even though we would now consider much of the original work on the lithostratigraphy and archaeology to be erroneous or misinterpreted,[34] the earlier excavations served to highlight the depth and complexity of the cultural sequence.

As a result of the work by Roche and others, the cave became principally known for its large assemblage of Iberomaurusian burials. The first comprehensive description of the human remains was published by Denise Ferembach, in which she calculated a cumulative total of 183–186 individuals, including 80 adults, six adolescents, 53–55 children, and 44–45 infants.[35] However, subsequent studies have suggested that the estimated minimum number of adults and adolescents for the entire osteological assemblage was nearer 35–40 individuals.[36] This figure does not include skeletons and isolated bones from the new excavations and will be revised in the light of current work.[37]

Aside from the main area of burials at the back of the cave, other parts of the cave seem to have been used mainly for habitation. In these areas the deposits are overwhelmingly anthropogenic in nature, consisting of debris that can be interpreted as resulting from repeated human occupation; human burials are also notably absent. A zone in which the occupational sequence is particularly well preserved is on the south side of the cave in Sector 8 (Figs. 2, 3, and 4). Fifty-four AMS radiocarbon dates from this sequence were subject to Bayesian modelling, providing a secure and consistent chronology.[38] In Sector 8, the sediments can be grouped according to two distinctive stratigraphic units consisting of a Grey Series (GS) of ashy deposits *(escargotière)* and an underlying Yellow Series (YS) made up of clayey sands. The Grey Series comprises an approximately 4.0 m thickness of dominantly anthropogenic deposits (ash, charcoal, bone and snail shell debris, burnt limestone, etc.). The strong anthropogenic input and the lenticular nature of the deposits has led us to describe them as midden-like.[39] According to the radiocarbon dating, they seem to have accumulated extremely rapidly at an estimated 1.7 m/kyr (meters per thousand years). In contrast, the underlying YS consists of an approximately 2.0 m thickness of finely laminated silts, sands, and clays, with an archaeological presence in many of its layers. These seem to have built up 7.5 times more slowly than the GS[40] and include occupation layers separated by sterile horizons, suggesting intermittent use of the cave by humans.

In Sector 8, the division between the YS and GS is not marked by a sharp erosive boundary, but instead reflects increased input of organic material and a change to more rapid sedimentation. As stated above, the Iberomaurusian deposits began to accumulate 22 292–21 825 cal BP. The major change in sedimentation seems to have occurred around 15 190–14 830 cal BP (95.4% probability), according to modelled Bayesian ages for the stratigraphic sequence.[41] The top of the cave sequence was truncated by military activity with the result that there are no deposits so far later than 12 709–12 554 cal BP (95.4% probability) and includes no in situ finds of the Holocene age.

4 Nature of the cultural differences between the Grey Series (GS) and Yellow Series (YS)

Excavations in two areas of Taforalt (Sectors 8 and 10) have allowed observations to be made on the nature and development of the Iberomaurusian and in relation to the stratified sequence of the YS and GS sediments. It should be emphasized that these excavations have been of a fairly confined nature due to the sheer volume of archaeological finds in both sectors. Most identifiable finds > 5 mm were three-dimensionally recorded, which included human and faunal remains, lithic artefacts, ostrich eggshell, bone points, shell ornaments, and red ochre. In addition, the sediments were systematically sieved, generally down

31 Roche 1973–1975, 149.
32 Courty, Goldberg, and Macphail 1989; Raynal 1980.
33 Barton, Bouzouggar, Bronk Ramsey, et al. 2007; Barton, Bouzouggar, Humphrey, et al. 2008; Bouzouggar, Barton, Collcutt, et al. 2006; Bouzouggar, Barton, Vanhaeren, et al. 2007; Bouzouggar, Barton, Blockley, et al. 2008; V. K. Taylor, Barton, et al. 2011.
34 See Barton, Bouzouggar, Hogue, et al. 2013.
35 Ferembach 1962.
36 Mariotti et al. 2009.
37 Humphrey, Freyne, et al. 2019.
38 Barton, Bouzouggar, Hogue, et al. 2013.
39 Barton, Bouzouggar, Hogue, et al. 2013.
40 Barton, Bouzouggar, Hogue, et al. 2013, 276, fig. 8.
41 Barton, Bouzouggar, Hogue, et al. 2013.

Fig. 3 Taforalt: Main section on the south side of the cave (Sector 8) showing the Grey Series overlying the Yellow Series sediments. Scale is 2 m long.

Fig. 4 Taforalt: close-up of excavation and sampling columns at the top of the Grey Series in Sector 8. Lenses of ashy deposits and burnt limestone rubble are visible in the section. The white-ish cement layer that lies atop the Grey Series indicates where the cave floor was artificially lowered by the French military in 1939. Scale is 1 m long.

to 2 mm, and samples were periodically taken for flotation and wet sieving. In terms of the areas excavated, Sector 8 consists of a column 2.0 m × 0.5 m that gradually widens to 2.0 m × 1.0 m in depth (Fig. 4).

The column that is situated midway inside the cave extends from the top of the GS and into the underlying YS, covering a total depth of > 4.0 m. It comprises most of the time depth of the Iberomaurusian in the cave.[42] Alongside the column were two further narrower columns from which additional samples were taken for palaeoenvironmental and dating studies. In contrast, Sector 10 lies near the back of the cave (Fig. 1) in an alcove where the cave roof is quite low, in an area left unexcavated by Roche. Here, the bulk of the newly excavated deposits belong to the GS and, according to sedimentary and dating evidence, are broadly the equivalent of the lower GS in Sector 8, although it is possible that the GS began to accumulate prior to the earliest of the currently known burials.[43] Up until 2013, an area of around 4.0 m^2 of the Sector 10 GS deposits had been excavated, yielding many examples of near complete and partial human skeletal remains.[44] In addition to three-dimensional recording of all the substantial finds in this area, drawing and photographs were made at every stage of excavation.[45]

Before considering the contrasts between the Iberomaurusian finds and behavioral activities in the GS and YS, it needs to be re-iterated that there are no major signs of cultural discontinuity or chronological gaps in occupation between these two sedimentary units. It is clear, for example, from the lithic and faunal assemblages that occupation continued across the sediment boundary. The lithic artefacts reveal a continuous presence of bladelet core reduction, the few differences include a slight reduction in the use of the microburin technique and it is noticeable that large La Mouillah points at the top of the YS are replaced by a much broader range of microlithic tool categories including curve-backed bladelets and more elongated pointed straight backed forms.[46] The large fauna in both the YS and GS is dominated by Barbary sheep *(Ammotragus lervia)*.

There do, however, appear to be some marked distinctions between human activities identified in the YS and GS summarized in Table 1.

Human remains have been found in Sector 10, with none so far in Sector 8. Up until 2013, thirteen partially articulated skeletons had been excavated in Sector 10.[47] All of them were recovered from the lower GS deposits, and direct dates on seven of the human bones provided results that range in age from 15 077 to

42 Barton, Bouzouggar, Hogue, et al. 2013.
43 Collcutt pers. comm.
44 Humphrey, De Groote, et al. 2014.
45 Humphrey, Bello, et al. 2012.
46 Barton, Bouzouggar, Hogue, et al. 2013.
47 Humphrey, De Groote, et al. 2014.

Yellow Series (Pre-Midden Levels)	Grey Series (Midden levels)
No burials?	Primary burials in a spatially demarcated area
Minor evidence for charred plants	Rich charred macro botanical remains
Few edible molluscs	Major accumulation of edible molluscs
Rare use of red ochre	Use of red ochre
Rare grinding stones	Presence of likely grinding stones
Discrete hearths	Discrete hearths and combustion zones
Few burnt rocks	Mass of burnt rock

Tab. 1 Differences between the YS and GS levels.

13 892 cal BP.[48] The remains found in the recent excavations consisted of adults, children, and infants and it appears very likely taking the evidence of the Roche excavations into consideration, that the burial deposits were contiguous and comprised numerous intercutting burials that were closely spaced and situated near the back of the cave.[49] It also seems likely judging by the presence of disarticulated bone that earlier burials must have been disturbed by later inhumations, suggesting intensive re-use of this area of the cave for funerary purposes. The location of a specially set-aside area for burial is consistent with its description as a cemetery. So far, none of the skeletons recovered by Roche have been directly dated, although the location of these burials closer to the cave opening suggests that some of them may be younger in age than the newly excavated burials.

Apart from the presence of burials in Sector 10, one of the signature features of the GS deposits is the abundance of charred plant remains. These occur both in the Sector 10 burial area and in contemporaneous deposits of Sector 8. Twenty-two plant taxa have been identified amongst the charred macrobotanical remains in Sector 8 and provide direct evidence of local plant foods that were consumed.[50] In particular, they show a prevalence of edible plants such as acorns from the Holm oak *(Quercus ilex L.)* and pine nuts belonging to the Maritime pine *(Pinus pinaster Aiton)*. Other edible plants included: juniper *(Juniperus phoenicea L.)*, terebinth pistachio *(Pistacia terebinthus L.)*, wild pulses *(Lens cf. nigricans, Lathryus sp., Vicia sp.)*, and wild oats *(Avena sp.)*. All of these plants are rich in carbohydrates and fats and indicate a deliberate selection of plant foods containing a broad range of nutrients. The majority would have ripened in the autumn and were probably collected at that time, although others could have been harvested in the late spring and summer. Despite superficially being an indicator of seasonality, both the nuts and seeds are storable foods that retain their high nutritional value if parched or roasted, and it is, therefore, possible that they could have been stored in baskets and used as staple foods throughout the year. In contrast, and despite similar treatment and flotation of samples from the occupation horizons in the YS, the density of macrobotanical remains and wood charcoal was manifestly lower than in the GS. For example, while oak and pine remains were regularly present throughout the GS, only one fragment of oak and none of pine was identified in the YS samples.[51]

In parallel with the study of plant macrofossils, an investigation was undertaken in order to produce a high-resolution mollusk sequence to identify any changes in molluscan fauna between the YS and GS and within the Grey Series itself.[52] A column 0.2 m square comprised of a sequence of 130 samples, (106 from the GS and 24 from the YS) was analyzed from Sector 8 and produced 5208 shell apices in the GS and 419 in the YS. If we assume that the exposed section through the GS is representative of that deposit as a whole and the column is also representative, then the GS could have contained something

48 Humphrey, De Groote, et al. 2014.
49 Humphrey, De Groote, et al. 2014.
50 Humphrey, De Groote, et al. 2014.
51 Humphrey, De Groote, et al. 2014.
52 V. K. Taylor, Barton, et al. 2011; V. K. Taylor and Bell 2017.

like 60 million snails. The GS accumulated over some 2100 years, suggesting deposition of an average of perhaps 28 000 shells per year. However, the deposition rate varied. Results of this work indicate that there were very high apical counts of mollusks in the upper GS deposits (~90 per liter of sediment), after about 14 300 cal BP, with a considerable diminution towards the base of the GS (~19 per liter of sediment) decreasing slightly to 18 apices per liter in the YS. The similarities in numbers seems to imply continuity across the sedimentary transition but this is not reflected in the species present, which reveal a very marked change in the nature of the molluscan assemblages. The results show that the GS contains a low species diversity, with the assemblages being dominated by only five species: the most abundant was *Dupotetia dupotetiana*[53] (60%), other species in decreasing order of importance were *Otala punctate,*[54] *Dupotetia type, Cernuella globuloidea,*[55] *Alabastrina solute;*[56] and *Helix aspersa* var *maxima.*[57] The majority of the mollusks from the GS were of species that are likely to have been eaten.[58] The restricted diversity is interesting for a number of reasons: first, although fragmented, almost all the shells appeared relatively fully grown, juvenile stages being very few; second, the species are not known to concentrate naturally together in anything like such quantities; and third, all are edible and many of the shells were burnt, suggesting that cooking took place prior to consumption.[59] In comparison to the GS, the top meter of the YS contains a much broader range of mollusks that would fit the criteria for an assemblage that was accumulated largely by natural processes. Some 83% of the YS mollusks were tiny shells of species not considered edible. Larger edible snails are not entirely absent in the YS, with a few large shells of *Otala punctata*, *Helix aspersa,* and *Alabastrina soluta* suggesting they were sometimes consumed. However, this could not have been on the same scale as in the GS, where mollusks seem to have been specifically selected for food and brought to the cave in impressive numbers.

The use of red pigment is recorded especially in the GS sediments in Sector 10. Human bone with deliberate ochre staining was found in 13 of the 28 burials from Roche's excavations.[60] The location of staining, sometimes in cut-marks (indicating defleshing) or on the insides of crania and teeth sockets, suggests that the bodies or individual bones were treated after decomposition. In our excavations, we have recovered pieces of red ochre, some revealing abrasion and red pigment traces are present on stones (palettes or mortars) that were either deliberately placed within individual burials or directly above them.[61] Red pigment has also been recorded in the grey deposits of Sector 8, but this generally consists of isolated fragments or traces on artefacts and it is not as common as in the burial area. So far very few, if any, pieces of red ochre have been found in the YS.

Plausible grindstones, some with ochre traces, have already been mentioned as coming from Sector 10.[62] Fragments of similar objects also occur, but only rarely, in Sector 8 GS,[63] while none have so far been found in the YS (Sector 8). Another notable difference concerns the degree of burning observed in the YS and GS. Except for the occurrence of charcoal-rich layers in some of the early Iberomaurusian levels[64] and several shallow scooped-out hearth-like features (discrete hollows with charcoal and burnt bone) in the younger YS, signs of persistent burning and charcoals are generally rare. This can be contrasted with the GS: the sediments are dominantly anthropogenic; they are made up of enormous quantities of ash, charcoal, thermally altered bone and lithic artefacts, snail shell debris, burnt ostrich eggshell, fire cracked limestone, etc. Various hearth features and charcoal lenses can be detected in Sector 8, but the lenticular nature of the bedding in the GS indicates a constant shifting of occupation activities across the site.[65] One of the most intriguing and distinctive features of the GS in Sector 8 are large accumulations of limestone fragments that have been thermally shattered. Even allowing for increased rock fall due to the thermal shock of the fires, it is difficult to envisage how there would

53 Terver 1839.
54 Müller 1774.
55 Terver 1839.
56 Michaud 1833.
57 J. W. Taylor 1913.
58 V. K. Taylor, Barton, et al. 2011, 12.
59 V. K. Taylor, Barton, et al. 2011.
60 Mariotti et al. 2009, 347.
61 Humphrey, De Groote, et al. 2014; Barton, Collcutt, et al. 2019.
62 Barton, Bouzouggar, Hogue, et al. 2013.
63 Some were also recorded in Roche 1963.
64 Barton, Bouzouggar, Hogue, et al. 2013.
65 Barton, Bouzouggar, Hogue, et al. 2013.

be enough natural stones (scree) within the cave itself. Thus, it is quite likely that they were deliberately introduced from a source outside the cave[66] and brought in as an aid for cooking. For example, meat or ground acorns could have been directly placed on the heated stones or the hot stones (potboilers) dropped in water for boiling foods.[67]

5 Discussion points and implications

Addressing, in turn, the main themes outlined at the beginning of this paper: first, are the changes in sedimentary deposition at Taforalt unique or are they representative of a wider, regional pattern reflected at other sites of similar age in the Maghreb? This is not a particularly easy question to answer at present given that Taforalt is the only detailed excavated sequence for this period and a fine-grained chronological record is so far missing for other Iberomaurusian sites in the region. However, as alluded to above, one of the prominent and recurrent features observed at many sites where Iberomaurusian finds have been recorded is the presence of anthropogenic deposits known as *escargotières* or *rammadiya*. These have been widely reported in the literature from Morocco to Tunisia in what appear to be similar Iberomaurusian contexts. Apart from Taforalt, analogous grey ashy deposits have been described in the Iberomaurusian at Abri Alain,[68] El Khenzira,[69] Dar es Soltane 1,[70] Contrebandiers,[71] Ifri el-Baroud,[72] Kehf el Hammar,[73] and Ifri N'Ammar[74] amongst other cave and rock shelter sites. In many of these cases, it has also been noted that the grey sediments rest on reddish yellow deposits, indicating a clear transition from pre-midden to midden layers. *Escargotières* are also found in Holocene contexts in the Capsian of Tunisia[75] and even in the early Neolithic in Morocco.[76] Together with artefacts and other cultural debris, this might reflect a degree of behavioral continuity at a local and even at a regional level. At Taforalt, the dating evidence indicates that the GS midden deposits began to accumulate at ca. 15 000 cal BP.[77] A similar age has been reported from the nearby location of Ifri el-Baroud.[78] There is no reason to believe that the appearance of middens would be absolutely synchronous across the whole region, but it does suggest that similar processes occurred at Iberomaurusian sites across a relatively wide area of North Africa.

From the study of Taforalt, it can be surmised that the grey ashy midden horizons mark a significant shift in the nature and intensity of site use. Up until that point, the cave had been marked by intermittent episodes of occupation in the YS, punctuated by phases of human absence. This does not mean that some of the same activities might not have occurred in the lower sequence, but the build-up of the grey ashy series indicates densely packed, high volume, and possibly more or less continuous site use. In considering various factors that might have led to these changes, we have examined the possibility that the middens coincide with largescale changes in subsistence patterns. In discussing these, we focus on the related themes of broad-spectrum subsistence patterns, economic intensification, and increasing sedentism.

Before considering these themes in more detail, it is important to stress that we recognize no compelling evidence for the precocious domestication of either plants or animals in the Iberomaurusian. There is nothing, for example, to suggest deliberate strategies to enhance or increase locally the abundance of molluscan resources.[79] Instead, it appears more likely that edible snails were intensively harvested, but this did not involve deliberate animal husbandry in any strict sense.[80] Another food source that might have offered opportunities for management or domestication was the Barbary sheep.[81] However, despite the ubiquitous nature of this animal at Taforalt, present in virtually all Iberomaurusian and earlier occupation levels, there is no indication in the GS of a change in the selection pattern according to age or sex of the animals, and there are no other signs in the

66 Collcutt 2019.
67 Humphrey, De Groote, et al. 2014.
68 Campmas, Amel, and Souhila 2016.
69 Ruhlmann 1936.
70 Ruhlmann 1951.
71 Roche 1963.
72 Görsdorf and Eiwanger 1998.
73 Barton, Bouzouggar, Collcutt, et al. 2005.
74 Nami and Moser 2010.
75 Lubell 2001; Mulazzani, Le Bourdonnec, et al. 2010.
76 Chennaoui et al. 2005.
77 Barton, Bouzouggar, Hogue, et al. 2013.
78 Görsdorf and Eiwanger 1998.
79 V. K. Taylor, Barton, et al. 2011.
80 Cf. Lubell 2004.
81 Saxon et al. 1974.

cave such as layers of dung or linear postholes to imply deliberate corralling or penning of animals, as suggested elsewhere in the Sahara.[82]

Looking at alternatives to domestication, a core assumption of broad-spectrum and dietary breadth models[83] is that resource diversification generally only took place in response to a diminution in the availability of higher-ranking foods. Expressed another way, according to optimal foraging theory,[84] if encounter rates with higher-ranking prey are reduced, the prediction would be for a generally greater concentration on foraging for lower-ranking resources. Although there are some exceptions to this rule,[85] one of the questions at Taforalt is whether there are signs of similar changes in the GS that might have led to an increased reliance on certain lower-ranked foods. At face value, a potential candidate for this would be evidence for the growing importance of plant foods in the diet represented by the high incidence and diversity of charred macrobotanical plant remains in the GS. It can also be shown from the prevalence of caries in the teeth of humans in burials that there was a significant reliance on highly cariogenic wild plant foods such as sweet acorns and pine nuts.[86] The presence of grinding stones in the same deposits suggest usage in plant processing although, equally, the nuts and acorns may have been prepared in some other way, e.g. by boiling, roasting or simply eaten raw. In the same levels, we also observe significant increases in the exploitation of edible land snails. Not only are these found in vast quantities that cannot be explained by natural taphonomic processes, but there is clear evidence of burning and an association with hearths. We believe that this is likely the result of cooking preparation, rather than only due to disposal. Whether this gradual diversification in resources occurred in the context of shortages in other foods is of course debatable. From the point of view of broader spectrum subsistence patterns, it is certainly possible that this could have resulted from the increased availability of lower-ranked resources, rather than in response to diminution or scarcity of other higher-ranked foods. It can be hypothesized that if there was an improvement in new harvesting or processing techniques that might have increased food yields considerably and made them more attractive as dietary sources. For example, we would argue that basketry technology was used at the site based on the presence of charred aerial roots of esparto grass *(Stipa tenacissima L.)*. This shows that uprooted plants were brought to the site in large numbers and the rhizomes discarded, which often happens after the leaves are used during basket making.[87] Baskets produced from esparto grass could have been important for the collection and storage of acorns and pine nuts. It can also be added that such receptacles may have been useful for harvesting and perhaps short-term storage of snails. Today, edible snails can be quickly and efficiently collected by hand,[88] they are also known to aestivate on bushes and shrubs, where at times they can be easily gathered. A survey of modern molluscan occurrence around the cave and down the Moulouya Valley revealed one location at a lower elevation and 25 km NW from Taforalt, where large numbers of *Dupotetia dupotetina* were aestivating on scrubby vegetation. With up to 100 on one bush, one could easily have gathered 2000 or more in a short time. *Alabastrina soluta* was also frequent in hollows in the limestone cliff close to the cave, although this species was not among the most frequent in the Iberomaurusian assemblage.

One of the potential problems with the traditional models of broad-spectrum subsistence and intensification is that there ought to be a predictable fall-off in the quantities of high-ranking hunted prey. If Taforalt followed the expectations of optimal foraging theory, we might predict a diminution in the numbers of Barbary sheep *(Ammotragus lervia)* at the site, or at least expect to see a change in the mortality profiles of these ungulates and perhaps increased evidence for bone fragmentation linked to extraction of marrow grease and the rendering down of tallow. While the study of the fauna is still underway and not all of the information is yet published,[89] it appears that these large ungulates are prevalent both in the faunal assemblages from the YS and GS and there is no perceptible increase in abundance of 'low-ranking' smaller game such as tortoises, birds, lizards, fish, etc. However, Taforalt might not be unique in this respect;

82 Di Lernia 2001.
83 Davis 2005; Munro 2004; Munro 2009; Stiner, Munro, and Surovell 2000; Stutz, Munro, and Bar-Oz 2009.
84 E. A. Smith 1983; Winterhalder 1981.
85 See Zeder 2015.
86 Humphrey, De Groote, et al. 2014.
87 Humphrey, De Groote, et al. 2014.
88 V. K. Taylor, Barton, et al. 2011; V. K. Taylor and Bell 2017.
89 Turner 2019.

similar patterns have been observed in sites in the eastern Mediterranean,[90] where it is suggested that the BSR sometimes took place even in the absence of evidence for a depression in higher-ranking resources. In these cases, simple growth in the abundance of low ranking-resources have been explained either by increased population pressure or environmental and climatic deterioration.[91]

Another discussion point concerns the arguments linking broad-spectrum subsistence with increased sedentary behavior (also sometimes characterized as a reduction in residential mobility). According to optimal foraging theory, one prediction is that resource diversification is a likely precursor of sedentism and can lead to year-round residence at a single location.[92] For Taforalt, study of this topic is still ongoing, so only some interim observations will be made here. To begin with, one of the leading indicators of sedentary behavior is likely to be seasonality evidence. At Taforalt, analysis of the faunal remains is still in progress and we are awaiting information on the study of seasonal growth patterns on the Barbary sheep teeth to determine the season that the animals were hunted.[93] However, based on ripening patterns of the edible plant foods at Taforalt, it would appear that people must have been present at the site at least from the late spring to the autumn. This does not of course preclude the possibility that they moved away during this period or were present at other times of the year, especially if certain foods such as the nuts and seeds were storable. However, year-round occupation would be difficult to prove on presently available subsistence data. Other information on this is expected to be forthcoming from contrasts in lithic raw material selection and tool use in the GS and YS.[94] Circumstantial evidence for greater sedentary behavior in the GS also arises from the cemetery itself. Here it can be shown that the dead were regularly brought to the cave for burial. The earliest burials were primary interments of complete corpses, including those of infants, indicating that death probably occurred nearby and the bodies were buried before they had time to decompose.[95] None of this excludes the possibility of some degree of seasonal mobility, but it does imply that distinctive burial rites existed and that for cultural reasons it was important to be interred inside the cave. Another interesting point concerns the practice of dental evulsion (*ante-mortem* removal of the incisors). This is a common feature in the Taforalt humans and is present in other Iberomaurusian burials in the Maghreb.[96] In combination, such details may reflect a growing sense of identification within the community and in relation to the cave at this time. The existence of a cemetery in itself may be linked to ideas of territorial ownership and land use.[97] At present, however, we do not know how this might apply in the case of Taforalt. We can only speculate that although the size of social territory could have been extensive, it is conceivable that the core of the living population remained relatively close to the cave throughout most of the year.

So far in this paper, we have argued that during the Iberomaurusian there was a clear shift in food gathering behavior that led to the adoption of broader-spectrum subsistence patterns, accompanied by economic intensification and dietary change, and a shift towards greater sedentism. We have suggested that the period of accelerated change most probably occurred around 15 000 cal BP and that this was reflected in the sedimentary transition from YS deposits to the midden-like *escargotière* of the GS. Underlying these behavioral changes of course is the bigger question of what factors might have facilitated or forced such novel developments on hunter-gatherer societies that had previously occupied the region for up to 10 000 years. In examining this question, an important line in our research has been the investigation of palaeoclimatic change. The period covered by the Iberomaurusian occupation of the Maghreb (ca. 25 000 to 11 000 cal BP), is one of dramatic climate change, characterized by sharp oscillations in temperature and rainfall.[98] A fundamental question to be considered, therefore, is how humans adapted and reacted to such variability in climate, in some cases within

90 Zeder 2012.
91 Zeder 2012.
92 Zeder 2012.
93 Wall-Sheffler 2019.
94 Hogue 2019.
95 Humphrey, Bello, et al. 2012; Humphrey, De Groote, et al. 2014.
96 De Groote and Humphrey 2016; Humphrey and Bocaege 2008.
97 Pardoe 1988; Rowley-Conwy 2001; Saxe 1970.
98 COHMAP members 1988; Penaud et al. 2010; Wengler and Vernet 1992.

the timescale of a single human generation. Bayesian modelling of the radiocarbon record at Taforalt[99] enables the cave's sedimentary and cultural stratigraphy to be compared with the Greenland Ice Core (NGRIP) $\delta^{18}O$ stratigraphy.[100] Although not a direct parallel, the Greenland record can serve as a useful proxy for climatic conditions within the North Atlantic region, which includes Morocco. The dating model demonstrates that the GS sediments began to accumulate in a time equivalent to Greenland Interstadial 1, a period of rapid climatic amelioration across the whole region.[101] Thus, at the very least, these data would confirm that after 15 000 cal BP there was a stabilization of climate and a return to more humid conditions, and that these may have been responsible for a local resurgence in plants and other foods that were exploited in the Iberomaurusian GS. A key aim of our project has been to reconstruct the climate and environment of the area surrounding Taforalt. More detailed information based on an examination of various proxies for climate and environmental change is presented in the final monograph.

Lastly, we would make the point that the Iberomaurusian constitutes an interesting but by no means unique example of a forager society that underwent economic intensification, but without any evidence for incipient domestication. We would also not wish to imply that this represents an evolutionary stage or inevitable step on the 'path towards agriculture'. Instead, we believe hunter-gatherers were highly flexible and developed multiple ways of responding to changing conditions. As a result, various outcomes were possible that only rarely led to Neolithisation as an end point. Such variable responses can equally be shown in low-level food-producing economies that combined the use of domestication with loosely managed or entirely wild resources that never developed into agricultural economies.[102] Similarly, it is not unknown for societies to have resumed broad-spectrum foraging strategies after many thousands of years of pursuing an agricultural way of life.[103]

6 Conclusion

In this paper we have proposed that there was a major change in subsistence behavior in the Iberomaurusian that can be pinpointed as having begun around 15 000 cal BP. We have identified the main changes in economic subsistence, which involved a broadening of the dietary spectrum that included an increase in the exploitation of plant foods and the consumption of large edible land snails. However, despite the greater focus on plant foods and low-ranking resources such as mollusks, this does not appear to have coincided with any disruption in the hunting of ungulates, such as Barbary sheep, which remained an important part of the diet. We have also noted that the major transition in food behavior overlapped with the change in uses of Taforalt Cave, which became a recurrent location for elaborate funerary activity. We would not attribute the change in food behavior specifically to an increase in feasting or communal activities surrounding funerary rituals. Our reasons for doubting this as an explanation rest partly on the widespread phenomenon of *escargotières* in the Maghreb, not all of which are associated with primary burials in spatially demarcated areas. While there is so far no support for the idea that these developments were absolutely synchronous across the whole of the Maghreb, or were associated with a climatic downturn,[104] we believe it is significant that at Taforalt they occurred at the beginning of Greenland Interstadial 1, during a period of marked climatic amelioration and when many of the foods would have experienced an increase in distribution and abundance.

99 Barton, Bouzouggar, Hogue, et al. 2013.
100 References in Barton, Bouzouggar, Hogue, et al. 2013.
101 Moreno et al. 2005; Rodrigo-Gámiz et al. 2011.
102 B. D. Smith 2001; Zeder 2015.
103 Rowley-Conwy 2013.
104 Cf. Zeder 2012.

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The Neolithisation Process in Nubia: New and Old Data

Summary

This paper aims at reconstructing the process of Neolithisation in Nubia. The model elaborated for the Near East that recognizes four developmental stages in the pathway to food production is used as theoretical background to frame the sequential flux of archaeological facts available for Nubia. The beginning of a stage of low-level food production with domesticates is marked by the adoption of Levantine domesticated animals around 7850 cal BP. Food production is established by the seventh millennium cal BP, when Levantine grains are also added. A possible stage of low-level food production without domesticates, preceding the arrival of Levantine animals and based on intensive management of autochthonous species, is hinted at by limited evidence dated as early as the Late Palaeolithic.

Keywords: Nubia; Neolithisation; low-level food production; palaeoenvironment; cattle

Dieser Beitrag möchte den Neolithisierungsprozess in Nubien rekonstruieren. Das für den Nahen Osten ausgearbeitete Modell, das vier Entwicklungsstufen der Nahrungsproduktion vorsieht, dient als theoretischer Hintergrund, um die Abfolge archäologischer Fakten in Nubien zu fassen. Der Beginn einer Nahrungsmittelproduktion auf niedrigem Niveau mit Zuchtvieh wird markiert durch die Aneignung von Nutztieren der Levante ca. 7850 cal BP. Die Nahrungsmittelproduktion ist um das 7. Jahrtausend cal BP etabliert, als auch Nutzpflanzen der Levante hinzukamen. Eine denkbare Stufe geringer Nahrungsmittelproduktion ohne Nutztiere wird bereits im späten Paläolothikum, vor dem Eintreffen der Tiere aus der Levante und basierend auf der intensiven Nutzung autochthoner Tierarten, von begrenzten archäologischen Evidenzen nahegelegt.

Keywords: Nubien; Neolithisierung; Nahrungsmittelproduktion auf niedrigem Niveau; Paläoumwelt; Vieh

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1 Framing the Neolithisation

This paper discusses new and old data with the aim of reconstructing the process of Neolithisation in Nubia. Current evidence suggests there may have been multiple loci in Africa where intensive management of animals and plants was underway already before the adoption of Levantine domesticates by African communities around 8000 cal BP. [1] Nubia is one of those loci. The present approach to Nubia is not that of a geographical corridor along the Nile,[2] but rather of a fluid cultural territory including both the river valley and the nearby deserts,[3] which broadly corresponds to the Middle Nile region.

The shift in terminology that has taken place in the past decades, from 'Neolithic' to 'Neolithisation', has implied also a shift in paradigm,[4] from an economically and chronologically well-defined construct to a long and dynamic process. The latter is intended as a series of acts, changes and developments, which, due to unpredictable variables, may change trajectory and speed, synchronically and diachronically. The adoption of domestication, a paramount level and form of intervention by humans in the life cycle of plants and animals, has been the revolutionary factor defining the beginning of the Neolithic.[5] Within the Neolithisation paradigm, instead, it represents a landmark of the amazingly long and complex transitional 'middle ground' between non-food-producing and food-producing economies.[6] The different forms and stages of incipient management of plants and animals are not considered part of domestication, since they do not imply genetic, physical and morphological changes in plants and animal species. However, incipient management is more than food procurement, because the relationship between human and nature has been substantially changed. These in-between economies are defined as 'low-level' and four developmental stages are recognized in the pathway to food production: food procurement, low-level food production without domesticates, low-level food production with domesticates, and food production.[7] These progressive stages, which have been developed based on data from the Near East, are used in this discussion to frame the sequential flux of archaeological facts currently available for Nubia. The economic factor, however, cannot be considered as the only one to account for shaping the Neolithisation process; ecological, social and cognitive factors were all of primary importance as well.[8]

The long history of archaeological enquiry in the Nubian Nile Valley and surrounding deserts has produced an abundant volume of data. Archaeological evidence dated from the Late Pleistocene to the Middle Holocene (ca. 25 000–5500 cal BP) is abundant and includes domestic, funerary, and ritual contexts. Alas, it has important methodological and interpretative biases. Not only has Neolithisation always been treated as a single event throughout the Greater Nile Valley, a case that has been disproved by more resent scholarship,[9] but data have been addressed following two main lines of enquiries. The first focused on discovering the earliest evidence of autonomous forms of domestication in Africa, particularly of cattle;[10] the second on relating it to the development of social complexity, and ultimately power, in Egypt.[11] Once more, recent scholarship has refuted both lines, finally releasing the debate toward new avenues of enquires.[12] It is within this new setting that the following definition of a process of Neolithisation in Nubia is framed.

2 Archaeological and palaeoenvironmental facts

So far, in northeastern Africa evidence of domesticated animals precedes that of domesticated grains.[13] The earliest secure evidence of domesticated animals (caprines) dates to the end of the ninth millennium cal BP (ca.

1 For the latest overviews see di Lernia 2013; Dunne et al. 2016; and the *Quaternary International* issues edited by Lucarini 2016 and Garcea, Karul, and D'Ercole 2016.

2 Contrary to Adams 1977.

3 Gatto 2011a; Gatto 2011b.

4 See Watkins 2013 for discussion and literature referring to the Near East.

5 Cauvin 1994; Childe 1936; Childe 1942.

6 Smith 2001; Smith 2015; Smith 2016.

7 Smith 2001.

8 Sterelny and Watkins 2015.

9 Gatto 2011a; Gatto 2011b; Usai 2016; Salvatori and Usai 2016.

10 Wendorf and Schild 2001, with references to previous research.

11 See discussion in Gatto 2011a.

12 See e.g. di Lernia 2013 on cattle domestication.

13 For a systematic and comprehensive report of most of the early data here discussed refer to Tassie 2014.

8000 cal BP[14]), and has been found in the Sodmein Cave (Fig. 1), in the Egyptian Eastern Desert.[15] In Nubia, the earliest secure evidence of domesticated cattle and sheep/goat is found around 7850 cal BP at sites in the Nabta-Kiseiba region of the Western Desert, and in the El Barga Cemetery of the Third Cataract region.[16] Thus, following Smith's sequential stages,[17] 7850 cal BP can (at least for now) be considered in Nubia as the threshold of a low-level food producing economy with domesticates, which is still a long way from an economy fully-based on food production. Archaeological data suggests Smith's final stage was reached around the end of the eighth millennium cal BP,[18] when evidence of domesticated plants is also recovered in Upper Nubia.[19] It must be pointed out, though, that during the Neolithic, in environments such as that of the Nile Valley and the surrounding deserts, activities like fishing, hunting and gathering continued to be practiced, alongside herding and farming. As a matter of fact, what developed in Nubia can be defined as an opportunistic and fluid economic pattern including more than one subsistence activity.

As a date, 7850 cal BP would mark also the end of a low-level food producing economy without domesticates. However, there are issues in piecing together the events that occurred during this stage. In fact, no wild sheep or goat ancestors are known in Africa and domesticated species were imported from the Levant.[20] This is also the case for wheat and barley.[21] The case of domesticated cattle is slightly different, as wild aurochs were present in North Africa.[22] In 1980s, the Combined Prehistoric Expedition (CPE) proposed an independent domestication for African aurochs based on a few bone remains found in Early Holocene sites of the Nabta-Kiseiba region, in the Nubian Western Desert.[23] According to Wendorf, Schild, and Gautier, the ecology of the Nabta-Kiseiba region during the Early Holocene was not capable of supporting large game animals like aurochs, therefore, those findings could only be related to animals brought into the region by humans.[24] Since then, the model has been much criticized both on the ground of lacking genetic modifications, as those bones morphologically fall into the range of wild aurochs,[25] and of questionable stratigraphic provenance, with many recovered from the surface.[26] The latter point is to some extent less relevant because despite their stratigraphic context, or lack of it, their wild morphological status would anyway support an early date for those remains. More recently, Brass has rejected the ecological foundation of the CPE model. Based on a re-evaluation of botanical and geological data, Brass advocates for an Early Holocene ecosystem in the Nabta-Kiseiba region capable of supporting aurochs and sees those findings as remains of hunted animals.[27] Against the CPE model are also the genetic studies, which have proved domesticated cattle too, in Africa as in Europe, came from the Near East,[28] pointing only to interbreeding with local wild species.[29]

Therefore, data at hand would suggest no Neolithisation process was underway in northeastern Africa prior to the arrival of domesticates from the Levant. But can any local attempt to tame aurochs be ruled out? In fact, in the Early Holocene there is evidence of taming Barbary sheep in the Central Sahara.[30] Moreover, the finding of only genetically wild individuals during the Early Holocene could fit in Smith's low-level food production stage without domesticates. That domesticating aurochs was a complex and challenging process, constrained by the difficulty of sustained managing and breeding, is indicated by the fact that only ca. 80 female aurochs were initially domesticated in the Near East, about a-thousand years after caprides, and that it all happened in a restricted geographical area.[31] It seems quite unlikely, though, that no one else in the Near East (or elsewhere) tried to do the same. Can we also rule out any

14 All radiocarbon dates have been calibrated using OxCal 4.3, calibration curve IntCal 13 (Bronk Ramsey 2009).
15 Vermeersch, Peer, et al. 1994; Vermeersch, Linseele, et al. 2015.
16 Wendorf and Schild 2001; Honegger 2004.
17 Smith 2001.
18 See among others Wengrow 2006; Wengrow et al. 2014; Gatto 2019; Usai 2016.
19 Madella et al. 2014; Out et al. 2016.
20 Zeder 2012.
21 Marshall and Hildebrand 2002; Zeder 2011.
22 Linseele 2004.
23 See Brass 2018 for an exhaustive critical review with bibliography therein.
24 Gautier 2001 with reference to previous publications; Wendorf, Schild, and Close 1984; Wendorf and Schild 1994.
25 Gautier 2001, Tab. 23.2.
26 Usai 2005.
27 Brass 2018.
28 See di Lernia 2013 with bibliography therein.
29 Decker et al. 2014.
30 di Lernia 1996.
31 Bollongino et al. 2012.

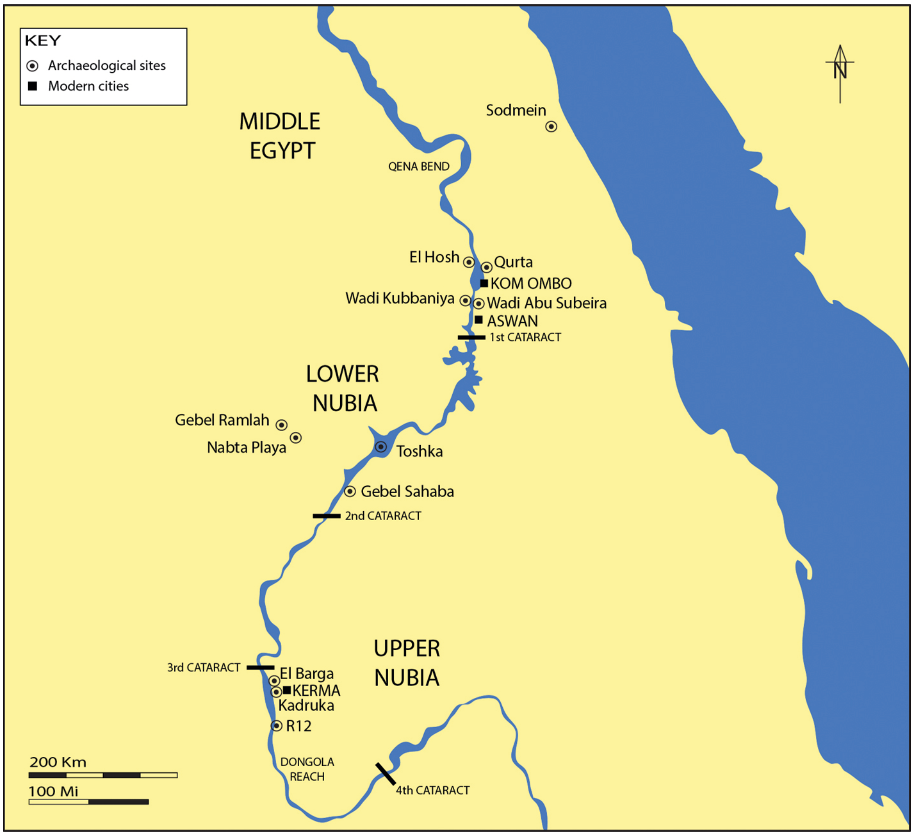

Fig. 1 Map of the Middle Nile region with the location of major sites mentioned in the text.

attempt at cultivating autochthonous cereals? In this respect, domesticated sorghum dating as far back as the sixth millennium cal BP has been recently discovered in the neighboring Kassala region of Eastern Sudan.[32] A long stage of intensive use of the plant before genetic modifications took place is expected, and in a broader geographical region as that. In fact, there is proof of an intensive use of sorghum in Nubia since the Early Holocene.[33]

Thus, albeit with differences in timing and nature from that recognized in the Near East, a stage of low-level food production without domesticates can be postulated also in Nubia. However, when did this stage start? In the archaeological record hints at changes in the relationship between humans and nature and in social and cognitive factors can be detected as early as the Late Palaeolithic.

Palaeoenvironmental and archaeozoological data from the Nile Valley suggest there were no aurochs south of the Third Cataract, while they were common in Middle-Upper Egypt and Lower Nubia.[34] The Late Palaolithic period (ca. 25 000–11 700 cal BP) was characterized by an arid climate (hyper-arid in the Late Glacial Maximum (LGM), ca. 25 000–14 500 cal BP), with a humid interval between ca. 14 500–12 900 cal BP. Arid conditions made the Nile Valley, or at least part of it, the only refuge for human settlement. The reconstruction proposed by the Combined Prehistoric Expedition[35] indicates the valley during the LGM would have been an open landscape of marshes and meadows, with shrubs and trees limited to the edge of the valley along the cliffs. The Nile was a much smaller, seasonal and sluggish river, which probably flowed through several braided channels. During the annual flood the height of the water would have left limited space for occupation by humans, animals and plants. Floodwater also penetrated the major wadis, creating seasonal lakes, again leaving little space for occupation. Outside the valley

32 Winchell et al. 2017.
33 Wasilikowa 2001.
34 Linseele 2004; Linseele 2012.
35 Wendorf, Schild, and Close 1989; Wetterstrom 1993.

there would have been a completely inhospitable arid environment, which would have made impossible any form of occupation. A new reconstruction of the LGM Nile environment, recently proposed by Vermeersch and Van Neer,[36] suggests dunes from the Western Desert invaded the valley in several places in Middle-Upper Egypt and Lower Nubia. The much-reduced activity of the river was unable to evacuate incoming aeolian sand and, therefore, several natural dams were created, which ultimately formed a series of lakes in place of the river and in nearby wadis. The two authors mention a lake formed in the Qena Bend, and another in the Wadi Kubbaniya, north of Aswan, was already mentioned by the CPE, as it was that found in Toskha in Lower Nubia.[37] Geoarchaeological survey in Wadi Abu Subiera,[38] opposite to Wadi Kubbaniya, identified lake deposits there as well, which could either pertain to the same Kubbaniya Lake or to a separate lake. It is likely this lake-dotted environment of the Late Palaelithic offered sufficient living conditions for humans, animals and plants to survive.

The desert hyper-aridity, coupled with the lake-dotted environment along the river, formed a quite limited and bounded space in which Late Palaeolithic people could live, and which may have: 1. permitted only short-distance movements; 2. produced higher population density; and 3. created a symbiotic interaction between humans, animals and plants. The strategy of the Upper Palaeolithic (50 000–25 000 cal BP) hunter-gatherers, which operated in small, mobile bands of fluid membership, likely changed to a new strategy operated by larger, almost sedentary groups, which surely had to manage increasing economic and social stress.[39] At a graveyard found at Gebel Sahaba, north of the Second Cataract the CPE found the earliest evidence of inter-communal violence.[40] Radiometric determinations date the site from the end of the LGM to the Early Holocene, but the actual chronological frame could be slightly older.[41] By then the Nile environment was again changing, with the beginning of a wet phase (interrupted by the Younger Dryas, ca. 12 900–11 700 cal BP) that would characterize the whole Early Holocene. Monsoonal summer rainfall increased in the Nile's headwaters generating catastrophic flooding (the so-called 'Wild Nile'[42]). Forty-five percent of the individuals found in the burial ground, which included men, women and children, died violently; others had bones showing healed injuries. The most logical assumption was that violence was related to food shortage, but osteological analysis of the skeletons disproved this hypothesis, as the individuals were all healthy.[43] The cognitive-cultural niche construction theory suggests social stress may have been the trigger for such violence.[44] Communities may have reacted by creating and setting off a powerful cognitive and developmental niche capable of supporting rapid innovation, creativity and cultural accumulation. All essentials in the Neolithisation process. Conflict and violence could have been a common occurrence within this scenario. It cannot be proven this was the case in Nubia, but it is certainly an explanation to keep in mind.

Smith[45] recognizes six patterns of human intervention and management of natural bio-niches, which include modification of vegetation communities and creation of wild stand of seed-bearing plants at the edge of water bodies, usually in zones exposed by receding waters. But also, landscape modification, for instance with drive lines or fish traps, to increase prey abundance in specific locations. The archaeological work done by the CPE in Wadi Kubbaniya and in other sites along the valley in Upper Egypt and Lower Nubia identified a shift from a subsistence strategy largely based on mammals to one focused on fish and wetland root foods. The finding of roughly made grinding stones in some of the Wadi Kubbaniya sites dated from ca. 22 900 cal BP suggests the extensive use, management and processing of plants started at least around that period. According

36 Vermeersch 2015.
37 Wendorf 1968c; Wendorf, Schild, and Close 1989.
38 Carried out in 2005 by the present author as part of the Aswan-Kom Ombo Archaeological Project (AKAP) field work (unpublished).
39 Sterelny and Watkins 2015.
40 Wendorf 1968b.
41 Antoine, Zazzo, and Friedman 2013; Zazzo 2014. Collagen preservation at the site was poor and, although in 1988 a skeleton was radiocarbon dated to 13 740 ± 600 BP, additional AMS dating by the British Museum, where the skeletal collection is kept, was unsuccessful. Recently four skeletons have been dated using bone, enamel and dentine apatite. The nine dates range between 11 650–11 050 BP and 10 032–7250 BP (ca. 13 500–8100 cal BP, Zazzo 2014). However, due to diagenesis affecting the samples it has been suggested (Antoine, Zazzo, and Friedman 2013) that at least part of the cemetery could be older than ca. 13 500 cal BP.
42 Butzer and Hansen 1968.
43 Judd 2007.
44 Sterelny and Watkins 2015.
45 Smith 2011.

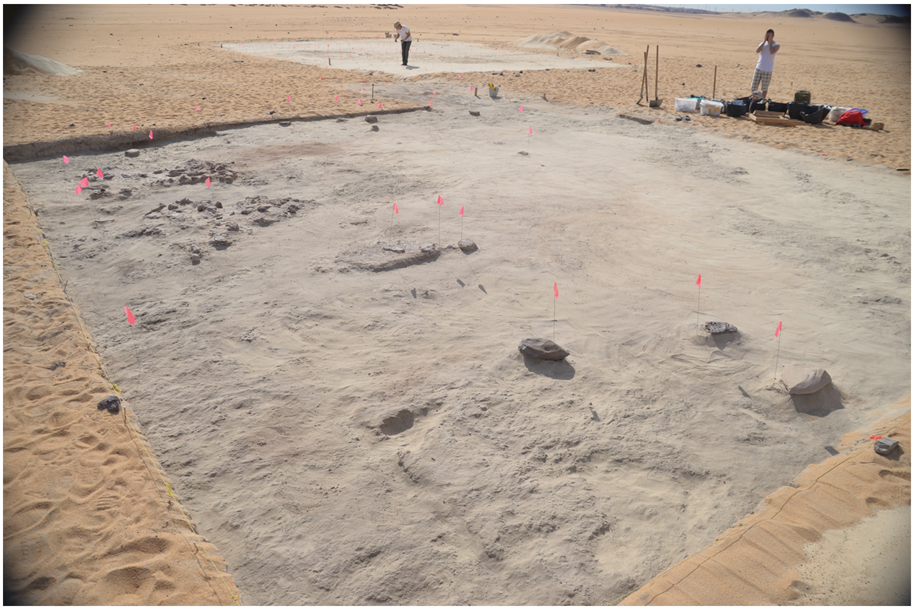

Fig. 2 Hearth installations from the Terminal Palaeolithic site WK26 in Wadi Kubbaniya.

to Wendorf et al.,[46] a great amount of fish bones were found in many of the sites, dated from ca. 25 350 cal BP, suggesting fish were by then being harvested for later consumption. Some geometric rock drawings found in the area north of Aswan and in the Second Cataract region, supposedly dated to the Early Holocene, have been identified as representing prehistoric fishing instalments, which could have been already available in earlier times.[47] The numerous drive lines present in the Aswan region and in Nubia, may instead be evidence of hunting instalments,[48] although thus far there is no secure dating for those impressive stone-built features.

A newly-found site in Wadi Kubbaniya (WK26) provides an insight into what a residential camp of the recent stage of the Late Palaeolithic consisted of.[49] The site is located along the shore of a temporary pool on the western side of the wadi across from, and at a higher elevation than, the dune field where most of the Late Palaeolithic sites were originally found by the CPE. Two occupational horizons were recovered in stratigraphical sequence, dated between 12 060 ± 50 BP (ca. 13 900 cal BP; Beta-319442, charcoal from ashy area below the surface) and 13 553 ± 34 BP (ca. 16 300 cal BP; PRI-14-041-3, charcoal from a feature in the bottom layer). The remains of hearths, ashy areas, postholes [likely evidence of windbreaks and/or drying stands], and storage pits were found in both phases, in a number that has no parallel among the dune field sites previously investigated by the CPE. These features (Fig. 2) suggest a well-structured residential setting suitable for long-term, although seasonal, use, where a variety of activities were performed and where a delayed-return strategy in use of resources was practiced. Faunal remains consisted almost exclusively of fish; no remains of large mammals were found during excavation. Fish processing, using techniques such as smoking or wind drying, was probably one of the main activities done at the site. As for plant processing, no botanical remains were found during the excavation and the only identifiable piece of charcoal was *Tamarix*.[50] However, a good quantity of grinding implements was collected. They differ from those in the dune field dated to the earlier Kubbaniyan period as the stones generally tend to be thin slabs with shallow grinding surfaces. Some were analyzed and pollen and a few phytoliths from members of the mustard and amaranth families were found, indicating seed processing. Ochre was identified on several upper and lower grinding implements and although there is no certainty yet about its function, some options can be considered, including for instance a use in leather processing or for

46 Wendorf, Schild, and Close 1989, 819.
47 Huyge and Storemyr 2012.
48 Storemyr 2011.
49 Banks, Snorthland, et al. 2015; Banks, Usai, et al. 2018.
50 Scott-Cummings, personal communication 2017.

ritual purposes. Contrary to older industries in the wadi, chert and Egyptian flint dominate the lithic assemblage at the site, suggesting for this later stage of the Palaeolithic long-distance exchange of raw materials (as both are not locally available) or movement of people, or a combination of the two.

Going back to the Late Palaeolithic subsistence in Wadi Kubbaniya, game, of course, was also a consistent part of the local economic strategy. Yet, aurochs' bones identified in the dune field sites are far less numerous, compared to other local species such as gazelles and hartebeests and as such there is no evidence for a predilection of aurochs as a food resource.[51] This is contrary to the trend in most of the Upper Egyptian/Lower Nubian Early Holocene sites where remains of aurochs among the archeofauna count for the 37–50% of the total, with gazelles and hartebeests present in far less number. Whereas, aurochs remains in Faiyum and Middle Egypt account for ca. 13–16% of the total, with hartebeests and gazelles being the most common.[52] The economic value of aurochs thus seems to have been confined to a specific area of the Nilotic region and in later times. Its importance in the symbolic realm of the Late Palaeolithic groups is instead clearly attested by contemporary rock art. In a site discovered in the northern Kom Ombo plain at Qurta over 75% of the drawings represent, in an impressive naturalistic way, aurochs, followed by birds, hippopotami, gazelles, fish and hartebeests.[53] The same set of representations, with the addition of Nubian ibex, wild ass and African wild dog, have also been found in El-Hosh, 10 km north of Qurta on the west bank of the Nile,[54] in Wadi Abu Subeira (six distinct locales; Fig. 3) and in Aqaba el-Seghira, both on the east bank opposite to Wadi Kubbaniya.[55] OSL dates obtained from a sand deposit that partially covered some of the Qurta drawings yield the date of ca. 16 000 ± 2000 calendar years for the bottom part of the sediment. The date is intended as a *post quem* for the rock drawings, which thus must be considered older than 16 000 calendar years.[56] All these rock art locales are positioned on top of the rocky ridges overlooking the valley below, the perfect location to watch animals approaching the water and drinking. Such locales are thus highly ritualized loci used for hunting. A possible use of aurochs in funerary symbolism is instead implied by the discovery, in another graveyard of Lower Nubia, of three horn-cores on the surface of as many graves. The site was located at the edge of a palaeo lake 3.5 km inland Toskha West and was roughly contemporary with the Gebel Sahaba burial ground.[57] In all three instances, the horn-cores were found located close to the skulls, although not in direct contact, but in the deposits above them. It could well be the three occurrences were accidental, yet the chance of finding three times a horn-core right close to a skull seems suspicious. In the same location evidence of a contemporary settlement was recorded. Bones of aurochs were the most frequent faunal remains found there. The interpretation of this high number of aurochs bones is not an easy task as either mundane or ritual consumptions may have been possible motivations for such.

Fig. 3 Late Palaeolithic depiction of aurochs from Wadi Abu Subeira; the figure is ca. 0.80 m in width.

With the climate amelioration of the Early Holocene (11 700–8200 cal BP), the Nilotic communities were finally able to disperse and enlarge their sphere of interaction. Short-term campsites are found in areas such as the Nabta-Kiseiba region.[58] Climatic conditions at the beginning were not humid enough for the water collected in seasonal lakes to last long in the playa basins. Because of this, the CPE suggested the sites were occupied only after summer rains. Those earliest re-settlers shared cultural traits with the Arkinian of Lower Nubia.

51 Wendorf, Schild, and Close 1989; Wetterstrom 1993.
52 Vermeersch 1992; Vermeersch 2002.
53 Huyge, Aubert, et al. 2007; Huyge and Ikram 2009.
54 Huyge 2009.
55 Kelany 2014.
56 Huyge, Vandenberghe, et al. 2011.
57 Wendorf 1968a.
58 Wendorf and Schild 2001, with reference to earlier research.

Both sites along the Nile and in the desert were seasonal occupations; if in the desert a temporary occupation was mainly related to climatic conditions, in Lower Nubia the nature of the settlement might have been affected by the landscape. As a matter of fact, the region has a narrow valley, highly rocky at specific points due to the presence of granitic obstructions along the river and outcrops approaching the Nile from both sides. Considering the many similarities in the lithic assemblage as symptomatic of a common cultural affiliation, seasonal movements between the valley and the desert have been assumed.[59] Lithic raw materials from desert sites included chert and Egyptian flint, which were alien to both the Nubian Nile Valley and nearby deserts, suggesting connection with the Egyptian Nile Valley and the Western Desert oases, where instead these raw materials are common. There are only a few desert sites dated to this early phase. What characterizes them is not only the presence of postholes, hearths, pits or grinding stones, which were already reported from the most recent Late Palaeolithic sites, but the finding of pottery.[60]

From the ninth millennium cal BP, there is a proliferation of sites in the desert on both sides of the Nubian Nile Valley.[61] Abundant remains of wild cereals (mainly sorghum) were discovered in association with a large semi-permanent village located around the playa basin of Nabta. The large number of sorghum remains compared to those of other recovered taxa was remarkable, as it was the uneven spatial distribution, with clusters inside two of the huts and in association with one of the hearths [storage pits at the site were found largely empty].[62] This evidence led to suggest an incipient management of the wild sorghum. Systematic analysis of the lithic and ceramic assemblages has reconstructed the spatial and chronological distribution of these 'Nubian' communities, seasonally moving from the valley to the desert and showing a shift southward to include, by the end of the millennium, the Dongola Reach into their territorial sphere.

New forms of rituality and communal activities are also established in the desert. At Nabta Playa a ceremonial complex has been recently identified, consisting of numerous megaliths, tumuli, groups of stelae, and a stone circle.[63] Most of them are dated to the Late-Final Neolithic phases; although some are from earlier periods. The latter were found in the so-called Sacred Mountain, which comprises a distinct, shabby massive of ca. 1 km in diameter rising above the flat surface of the northern portion of the Nabta Playa basin, beyond the edge of the palaeo lake. It includes the remains of huge hearths and tumuli, and flat surfaces paved with stone slabs covering offering pits. Nearly 40 tumuli and flat stone slab concentrations have been excavated, as well as the remains of three gigantic hearths. The most interesting of these includes a tumulus along with the stone constructions accompanying it. Beneath four of these concentrations and below the tumulus superstructure a series of pits were found, most of them deep and sealed with a layer of sandstone blocks or slabs. Some contained remains of gazelle and pieces of charcoal. In two examples the pits contained microlithic tools. The pits under two of the structures had hidden stone slab arrangements, dividing the space within the shaft into separate areas. Two features from the complex in question were radiocarbon dated to ca. 8000 BP (9000–8700 cal BP) and represent the earliest evidence of rituality out in the desert. It is interesting to note that the animal remains found in this early context are not of cattle or any other domesticated animal, but of gazelles.

In North Africa, the end of the ninth millennium cal BP (8200 cal BP) marks the abrupt arid/cooler spell of the end of the Early Holocene.[64] There is no evidence of occupation in the Nubian deserts during these last few centuries,[65] although it is well-reported along the Nubian Nile. It is some time in this period that domesticated animals entered Africa from the Levant. The climatic deterioration of the end of the Early Holocene caused the abandonment of intensive gathering of plants in the deserts while it continued along the Nile valley. Areas such as Upper Nubia were certainly highly favorable for such kind of economic practice. Domesticated cattle and caprines were definitely better suited to the desert environment because they could be moved to exploit different places according to necessity.[66] The

59 Usai 2008; Gatto 2006.

60 Gatto 2011a.

61 Wendorf and Schild 2001; Gatto 2012.

62 Wasilikowa 2001.

63 Bobrowski, Czekaj-Zastawny, and Schild 2014.

64 Gatto and Zerboni 2015, with further bibliography.

65 Wendorf and Schild 2001.

66 Marshall and Hildebrand 2002.

deserts of the Middle Nile region were particularly suitable for husbandry as they consisted of plains with seasonal lakes and wells fed by the high stand of the water table, providing enough grasslands and water for herds even in the more arid periods. The absence of the Tsetse fly at this latitude is worth remembering, a problem for the adoption of cattle farther south in the Upper Nile region during the early Middle Holocene. As already said, the earliest evidence of secure domesticated cattle in Nubia comes from the Nabta-Kiseiba region[67] and the area of Kerma in Upper Nubia where a bucranium was found inside a grave dated to 7850 cal BP.[68] The graveyard, which is broadly dated to the first half of the eighth millennium cal BP, is also the earliest in the Greater Nile Valley to show evidence of funerary offerings in the form of personal adornments, such as lip plugs, earrings, bracelets and necklaces, but also small palettes and grinders, a few pottery vessels, some worked animal bones, rare lithics, etc. Many objects were made of exotic raw materials, such as granite, amazonite and ivory, as well as Red Sea shells. The provenance of such materials suggests long-distance exchange and/or mobility; while the large number of graves with offerings, about two thirds, suggests a richer society with incipient inequality.

With the summer monsoon regime moving farther south, gradual desiccation began at ca. 7300 cal BP with arid conditions being established by ca. 4850 cal BP.[69] At the same time, it is also detected a southward movement of Mediterranean winter rains affecting the Lower Nile region in Egypt.[70] Such changes forced people into longer-distance movements and readjustments of their territorial, economic, social and symbolic systems. During this phase the Nile Valley may have faced increased population stability and thus a need to use the valley subsistence's potentiality at its best. Fishing and foraging/farming were certainly the main activities performed along the Nile. Till recently, the oldest evidence of domesticated grains in Upper Nubia were reported from Kadruka Cemetery KDK1, which dates to the second half of the seventh millennium cal BP.[71] There, remains of barley glumes were recorded in many tombs. However, thanks to micro botanical discoveries at Cemetery R12, south of Kadruka in Upper Nubia, the introduction of domestic cereals in the Middle Nile Valley, consumed along with wild species, has now been pushed back by several centuries, to the second half of the eighth millennium cal BP.[72] An increase in plant consumption by the Neolithic population of Nubia (at least that living along the Nile) has been recorded in Cemetery R12. The isotope analysis of human remains highlighted a change in diet by the second half of the seventh millennium cal BP.[73]

Husbandry and hunting however, were mainly performed in the desert, with communities now probably being seasonally split between those people staying in the valley and others going into the desert. For semi-mobile and mobile groups a campsite served as temporal loci of social activity where people could gather at specific times of the year for particular functions or activities. Their perception of land property and group membership was more on a regional scale than on a site level. Thus, different patterns were applied in ritualizing Nilotic and desert landscapes. Formal disposal areas, such as necropolises, were located mostly along the Nile, except for that found at Gebel Ramlah, in the Nabta-Kiseiba region.[74] This is a unique funerary complex, which included human inhumations, huge fireplaces for ritual feasting and a burial ground exclusively dedicated to infant, new-born and unborn children.[75] The desert, otherwise, was mainly marked by stone structures and stone tumuli functioning as media for monumentalizing and ritualizing the desert.[76] Some of these tumuli were used for single or multiple human inhumations (Fig. 4), others for animal inhumations. The oldest was found in Nabta Playa and dates to ca. 7500 cal BP.[77] Inside that particular tumulus there was a young cow, evidently a ritual sacrifice. In the seventh millennium

67 Gautier 2001, with references. Still following the CPE ecological model, Gautier indeed continues to define the Early Holocene remains as domesticated despite their falling within the range of wild cattle, as clearly presented in his fig. 23.2.
68 Honegger 2004.
69 Kuper and Kröpelin 2006.
70 Phillipps et al. 2016.
71 Reinold 2001.
72 Madella et al. 2014; Out et al. 2016.
73 Iacumin 2008.
74 Kobusiewicz et al. 2010.
75 Czekaj-Zastawny et al. 2018.
76 di Lernia, Manzi, and Merighi 2002; Gatto 2011b.
77 Wendorf and Schild 2001.

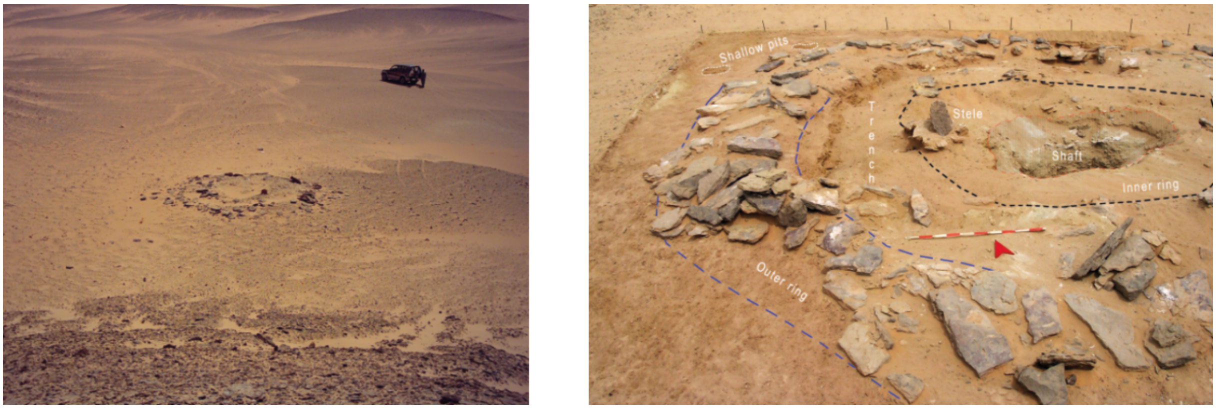

Fig. 4 Seventh millennium cal BP tumulus from Wadi al-Lawi in the desert east of Kom Ombo. Left: before and right: after excavation.

cal BP, cattle bucrania and remains of caprines are commonly found among the funerary offerings in the many cemeteries of Upper Nubia. The ceremonial complex at Nabta Playa expanded considerably in this phase to include megaliths, tumuli, groups of stelae, and a stone circle identified as calendar.[78]

Such mobile communities, engaged in seasonal movements involving larger areas and longer and more random routes, compared to those detected for the Early Holocene.[79] This movement became fundamental in expanding the superregional sphere of cultural contact, creating what Wengrow et al.[80] have defined as 'a cultural convergence' in the Neolithic of the Nile Valley.

3 Defining the process of Neolithisation in Nubia

In Nubia the Neolithisation process is well-documented from ca. 7850 cal BP, the date of the earliest secure evidence of domesticated animals in the archaeological record. Three out of Smith's four developmental stages (Fig. 5) are clearly recognizable, namely the food procurement, the low-level food production with domesticates, and the food production. The latter is in place by the seventh millennium cal BP, when domesticated grains are also recorded. However, what developed in Nubia is a multi-spectrum economy, including fishing, foraging, farming, husbandry, and hunting. Communities were not relying mostly on domesticated species for consumption.[81] For instance, hare and gazelles are more common than domesticates among the faunal remains from Nabta Playa.[82] As for the latter, caprids are always in the majority compared to cattle. Yet, cattle achieve a unique symbolic and ritualistic value within the Nubian society. This can be inferred, among others, by the burial of a sacrificed cow from Nabta and by the bucrania found inside the human graves in Upper Nubia. Funerary offerings of domesticated animals, including caprids, are also common, pointing to a distinctive importance of pastoralism among the different economic strategies. By the end of the sixth millennium cal BP, cattle burials are found in elite cemeteries accompanying human graves. They are clearly used as display of wealth and power, a use that will continue also in later times.[83] In the Middle Kerma period (fourth millennium cal BP) hundreds of bucrania were placed around the richest tumuli in the royal cemetery of Kerma.[84] Ethnographic studies show how cattle are the most valued animals in many pastoral societies of East Africa, albeit the larger portion of the livestock usually consists of sheep/goat. Caprids can be used as goods and money, but cattle are those sacrificed for ritual purposes.[85] In those societies, a herder with a large flock but no cattle is considered a

78 Schild and Wendorf 2004; Ibrahim 2012.
79 Gatto 2006; Usai 2008.
80 Wengrow et al. 2014.
81 Smith 2001 marks the beginning of food production in the Near East with 50% of domesticates in the assemblage.
82 Gautier 2001.
83 Gatto 2019.
84 Bonnet 2000.
85 P. Gulliver and P. H. Gulliver 1953.

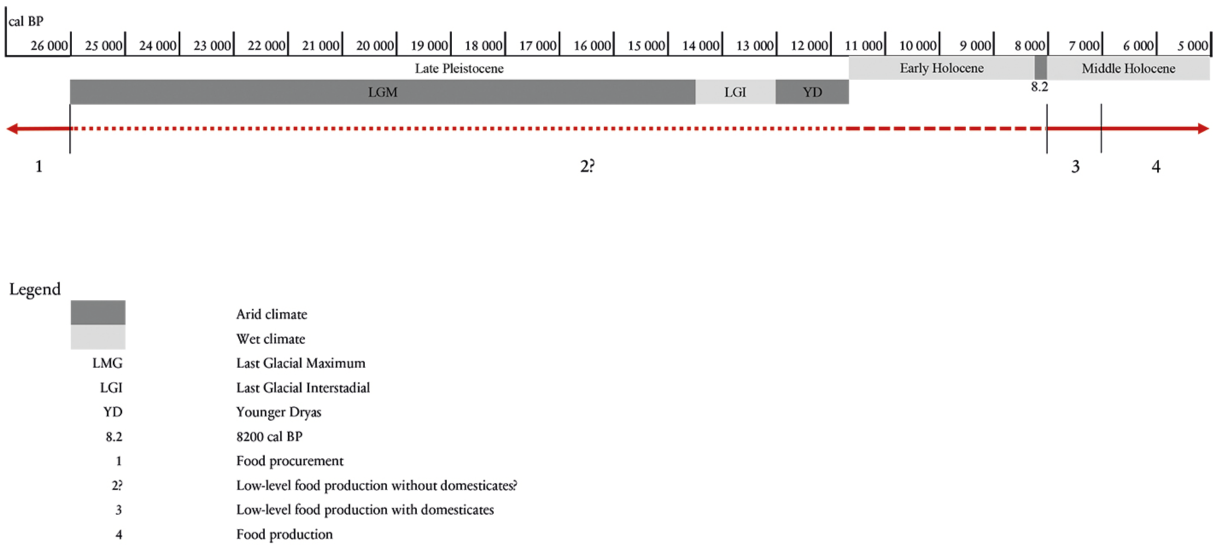

Fig. 5 Timeline of the four stages (*sensu* Smith 2001) characterizing the process of Neolithisation in Nubia.

poor man.[86] What developed in Nubia could be seen as the forerunner of this type of African pastoral societies.

More difficult is to detect a possible local process before the arrival of domesticates. Current data suggest a symbolic importance of wild cattle already by the Late Palaeolithic, when aurochs were the most common rock art subject. A possible use in funerary rituality is hinted by the Toskha findings. Only in the Early Holocene, though, aurochs become the most common faunal remains in domestic contexts of Upper Egypt and Lower Nubia, pointing to a change in diet and possibly in the human-animal interaction. The earliest evidence from the Nabta-Kiseiba region are from this phase. A direct link between the aurochs-human interaction of these early phases and the role that domesticated cattle will achieve in later times cannot be proved, and probably does not exist. However, the knowledge of the wild cattle was already present in those Nubian communities at the arrival of domesticated cattle from the Levant, a fact that could have facilitated its adoption. As for plants, a change in collection, storage, and consumption of different taxa is attested already by the Late Palaeolithic in Wadi Kubbaniya, while an incipient management of sorghum is supported by data from Nabta Playa dated to the Early Holocene. Are those elements enough to postulate a phase of low-level food production without domesticates at least by the Early Holocene, if not earlier? Probably not by Near Eastern standards. Additionally, if those standards are followed thoroughly, the very definition of Neolithisation should be questioned in Nubia as in Africa. Flexibility is then needed when applying Smith's model to Nubia, and more broadly to the African continent. His parameters require being adjusted to the peculiarity of the local events and trajectories, and future research should focus on better defining those parameters.

Ecological, social and cognitive factors can also be used as proxy. A chain of acts of resilience and changes was set in motion by the distinctive Late Palaeolithic socio-environmental setting, which included technological and ecological innovations that needed to be reliably retained, and an increasing complexity of intercommunal life and commitment, with a subsequent need for new social rules that required to be learned and inherited. Shared activities, such as ritual ceremonies, or legacy to collective actions may have helped sustain and maintain social bonds and regulate intra-social behaviors.

Environmental and palaeoclimatic changes throughout the period under investigation and later strongly affected the Neolithisation process in Nubia, resulting in a Neolithic primarily based on group segmentation, mobility, fluid territoriality, multi-spectrum economy, and a unique social importance of pastoralism expressed in the symbolic realm through communal as well as funerary rituality.

86 Majok and Schwabe 1996.

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Revolution(s) in Egypt. Over a Century of Research on the Egyptian Neolithic

Summary

Researchers have studied the Neolithic and the process of Neolithisation of Egypt for only the last 100 years, which is short in comparison to the history of studies on Europe or the Near East. However, there have been some key research moments with particularly strong influences on our still developing knowledge about the Egyptian Neolithic. These moments could be referred to as revolutions, as they completely changed knowledge about the Neolithic period in Egypt. This paper reviews five such 'revolutions' in the research: 1) the introduction of the Neolithic period in Egyptian Prehistory, 2) and 3) the discoveries of the first domesticates in Northeastern Africa (Lower Egypt, Western Desert), 4) the application of absolute chronology for Egyptian archaeology, and 5) recent discoveries of the oldest ovicaprines in Egypt.

Keywords: Neolithisation; Neolithic revolution; Egyptian Neolithic; domesticated plants; domesticated animals; Predynastic Egypt

Wissenschaftler haben das Neolithikum und den Prozess der Neolithisierung Ägyptens erst während der letzten hundert Jahre untersucht, was im Vergleich zur Erforschung Europas oder des Nahen Ostens kurz ist. Jedoch haben sich einige zentrale Erkenntnisse herauskristallisiert, die unser sich immer noch erweiterndes Wissen über das ägyptische Neolithikum stark beeinflussen. Diese können als Revolutionen bezeichnet werden, da sie unser Wissen über das Neolithikum in Ägypten völlig veränderten. In diesem Beitrag werden fünf dieser ‚Revolutionen' betrachtet: 1) die Einführung der neolithischen Periode im prähistorischen Ägypten, 2) und 3) die Entdeckung erster domestizierter Tiere im Niltal, 4) die Anwendung der absoluten Chronologie in der ägyptischen Archäologie und 5) neue Entdeckungen levantinischer Schafziegen aus der Arabischen Wüste.

Keywords: Neolithisierung; neolithische Revolution; ägyptisches Neolithikum; Nutzpflanzen; domestizierte Tiere; prädynastisches Ägypten

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1 Introduction

Archaeologists generally accept that the introduction of domesticated plants and animals marked a fundamental change in people's lives and food production. V. G. Childe coined the term 'Neolithic revolution', seeing this particular period as a break-through.[1] The emergence of agriculture and the domestication of plant and animals are still important research issues in many disciplines. Research on these processes mostly focuses on the Near East, where ancient communities took the first steps toward plant and animal domestication. New data, theories, approaches, and hypotheses have appeared during the last 15 years, pushing forward our knowledge of the origins and spread of domesticates.[2] Although Egypt is often considered a Near Eastern country, research on the introduction of domesticated plants and animals seems to be 'underdeveloped' and isolated from the research of other aspects of the Near Eastern prehistory.[3] Although in 2008 M. Zeder termed the southern margin of Mediterranean Basin, including Egypt, as 'terra incognita', she also mentioned this part of the world's great potential for future research.[4] In the opinion of the author, research on the introduction of domesticated plants and animals into Egypt has suffered from three major difficulties: geomorphologic situation influencing the accessibility of evidence, great environmental variability of this region requiring a flexible research approach, and the short history of research. First of all, the Nile activity in the past influenced the state of preservations of the oldest remains of human activity in Egypt. A large percentage of sites were probably destroyed by the river or covered by a thick layer of silt. Secondly, research on the Egyptian Neolithic focuses on two different ecological niches – the fertile Nile Valley and the Delta on the one hand, and the Sahara on the other. Moreover, in each of these two niches two Neolithic economic models of different origins were registered. Finally, research into the Neolithic and the process of Neolithisation of Egypt has been conducted for only the last 100 years. The history of research seems very short in comparison to the history of research on Europe or the Near East. However, during this time our knowledge on the emergence of agriculture and the introduction of domesticated plants and animals into Egypt has been developing. Despite many unanswered questions, research allows us to understand the complexity of changes in Neolithic Egypt.

The short history of research has some advantages too. We are able to easily observe a number of changes, great and small. As some of them have completely changed, or rather turned upside down, our knowledge of this topic, the author has decided to call them 'revolutions' to underline their importance. The choice of this term is not accidental. These 'revolutions' in the research on the Egyptian Neolithic influenced the current way of thinking about the period and the region in question.

2 First revolution – discovering Prehistoric Egypt

At the early stage of archaeological research outside Europe, the entire terminology on chronology and periodization was adapted from Europe. Scholars used the term Neolithic, originally devised in 19th century Europe, also with reference to Egypt. At the turn of the 19th and 20th century, two terms – Prehistoric/Predynastic and Neolithic – were closely interconnected in Egyptian archaeology. They both generally encompassed all finds dated to the period preceding the emergence of the Pharaonic civilization. Already towards the end of the 19th century, J. de Morgan considered materials from Predynastic sites (including Naqada and Ballas) to be Neolithic.[5] In the opinion of W. M. F. Petrie, the Neolithic encompassed a period below his famous "S.D. 60".[6] Although the Neolithic was officially introduced in the periodization of Ancient Egypt, it attracted little interest. Archaeological works focused mostly on Upper Egyptian cemeteries and the interest of researchers was directed towards finds, their chronology within the Predynastic period, their cultural affinity, and their classification/typology. At the very beginning of the 20th century the terms Prehistoric/Predynastic

1 Childe 1936.
2 Zeder 2008; Zeder 2015.
3 See Shirai 2013b.
4 Zeder 2008.
5 De Morgan 1896, 67–167.
6 Petrie 1901, 28–29.

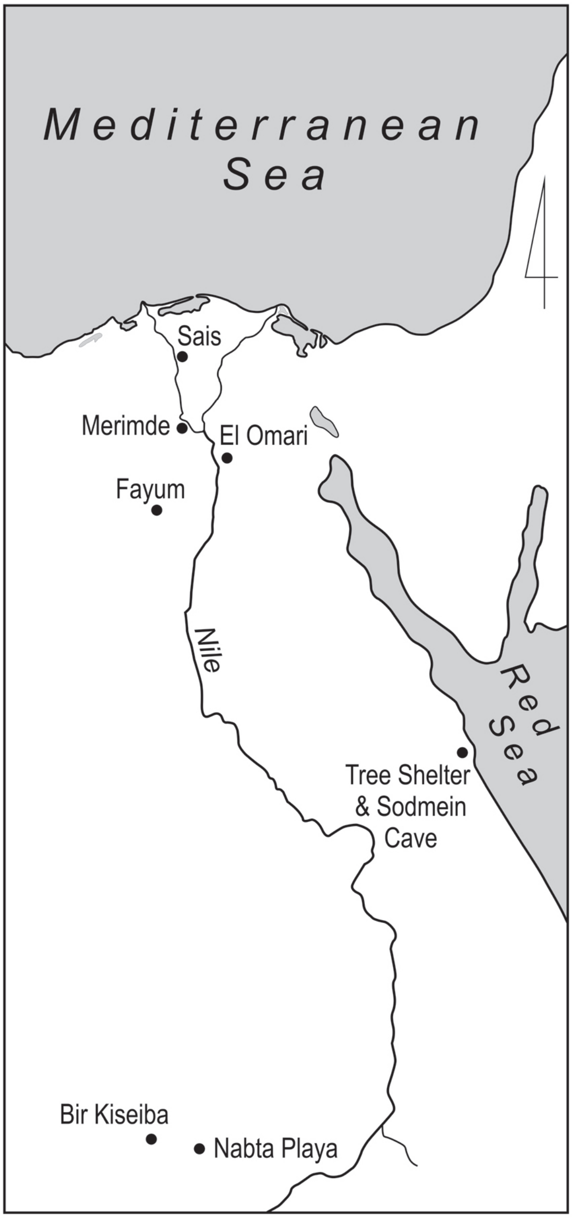

Fig. 1 Map of Egypt showing the locations of sites mentioned in the text.

ousted the term Neolithic. It was only thanks to finds directly related to domesticated plants and animals (grains and bones in the Faiyum and Badari) that the term Neolithic returned to Egyptian prehistory.[7] However, it is worth mentioning that many researchers have questioned the use of the term in a Northeast African context since the 1950s.[8]

Although research on the Neolithic is now in a different place than a century ago, the use of the terms Neolithic and Predynastic may still cause a problem, since a precise definition of both terms is difficult, if not simply impossible. Moreover, their relationships are also not easy to establish and depend on the researcher's views on Egyptian prehistory. In some approaches, the Neolithic is part of the Predynastic Period.[9] However, there have also been researchers treating the Neolithic and Predynastic as two different, separate periods.[10] In the most recent attempts at determining the chronology for the Nile Valley, the term 'Neolithic' appears alongside other general terms: 'Chalcolithic' and 'Early Bronze Age'. They are all used simultaneously with the terms 'Predynastic' or 'Protodynastic' and the names of archaeological cultures.[11]

3 Second revolution – early domesticated plants and animals recorded in Egypt

The 1920s and 1930s saw another revolution in research on the Neolithic period. Early sites in the Badari area, in Faiyum, Merimde Beni Salama, and Wadi Hof were discovered and excavated (Fig. 1). In this way, archeology gained new inputs for the discussion on the Neolithic and on the introduction of domesticated plants and animals.[12] Undoubtedly, archaeological research on the northern shores of Lake Qarun by G. Caton-Thompson and E. Gardner in the 1920s needs be mentioned here.[13] The two researchers recovered bones of domesticated animals and grains of domesticated plants, indicating the presence of subsistence strategies other than hunting,

7 Brunton and Caton-Thompson 1928; Caton-Thompson and Gardner 1934.
8 E.g. Goodwin 1946; Clark 1957; Bishop and Clark 1967; Shaw 1966; Shaw 1967; Sutton 1973, 88–90; Bower 1976, 47–49; Phillipson 1985, 113–134; Smith 2013.
9 Butzer 1976, 12; Hoffman 1979; Trigger 1983, 13–21; Ciałowicz 2001; Tassie 2014, 195.
10 Hayes 1964; Arkell 1975; Hassan 1985; Wenke 1989; Wenke 1991; Kobusiewicz 1992, 209–210; Midant-Reynes 1992; Midant-Reynes 2003, 385; Vercoutter 1992; Hendrickx 2006; Wengrow 2006, 274.
11 Hendrickx, Huyge, and Wendrich 2010, Tab. 2.1; Köhler 2010, Tab. 3.1.
12 Brunton and Caton-Thompson 1928; Caton-Thompson and Gardner 1934; Debono and Mortensen 1990.
13 Caton-Thompson and Gardner 1934.

gathering, and fishing. In fact, later research indicated a great prevalence of fowling and fishing over farming and stock keeping at the Neolithic Faiyum sites. Nevertheless, the presence of bones from domesticated cattle, sheep, goats, and probably pigs and dogs, as well as grains of emmer wheat and hulled six row barely started to be quoted in the context of early agriculture in the Nile Valley and Delta.[14]

The presence of grains of domesticated plants and bones of domesticated animals sparked a discussion on their origins and the direction from which they were introduced into Egypt. The prevailing view in Egyptian archaeology is that domesticated animals and plants appeared in Lower Egypt first and were introduced from Southwest Asia.[15] Arguments used to support this hypothesis include: convergence of species from the Levant and Lower Egypt, non-endemic character of ovicaprines in North Africa, and also the proximity of these two regions. Moreover, genetic studies confirmed Levantine origins for these domesticated animals.[16]

Nearly simultaneous with the discoveries in Faiyum were the excavations conducted at Badari and Hemmamieh in Upper Egypt, which also revealed remains of domesticated plants and animals.[17] Aware of the early date of some of the finds at these sites, preceding the Predynastic period, G. Brunton coined the word 'Badarian', a new term in Egyptian archaeology.[18] However, most studies on the Badarian consisted of analyses of graves and grave goods, as opposed to settlements. Also, the relationship with other Predynastic cultures known at the time became an important issue in Badarian research. As such, the question of the introduction of domesticated plants and animals into Upper Egypt was overshadowed. W. Wetterstrom mentions the lack of interest in the presence of domesticates in the Badarian, describing the research into and collection of Badarian plants and animals as "highly unsatisfactory and incomplete".[19] The issue was not subject to systematic studies until 2007.[20]

In the first part of the 20th century before WWII, archeologists explored a number of other new Neolithic sites in Lower and Upper Egypt. The discussions on early Egyptian farming concentrated mostly on materials from the northern sites at Merimde Beni Salama and Wadi Hof.[21] At the same time, research into cemeteries dominated in the archaeology of Upper Egypt, thus creating an imbalance in the character of finds between the southern and northern parts of Egypt.[22] It is also worth mentioning that all finds from both parts of Egypt were put in the artificial framework of 'archaeological cultures' and fitted to a 'perfect' vision of early farming societies with domesticated plants and animals, pottery, and sedentary way of life.

Surprisingly, the state of research on the Neolithic of Lower Egypt had not changed much until the end of 20th century. However, during the last few years archaeologists have started to undertake research at already known sites – on the shores of Lake Qarun in the Faiyum and also at Merimde Beni Salama. Combined with new excavation projects (e.g. in Sais) these studies are providing new evidence that will not only enrich our knowledge, but also change it significantly.[23]

4 Third revolution – chronology reconsidered

The post-war period in Egyptian archaeology saw researchers returning to already known Neolithic sites and a general intensification of excavation projects in both Upper and Lower Egypt. New excavation methods and new dating technologies made it possible to obtain data that shed new light on the introduction of domesticated plants and animals into Egypt. Certainly, an important and revolutionary event was the introduction of radiocarbon dating into the Predynastic Egyptian chronology. Relative dating methods used in establishing a chronological sequence of archaeological cultures led to different results or even misunderstandings.[24] However,

14 Von den Driesch 1986; Brewer 1989.
15 Arkell and Ucko 1965, 147; Hayes 1964, 91–92; Stemler 1980, 505; Trigger 1983, 20; Hendrickx and Vermeersch 2000, 37; Wengrow 2006, 44–45; Hendrickx, Huyge, and Wendrich 2010, 19; Tassie 2014, 185.
16 Gifford-Gonzalez and Hanotte 2011.
17 Brunton and Caton-Thompson 1928, 41.
18 Brunton and Caton-Thompson 1928, 1, 38–41.
19 Wetterstrom 1993, 216.
20 Cappers and Hamdy 2007.
21 Eiwanger 1984; Eiwanger 1988; Eiwanger 1992; Debono and Mortensen 1990.
22 Hendrickx and Brink 2002; Köhler 2008.
23 E.g. Linseele, Van Neer, et al. 2014; Wilson, Gilbert, and Tassie 2014; Holdaway et al. 2018; Rowland and Tassie 2014.
24 I.e. Kantor 1954; Baumgartel 1955; Baumgartel 1960; Baumgartel 1965; Forde-Johnston 1959; Menghin 1961/1963; Arkell 1975; Krzyżaniak 1977.

the first attempt at the introduction radiocarbon dating to Predynastic Egypt in the 1950s was unsuccessful and met many objections.[25] In 1985, F. Hassan published his proposal for the chronological framework for the Neolithic and Predynastic sites from the Delta and Upper Egypt.[26] This framework still remains useful, although it has undergone some modifications due to new ^{14}C dates and more precise methods.[27] The most recent attempt was made by M. Dee et al. who proposed a new version of the absolute chronology for early Egypt by combining radiocarbon determinations and archaeological evidence within a Bayesian paradigm.[28] Using known radiocarbon dates combined with new measurements, researchers constructed the Bayesian models for the Badarian, Naqadan, and the First Dynasty kings. According to the new models, the conclusion of the Badarian was 200–300 years later than previously thought. Undoubtedly, radiocarbon dating is an important tool in research into the Neolithic period whose chronology is still mostly based on relative methods.[29] New excavation or survey projects on the Egyptian Neolithic promise new evidence and new possibilities of radiocarbon dates, which could not only complete our knowledge, but even trigger a new revolution in the future.

5 Fourth revolution – domesticates in the Western Desert

For many years, the interest of archaeologists focused on areas in the vicinity of the Nile or in the Delta. Scholars had generally accepted that the Sahara was occupied; however, no-one had conducted any comprehensive archaeological research in the desert until the 1960s.[30]

Until the 1970s, the view of early Egyptian farming societies seemed to accord with the perspective of the Neolithic based on the European continent or the Near East. The various features of the Neolithic in Europe and the Levant were all registered among the evidence coming from Lower Egyptian and Faiyumian sites – farming and stock keeping, sedentism, and technological improvement (pottery, flint, and worked stone assemblages). The discoveries of 'domesticated' cattle remains on Early Holocene sites in the Nabta Playa – the Bir Kiseiba area[31] 'destroyed' this perfect vision. As they are dated as early as the 9th–8th millennium BC, they are the earliest known – possibly domesticated – animals in Egypt. According to V. Linseele et al. in the context of these early finds, "cattle keeping in Africa is as old as or older than in the Near Eastern domesticated centres".[32] Archaeological research in both the Western and Eastern Deserts has progressed significantly since the 1960s with new evidence (e.g. earliest pottery, intensive use of wild plants). The great regional variability of the Egyptian (and in fact the Northeastern African Neolithic) has been demonstrated. This new research into the beginnings of food production cannot be put into the framework of the Near Eastern prehistory. Although there is still a lot of controversy surrounding the earliest domesticated cattle in Egypt, these discoveries initiated new discussions on Egyptian and African archaeology. The most important problems include the use of the term Neolithic in Northeast Africa, the existence of an independent African center of early cattle domestication, or even the origin of African pottery. As the research is still ongoing, this revolution has yet not ended.

6 Fifth revolution – the Eastern Desert corridor

Compared to the Western Desert, the Eastern Desert is relatively under-investigated. The discovery of two sites – Sodmein Cave and the Tree Shelter, both with several phases of Neolithic occupation dated to the 7th millennium BC and later with remains of domestic ovicaprines, should be treated also as a revolution. Although bones of domesticated animals are very rare (the only species identified so far is goat), dung of domesticated ovicaprines was recovered on both sites. Thus, it is possible that the sites served as temporary shelters, used repeatedly for short periods.[33] Archaeological evidence

25 E.g. Arnold and Libby 1949; Libby 1955; Hassan 1985; Wendorf 1992; Manning 2006.
26 Hassan 1985.
27 Hendrickx 1999; Shirai 2010; Wengrow et al. 2014; Tassie 2014.
28 Dee et al. 2013.
29 Rowland 2013.
30 Caton-Thompson 1952.
31 E.g. Wendorf, Schild, et al. 1976; Gautier 1984; Wendorf and Schild 1984; Wendorf and Schild 2001; Wendorf and Schild 2003; Jórdeczka et al. 2013.
32 Linseele, Van Neer, et al. 2014.
33 Linseele, Van Neer, et al. 2014.

from both sites shows a close relationship to the Western Desert materials, although ovicaprine bones are not accompanied by the presence of cattle, unlike at the sites on the Western Desert. According to E. Marinova et al. the environmental conditions of the Eastern Desert did not favor cattle keeping, for there are no playa deposits indicating seasonal lakes to provide water and pasture in this area.[34] The same reasons could also explain the lack of sheep. In this context, it is probable that local foragers kept only goat and did not domesticate any other animals and plants.

Undoubtedly, the Sodmein Cave and the Tree Shelter sites are unique in the Egyptian Eastern Desert, with the only parallels found in the Central Sahara. According to V. Linseele et al., these finds belong to the oldest evidence of domestic ovicaprines on the African continent.[35] As ovicaprines are not endemic species and their wild ancestors never lived in Africa, these discoveries are also important in the discussions on the introduction of domesticated animals into Egypt. The introduction corridor of ovicaprines into Egypt from the Southern Levant through the Eastern and Western Deserts could be one possible explanation of the presence of goat at Sodmein Cave and the Tree Shelter sites.[36] However, this problem needs more investigation as the data we currently possess are not sufficient to indicate the exact route.[37]

7 Conclusions and the future of research on the Neolithic and the Neolithisation in Egypt

The history of research into the Egyptian 'Neolithic Revolution' is rather short when compared to the research on the spread of the European Neolithic or the beginnings of food production in the Near East. However, just one century of studies has considerably changed our knowledge on the introduction of domesticated plants and animals. The key moments in this research are here subjectively referred to as revolutions and made from the perspective of someone involved in Neolithic research for only a short period of time. Thanks to analyses of the Neolithic data it is possible to appreciate the great importance of new evidence (the oldest, the earliest) in research into the Neolithic, which appeared in the course of archaeological works and finally changed the view of the period in question.

Archaeologists involved in studying Egyptian prehistory are seeking new data for a number of reasons:

- due to the short history of research the discipline has been under-developed,
- the development of new analytical methods makes it possible to ask more nuanced questions, and
- the general difficulties in obtaining new evidence or even its nonexistence from old excavations.

New excavations and surveys are providing more and more data, including some particularly important data sets, which hold the possibility to turn Egyptian archaeology upside-down and to find answers to previously unanswered questions. However, new evidence is not all that is needed. The lack of balance between data and theories is also clearly visible in Northeastern African Neolithic research. There are still only a few works proposing new models or ideas following general archaeological theories concerning the Neolithic or the Neolithisation in this region.[38] Egypt became a periphery in comprehensive discussions on the Near Eastern prehistory where the theoretical background almost always follows analyses of archaeological evidence. Meanwhile, Egypt has a special geographical and cultural position. It is part of the Near East and also the African continent. Analyzing available evidence from the Delta, the Nile Valley, and the deserts, it is possible to observe two important components of the Neolithic societies: Levantine and African.[39] Moreover, regional variability and climate changes during the Early to Mid-Holocene influenced people's behavior and diversified human cultures.[40]

34 Marinova, Linseele, and Vermeersch 2008.
35 Linseele, Marinova, et al. 2010.
36 Vermeersch et al. 1994; Vermeersch 2008; Linseele, Marinova, et al. 2010; Linseele, Van Neer, et al. 2014; Linseele 2013.
37 See Wengrow 2006, 25; Tassie 2014, 157.
38 E.g. Dittrich 2013; Shirai 2006; Shirai 2013a; Gatto and Zebroni 2015.
39 Tristant 2012; Wengrow et al. 2014.
40 Gatto and Zebroni 2015.

Although at first sight the Intertropical Convergence Zone (ITCZ) divided Early to Mid-Holocene Northeastern Africa into two parts, the northern followed the Near Eastern model of Neolithisation and southern primarily followed African pastoralism. However, some see this as an over-simplification. Recent research has shown that the situation in Egypt in the Early to Mid-Holocene was more complicated than previously assumed. The Egyptian Neolithic was not uniform and consisted of many 'worlds'. On the one hand, the diversity of the Egyptian Neolithic makes it impossible to put it into any well-established framework of the Near Eastern Neolithic. On the other hand, these 'worlds' were not isolated. It is possible to find some similarities in the archaeological evidence or even a common background as an effect of various relations between them. Further research on the Egyptian Neolithic should focus on both variability and convergence within the supra-regional context, without being limited by any geographical, environmental, or political borders.

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Joanne M. Rowland

New Perspectives and Methods Applied to the 'Known' Settlement of Merimde Beni Salama, Western Nile Delta

Summary

The Neolithic settlement of Merimde Beni Salama is unique in providing the earliest evidence for a built Neolithic settlement in North Africa. Previous excavations at Merimde Beni Salama from the 1930s until the 1990s have successfully provided evidence of domestic structures, a mixed economy of domesticated species, hunting, and fishing, and a great deal of artefactual evidence. Recent investigations at Merimde Beni Salama have started to yield new data that contributes to a reassessment of how the settlement changed during the period of use, the spatial extent of the settlement, and the settlement's chronology.

Keywords: Neolithic; Egypt; Delta; Merimde Beni Salama; North Africa

Die neolithische Siedlung Merimde Beni Salama ist einzigartig, da sie die früheste Evidenz in Ägypten für eine gebaute, neolithische Siedlung in Nordafrika darstellt. Frühere Grabungen in Merimde von den 1930er bis 1990er Jahren brachten erfolgreich häusliche Strukturen, eine gemischte Wirtschaft domestizierter Tiere, Jagd und Fischfang sowie eine Vielzahl an Artefakten zutage. Jüngste Untersuchungen in Merimde Beni Salama ergaben neue Daten, die zu einer Neubewertung beitragen, wie die Siedlung sich während ihrer Nutzung sowie bezüglich ihrer räumlichen Ausdehnung und Chronologie veränderte.

Keywords: Neolithikum; Ägypten; Delta; Merimde Beni Salama; Nordafrika

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1 Introduction

1.1 Former investigations

Merimde Beni Salama (hereafter Merimde) presents the earliest evidence for mixed farming within the context of a Neolithic settlement with domestic architecture by the end of the 6th millennium/start of the 5th millennium cal BC in Egypt. Furthermore, it is a unique site in North Africa, having evidence for domesticated plants and animals within a built environment, albeit consisting of ephemeral structures in the earliest phases. Our knowledge to date of Merimde is derived from a series of excavations that took place between 1929 until 2019. The first excavations were made from 1929 to 1939 by Hermann Junker and the Austrian West Delta Expedition.[1] These, and subsequent investigations until the 1990s, have provided the evidence upon which our knowledge of the settlement has been based, including the standing domestic structures built of mud slabs, as well as more ephemeral structures, including windbreaks and shelters/dwellings supported by posts, storage facilities, associated artefacts and ecofacts, and also burials.[2] The limits of the settlement as understood based on Junker's investigations were expanded by the post-war expeditions and were outlined by Eiwanger following the campaigns of the Deutsches Archäologisches Institut (DAI) from 1977 to 1982, which had been initially instigated to re-assess the chronology of the site.[3] The DAI excavations uncovered further areas of the settlement and refined Junker's three settlement phases to five phases. Junker had established his '*Schicht*' I–III, and Eiwanger and his team refined Junker's phase III, into three separate phases: III, IV, and V.[4] The five phases have has been the standard until present. In 1976, the investigations of Hawass, Hassan and Gautier added further to the chronological and, in particular, environmental knowledge of Merimde,[5] building on earlier research published by Butzer.[6]

2 The Neolithic settlement: chronology and environment

Some of the earliest radiocarbon measurements to be conducted in Egypt were run on samples from Merimde. The first series of conventional ^{14}C measurements resulted from ten samples dated in 1959 in Uppsala that were contextually poor and in some cases contaminated.[7] By the 1980s, Hawass et al. contributed another two measurements, and Eiwanger a further eight.[8] These measurements are shown in Table 1.[9] These results originate from samples taken during three different excavations, and they do not have a straightforward contextual relationship. The organic material of the samples from the 1959 Uppsala series consisted of charred grain, wood charcoal, and hippopotamus bone.[10] The security of the contexts is not always clear; some of the samples are related to a depth below surface in meters, associated with a (10 × 10 m) grid square location and for other samples only the grid or the depth are known. Hassan took two further samples during the excavations in 1976, which are related to precise stratigraphical positions.[11] Eiwanger selected charcoal samples from specific layers.[12] Given that short-lived plant remains are generally the most reliable for precise measurements,[13] wood charcoal might not be regarded as optimal today.

In terms of adding absolute chronological data to the Merimde phases, the DAI excavations successfully brought new data to the earliest and latest phases, I and V, but nothing for phases II–IV.[14] Eiwanger expressed uncertainly over the date range during which Merimde

1 Junker 1928; Junker 1929; Junker 1930; Junker 1932; Junker 1933; Junker 1934; Junker 1940.
2 These include Badawi et al. 2014; Eiwanger 1984; Eiwanger 1988; Eiwanger 1992; Hawass, Hassan, and Gautier 1988.
3 Eiwanger 1988, fig. 1.
4 The relationship between Junker's Schicht and Eiwanger's phases are referred to in the discussion below on the new radiocarbon results.
5 Hawass, Hassan, and Gautier 1988.
6 Butzer 1960.
7 Olsson 1959, 96–97; Hassan 1985, 104–105; von den Driesch and Boessneck 1985, 2.
8 Hawass, Hassan, and Gautier 1988, 32, Table 1; Hassan 1985, 104–105; von den Driesch and Boessneck 1985, 2.
9 Tab. 1 includes a new series of accelerator mass spectrometry (AMS) measurements on material from Junker's excavations held in the Medelhavsmuseet in Stockholm and the Petrie Museum of Egyptian Archaeology, University College London.
10 Olsson 1959.
11 Hawass, Hassan, and Gautier 1988.
12 Hawass, Hassan, and Gautier 1988, 33; von den Driesch and Boessneck 1985, 2; for discussion of suitability of materials in radiocarbon measurements see Dee et al. 2012, 868–883.
13 Dee et al. 2012, 875.
14 von den Driesch and Boessneck 1985, 2.

was in use (see Tab. 1), suggesting that phase I should be earlier and phase V later. Uppsala Series U-6 returned a range of 5202–5003 cal BC, although it seems to have been accepted in the past that the earliest date for Merimde may have been 4800 cal BC.[15] The aforementioned samples were all charcoal.[16] Overall, from the samples measured prior to 2015, the material types varied from reliable to much less reliable samples (from charred grain, to charcoal, to bone apatite from animal remains). Some samples have been reasonably considered less reliable, predominantly due to a lack of contextual integrity, and were rejected in the modelling by Hassan amongst others.[17]

Already in 1960, the natural local environment of Merimde was the subject of discussion in an article by Karl Butzer, charting the environment in Egypt from prehistory and into the dynastic period.[18] In more recent times, Butzer reassessed the Merimde environment within research into the wider geographical context of the Nile Delta.[19] A brief environmental coring survey was carried out during Eiwanger's work in the 1970s and 1980s,[20] but a specific focus of Hassan during his work with Hawass and Gautier in 1976 was to examine the archaeological contexts within their natural environment and to consider the absolute dating, within a wider reassessment of the site's absolute chronology.[21] They arrived at the conclusion that groups first settled at Merimde following a wet phase, and that an arid environment prevailed throughout the period during which the Merimde settlement – or settlements – was in use.[22] The earliest possible date (Uppsala series) would bring the date of the earliest occupation to 5202 BC,[23] but in general the radiocarbon measurements range from ca. 4900 BC through to ca. 4000 BC.[24]

Although Merimde is presented in some sources as a well-known site, with defined phasing, there are lacunae as well as problems with earlier results. To a great extent, the results reflect the time of the excavations, notably for the 1930s, in terms of contextual integrity. By the 1970s and 1980s, field methods were dramatically different, with much greater stratigraphic control. However, the dispersed and fluid nature of the settlement, which moved most probably according to natural environmental changes, makes it difficult to assess the site (stratigraphically at least) as a whole. A second key issue is that the excavations focused upon the area thought to be the main site, and much less intensive attention was given to the surrounding areas.

3 Neolithic settlement and activity across the hinterland of Merimde Beni Salama

With the benefit of geomagnetic survey, new, enlarged limits of the Neolithic settlement have been established since 2013, notably to the southwest of the earlier known settled area (Fig. 1, Area A and Area B).[25] Features, including possible structures and pits, have been confirmed through excavation as being Neolithic by artefactual association. The size of the settlement, and in particular the hinterland used, is substantially larger than had been assumed previously.[26] The Neolithic settlement had been considered to be ca. 25 hectares on the basis of previous research, but today at least 40 hectares seems reasonable, and potentially 50–60 more accurate.[27]

15 Hassan 1985, 105, suggested that the settlement at Merimde might date from ca. 4800 cal BC, although later Hawass, Hassan, and Gautier 1988, 32, 38, suggest that it might date to the beginning of the 5th millennium BC. Eiwanger (personal communication) considers a pre-5th millennium date possible.

16 Eiwanger 1980, 60; von den Driesch and Boessneck 1985, 2.

17 Hawass, Hassan, and Gautier 1988, 31–32.

18 Butzer 1960.

19 Butzer 2002.

20 Eiwanger, personal communication.

21 Hawass, Hassan, and Gautier 1988. The new radiocarbon measurements were conducted on grain and charcoal, with other previous samples from these materials, as well as apatite and collagen.

22 Hawass, Hassan, and Gautier 1988, 35, 38.

23 U-9A and U-9B (of unknown depth) as well as U-6 provided the earliest results – see Tab. 1 – and are amongst the first radiocarbon measurements run on material from Merimde: Olsson 1959; Hawass, Hassan, and Gautier 1988, 32.

24 Olsson 1959. See Tab. 1.

25 The geomagnetic survey at Merimde was undertaken in 2013 by Cornelius Meyer and Dana Pilz of Eastern Atlas, Berlin. See Rowland 2015, 37–39; Rowland and Bertini 2016, Fig. 165–167.

26 Junker 1932, plan by K. Bittel; Eiwanger 1984, 9; Eiwanger 1988, Fig. 1, shows the suspected extent of the Neolithic settlement.

27 This takes into account fresh Neolithic finds uncovered by the Ministry of Tourism and Antiquities during their investigations ahead of the laying of a gas pipeline running west of the archaeological area. Tassie, this volume (p. 279) discusses 50–60 hectares as representing the wider catchment area, of which the Wadi el-Gamal (discussed below) is a part, and it could be larger still.

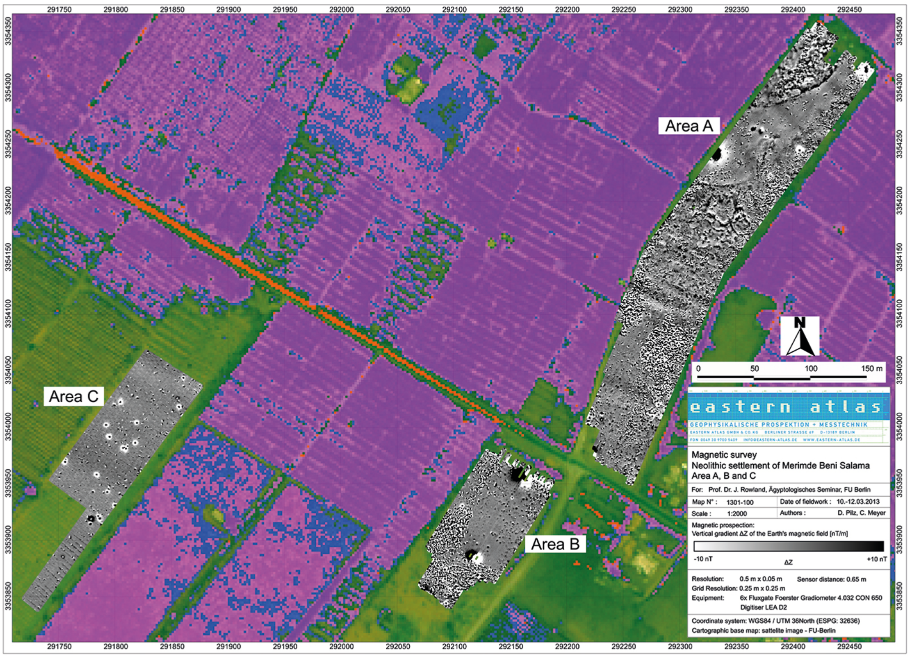

Fig. 1 Results of the geomagnetic survey at Merimde Beni Salama in 2013, showing the location of Area A (the registered archaeological land) and Area B on the very lowest part of the Wadi el-Gamal.

Much of the land preserved today as the registered archaeological land of Merimde Beni Salama has never been investigated archaeologically (see Figure 2 for areas of former and current excavation).[28] This strip of land is surrounded by cultivation today, but does not in any way represent the ancient extent of Merimde.[29] This is highlighted when looking at satellite images, and examining the location of the previous excavations in proximity to the strip of land, for which there is a minimal area of overlap. Excavations were made on three sides of Area A – the north, south, and westernmost sides of the site – investigated during the digging of foundations ahead of a protective wall and guardians' room.[30] These excavations revealed previously unknown areas of settlement, including pits, hearths, and staining that may be associated with ephemeral structures, including organic windbreaks. Area B on the magnetic survey had never been examined extensively, and excavation suggests that it might have, at times, been connected to the settlement. It includes pits and traces of a circular structure.[31] In association with this structure are frequent ceramics and large fragments of grinding stones, close by to an area with numerous animal remains possibly representing a place used for the preparation of meat. The faunal remains included a fragment of an articulated cow leg; it could have also been an area for communal consumption.

Moving higher up on onto the terraces cut during the Middle Palaeolithic, southwest of Areas A and B, both Middle Palaeolithic and Neolithic contexts were first located in test trenches in autumn 2015.[32] Investigations here on the Wadi el-Gamal[33] provided the first Middle Palaeolithic evidence *in situ* from this area.[34] Surface finds lying in the area of the Wadi el-Gamal include Neolithic rough ceramic sherds, some associated with cooking, and frequent chipped stone artefacts, although artefacts that have been subject to weathering. One of the largest grinding slabs ever to have been found at or near to Merimde also originates in this area (Area A, Sq. 41),

28 During excavations in the 1970s and 1980s, a small test trench by the DAI mission did reveal Neolithic remains near the asphalt road (J. Eiwanger, personal communication).
29 Area A in Fig. 1 corresponds to the registered site.
30 This low protective wall was funded by the American Research Center in Egypt's 'Antiquities' Endowment Fund' (ARCE AEF).
31 See illustration in Rowland and Tassie 2014, 38.
32 The results of these excavations will be published elsewhere.
33 Rowland and Tassie 2014; Rowland and Bertini 2016. The name Wadi el-Gamal has been used in the literature since the 1980s to refer to the Pleistocene terraces southwest of the registered antiquities' land (Schmidt 1980).
34 A broader discussion of the known surface evidence can be found in Schmidt 1980; Rowland and Tassie 2014; Rowland and Bertini 2016. The date of this activity is currently hypothesized as early as c. 120 000 BP, but potentially as late as 50 000 BP, but as yet this cannot be confirmed in absolute years.

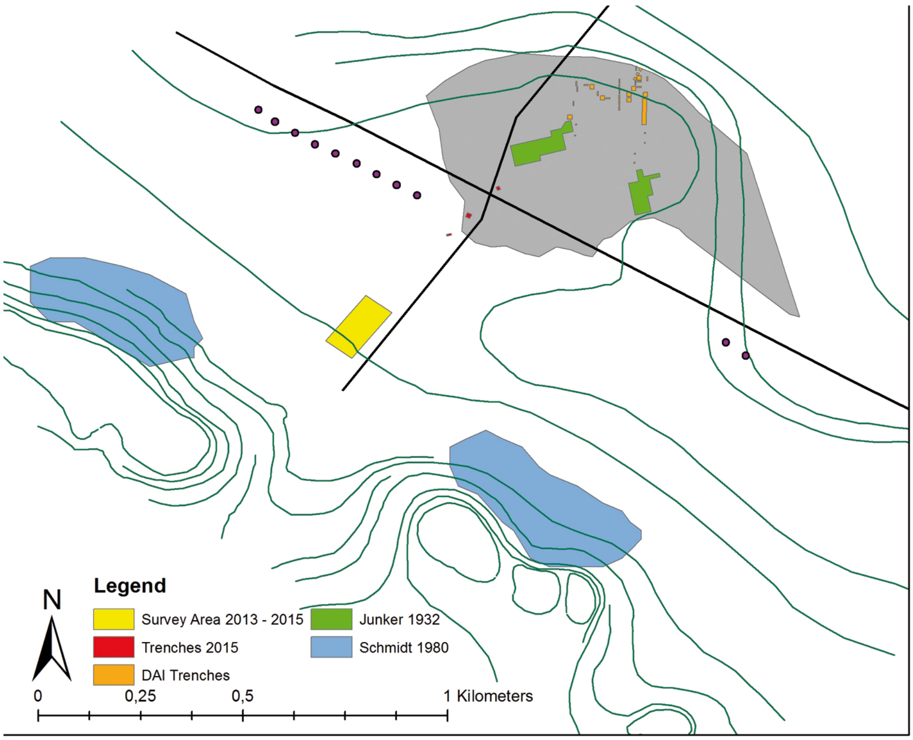

Fig. 2 Composite plan showing areas of investigation by missions at Merimde Beni Salama (relevant to the Neolithic: Junker = green, Hawass et al. and Eiwanger = orange, Rowland = red and yellow [later Wadi el-Gamal]; the line of dots represents location of the pipeline trenches referred to above). The area in grey defines what used to be considered as the extent of the Neolithic settlement.

with depressions close by containing dense deposits of debitage (Fig. 3). These terraces provide good sources for raw materials for tools, in the form of chert cobbles that have been washed down the wadi and deposited close to its mouth. The evidence from the Wadi suggests that groups of people were spending limited periods of time on the terraces, periods that may coincide with the passing through of animals looking to water at certain times of year. This area could have been utilized regularly at the time of the annual inundation, or limited to years of particularly high floods. Substantial excavations in this area revealed dozens of simple hearths, large postholes, with remains of the ceramics or stone pieces used as post packing, and frequent evidence of cooking vessels and lithics of Neolithic date.[35] Surprisingly, there were four human burials (two adults and two children) in this same area. This new evidence can support the hypothesis that groups may have been spending extended periods of time in this location, as opposed to only moving up to the Wadi to collect material/hunt and then walking the short distance back down to the settlement. Another question is whether the Wadi was utilized by groups inhabiting the Merimde settlement at all, or by other mobile groups who lived side-by-side with the villagers of Merimde, or by groups present prior to or during the very earliest stages of, the Merimde settlement. For now, as suggested, it might be hypothesized either that the Wadi may have been in greater use at specific times of the year, for example, to avoid the floodplain during the annual inundation, or to benefit from wild animal resources when water attracted species to the Wadi mouth area. The possibility of use being affected by abrupt climatic change, or even more gradually changing environmental conditions is one for ongoing consideration. Anticipated environmental and climatic work, including simulations should help in elucidating this; pollen samples will play a part in this research, as a key proxy for environmental change.

Establishing the environmental conditions prior to settlement will be important, in order to assess why groups began to settle at Merimde when they did. Although the recent fieldwork has not produced anything

35 The Wadi el-Gamal Rescue Project was funded by the National Geographic Society grant number GEFNE165-16 and the American Research Center in Egypt's Antiquities' Endowment Fund. These results are not discussed here, but the excavations proved that the Pleistocene terraces had been used extensively during the Neolithic.

Fig. 3 Wadi el-Gamal, Sq. 41, looking southwest, showing depressions that had been filled with debitage.

clearly definable as Epipalaeolithic in the toolkit at Merimde or on the Wadi el-Gamal as of yet, Eiwanger considered that the earliest phase at Merimde, the *Urschicht*, possesses a number of Epipalaeolithic traits in the lithic toolkit.[36] It can be, also, that we are looking for something very specific that never existed in the area. Evidence may be sparse in the area directly around the settlement of Merimde, but examination of material found further afield in much earlier investigations may prove informative.[37] A very preliminary discussion is found in Rowland and Bertini.[38]

3.1 Re-assessing the local environment at Merimde

Research in various regions in and around Egypt has long considered the extent to which the natural environment and climatic change are central issues connected with the emergence of 'Neolithic' lifeways. Hassan considered that the initial phases of settlement at Merimde correspond with an oncoming arid phase, and absolute dates correspond with the time at which desert sites, including the Hidden Valley Village in the Wadi el Obeyid at Farafra Oasis, show a considerable decline in the density of settlement activity.[39] Barich and Lucarini link this decline to the changing climate and the monsoonal retreat, although there is evidence for, if reduced, occupation in the Hidden Valley area until as late as 2500 BC, with the start of the final phase, Wadi el-Obeiyid C, starting at 5200 BC.[40] Researchers comment increasingly on the impact of global climatic change on such processes as Neolithisation.[41] This is extremely valid, however, the importance of local environmental data should not be understated. Preliminary environmental coring examined and exposed sections in the area around the settlement from the Pleistocene terraces in the west, through the site to the modern Nasiry and Beheiry Canals in the east.[42] A series of continuous and interrupted cores con-

36 von den Driesch and Boessneck 1985, 2. Eiwanger 1980, 69–70.
37 Menghin 1932a; Menghin 1932b.
38 Rowland and Bertini 2016, 162–164.
39 Hawass, Hassan, and Gautier 1988, 38; Barich and Lucarini 2014, 480–481.
40 Barich and Lucarini 2014, 480.
41 The impact of the 7300 cal BP climate event was raised in a number of papers during the Revolutions' workshop. A brief overview of former and more recent research into the changing environment is given by Phillipps et al. 2017, 10, and more specifically in relation to the Neolithic Fayum by Holdaway, Wendrich, and Phillipps 2017, 219–220.
42 The pilot project at Merimde Beni Salama, including the environmental survey, was funded by the Fritz Thyssen Stiftung. Additional project funding (not including the rescue project in 2016) has been generously provided by the TOPOI Excellence Cluster 264 at the Freie Universität Berlin and the Egypt Exploration Society.

tribute to the new environmental profile of the area;[43] with two further cores east of the Rosetta branch at Kom el-Ahmar Abu Awally, west of Ashmun; one core reached 22 m below the surface.[44] Initial analysis of the environmental core sediments extracted, combined with examination of exposed sections on the terraces of the Wadi el-Gamal, suggest a sheltered environment.[45] This could have rendered the area particularly suitable for settlement by the end of the 5th millennium BC.

Butzer argued that floodplain geomorphology was not central to the timing of the first settled farmers in Egypt.[46] However, it could be one factor amongst others that made it possible at a given time and place, if not causal by itself. Sedimentary analysis does indicate that clear changes existed at around the time of settlement at Merimde, as recognized by Hassan.[47] The sediments on the Wadi el-Gamal and the cores to the east, suggest a wooded environment during the Neolithic.[48] The area close to the fan of the Wadi el-Gamal and particularly the lower Pleistocene terraces probably provided a sheltered and suitable location for early settlement in the area at least by the Neolithic, probably by the Epipalaeolithic.

Analysis of the plant remains, including those selected for AMS, is crucial for ongoing environmental reconstruction, as well as consideration of the earliest farming practices. Analysis has been successful in revealing additional species, amongst them field weeds.[49]

3.2 Revisiting chronology and change at Merimde: planning from the past for the future

Pre-existing discussions on the phases and extent knowledge on the absolute chronology at Merimde have been touched upon here. In order, however, to better monitor changes during the lifetime of the settlement, a tighter chronological model with absolute dates is fundamental to improving our knowledge of what happened, when it happened, and correspondingly to the wider Neolithic of the Delta and beyond. Essential to this is a revisiting of the Merimde phasing and corresponding attempts to place this in more secure absolute terms, and this will be addressed in tandem with an assessment of the wider spatial distribution of contexts, finds, and functions at Merimde. Examination of archives for the spatial distribution is in progress, and will be collated with the records from the ongoing work. Merimde requires virtual reconstruction, including the fresh results from the Wadi el-Gamal as well as Area A and B. As part of this vision, museum-based research that has been carried out from 2013–2016 will be integrated within the ongoing research.[50] This is being made possible through the records of artefacts, plant, human, and animal remains from all of the worldwide collections holding material from Junker's excavations.[51] Archaeological contexts and associated finds from earlier investigations are contributing to a new examination of settlement patterns and change over time.[52] This approach, embedding environmental survey and modelling, will help to ascertain whether the site initially comprised a number of dispersed clusters of ephemeral dwellings that coalesced over time into a single larger settlement, with shared storage and food processing facilities, to withstand the variable climate and Nile floods.

A major part of any re-examination of the nature and growth of human occupation at and around Merimde, requires a revised chronological assessment. Although it is not possible to export excavated material for measurements outside of Egypt, and there is currently no AMS facility in Egypt, it is possible to run new series of radiocarbon measurements using AMS from secure contexts.[53] Re-examination of finds from Merimde, in-

43 The environmental coring survey with the continuous coring was directed by Prof. Mohamed Hamdan, Cairo University, and is in preparation for publication; an additional hand auger survey ran simultaneously directed by Dr Judith Bunbury, University of Cambridge.

44 The results of analysis on the environmental cores are subject of a dedicated publication (in preparation).

45 Hamdan, personal communication; Hamdan 2013.

46 Butzer 2002, 93–96.

47 Noted in Hawass, Hassan, and Gautier 1988.

48 Hamdan 2013.

49 The archaeobotanical analysis was carried out by Mennat-Allah El Dorry on material at the Medelhavsmuseet, Stockholm.

50 This research was carried out within the scope of the TOPOI A-2-4 project 'The Neolithic of the Nile Delta' directed by the author.

51 The finds are now available to search at: http://repository.edition-topoi.org/collection/MRMD/ (last visited: 07/10/2019).

52 This includes the finds from the DAI investigations in the 1970s and 1980s in co-operation with J. Eiwanger.

53 This includes a collaboration with J. Eiwanger and the TOPOI Excellence Cluster 264 funded A-2-4 project 'The Neolithic of the Nile Delta,' which enabled organic material from Junker's excavations to be examined from an archaeobotanical perspective by Dr Mennat-Allah El Dorry, and samples to be forwarded to the Poznań Radiocarbon Dating Laboratory from the Medelhavsmuseet (thanks to Dr

Laboratory No.	Accession No. where known	MBS Context/ Depth Below Surface	Raw Material	Radiocarbon Age BP	Calibrated Years BC from at 95.4%	Calibrated Years BC to at 95.4%
WSU-1846		TT2, 0.75 m m	Charred grain	5260 ± 90	4222	3998
W-4355		TT2, 1.02 m	Charcoal	5750 ± 100	4668	4546
U-73		T4, 0.60 m (same as U-10 A/B)	Charred grain	5640 ± 100	4495	4454
U-10B		T4, 0.60 m	Charred grain	5550 ± 100	4446	4351
U-10A		T6, 0.60 m	Charred grain	5430 ± 120	4335	4262
U-9A		1.80 m	Charcoal (tamarisk)	5970 ± 120	4898	4801
U-9B		1.80 m	Charcoal (tamarisk)	5940 ± 100	4841	4787
U-31		T4, 1.80 m (same as U-32)	Bone apatite (hippopotamus)	3630 ± 100	2026	1956
U-32		T4, 1.80 m (same as U-31)	Bone collagen (hippopotamus	4560 ± 140	3365	3141
U-6		1.80 m	Charcoal	6130 ± 110	5202	5003
U-7		R1	Charred grains	5700 ± 700	4548	4498
U-8		A18, depth unknown	Charcoal	5580 ± 230	4451	4366
KN-3275		I.1	Charcoal	5830 ± 60	4721	4687
KN-3276		I.2	Charcoal	5790 ± 60	4691	4606
KN-3277		I.3	Charcoal	5890 ± 60	4788	4724
KN-3278		V.1	Charcoal	5590 ± 60	4455	4369
KN-3279		V.2	Charcoal	5760 ± 60	4680	4550
Poz-79422	MM14224D.20	T6, 1.80 m, hearth	Charred grain (Triticum dicoccum)	5457 ± 38	4361	4241
Poz-79423	MM14224D.27	Q4, 1.00 m, hearth	Charred grain (Triticum dicoccum)	5518 ± 38 BP	4453	4273
Poz-79424	MM14224D.28	R4, 1.80 m, Burial 27	Charred grain (Triticum dicoccum)	5647 ± 37 BP	4549	4369
Poz-79453	MM14224D.29	S7, 2.80-3.00 m; SW corner	Charred grain (Triticum dicoccum)	5707 ± 32 BP	4669	4459
Poz-79454	MM14224D.48	R5, 0.40 m, floor of house 1	Charred grain (Triticum dicoccum)	5515 ± 31 BP	4449	4328
Poz-79455	MM14224D.23	R5, 0.40 m, Basket II	Charred grain (Triticum dicoccum)	5526 ± 28 BP	4449	4335
Poz-79456	MM14224D.52	R4, 1.30 m, with burial 12	Charred grain (Triticum dicoccum)	5707 ± 37 BP	4679	4459
Poz-79457	MM14224D.63	R4, 1.00 m, with burial 8	Charred grain (Triticum dicoccum)	5666 ± 32 BP	4585	4400
Poz-79460	MM14224D.14	T4, 0.20 m, basket I	Charred grain (Triticum dicoccum)	5611 ± 30 BP	4500	4361
Poz-79461	MM14224D.26	R1, 2.00 m (same context as Poz-79463)	Charred grain (Triticum dicoccum)	5707 ± 35 BP	4678	4459
Poz-79462	MM14224D.21	Q4 1.60 m	Charred grain (Triticum dicoccum)	5730 ± 36 BP	4687	4491
Poz-79463	UC10992	R1, 2.00 m (same context as Poz-79461)	Charred grain (Triticum dicoccum)	5792 ± 38	4726	4541

Tab. 1 All radiocarbon measurements that have been taken on material from Merimde Beni Salama, including by the current project.

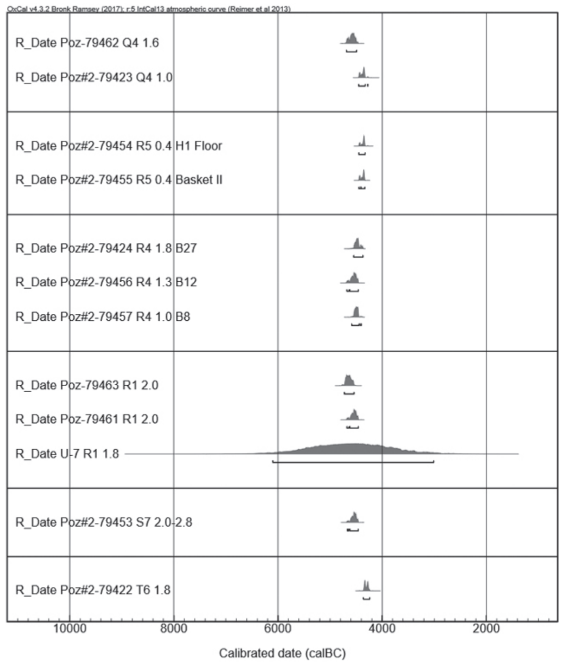

Fig. 4 Plot of all radiocarbon measurements from Merimde Beni Salama in OxCal, part 1. Dates are shown in calibrated years BC and are grouped by excavation areas and/or relative depths where the information is available.

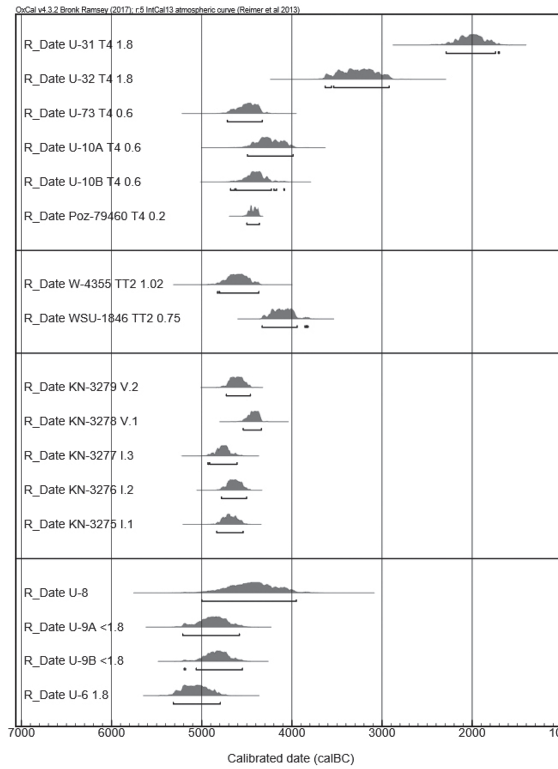

Fig. 5 Plot of all radiocarbon measurements from Merimde Beni Salama in OxCal, part 2. Dates are shown in calibrated years BC and are grouped by excavation areas and/or relative depths where the information is available.

cluding archival documents and museum-based faunal and plant remains from the site, led to the first 12 AMS samples for Merimde. They comprised samples of short-lived plant remains (charred grain) from the Junker excavations, with the maximum sample size of 11 mg (Tab. 1, including past results from Merimde, also plotted in Figs. 4 and 5, indicated by the Poznań [Poz] laboratory codes). Short-lived plant remains were selected (charred grain), which can lessen the problem of inbuilt age.[54] All of these samples were taken from the easternmost contexts excavated by Junker and were selected to cover a range of different phases during the occupation of Merimde (Tab. 1). Where possible, the samples were selected due to their contextual link to specific structures or burials. All measurements are shown at the 95.4% probability range, calibrated within OxCal version 4.3.2[55] on the r.5 IntCal13 atmospheric curve[56] (Tab. 1). The new AMS results are shown in Figs. 6 and 7, and are included together with previous results in Figs. 4 and 5. Figs. 4 and 5 group the results according to find location.[57]

The radiocarbon measurements obtained in the first set of dates, the Uppsala series (U dates in Tab. 1 and Figs. 4 and 5), consisted of samples taken mainly from the excavations in the easternmost Junker trenches, at varied depths below surface but without further contextual detail.[58] The first set of results from Eiwanger's excavations (KN in Tab. 1 and Figs. 4 and 5) are expressed in their relation to phases assigned by the excavators, three each to

Sofia Haggman and Ms Carolin Johansson) and the Petrie Museum of Egyptian Archaeology (thanks to Dr Alice Stevenson, Institute of Archaeology, UCL).

54 Ramsey et al. 2010; Dee et al. 2012.

55 Ramsey 1995; Ramsey 2009a; Ramsey 2009b; Reimer et al. 2013.

56 Reimer et al. 2013.

57 Find locations taken from Hawass, Hassan, and Gautier 1988; Olsson 1959. The new AMS results are published here for the first time.

58 Olsson 1959, 97.

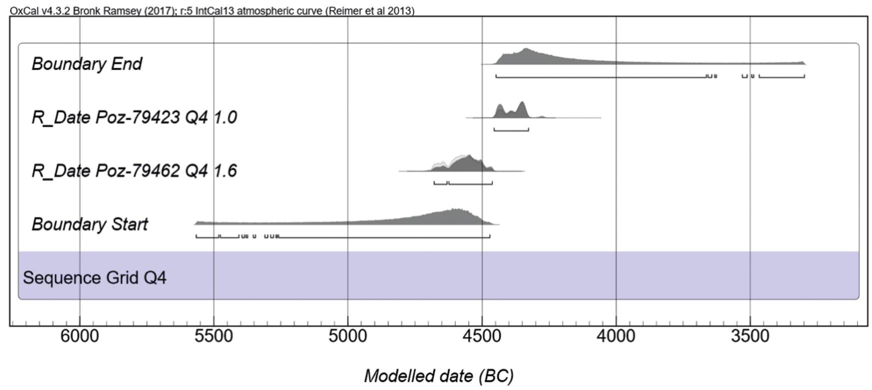

Fig. 6 Modelled AMS results from samples from Junker's excavation grid Q4. Dates are shown in calibrated years BC.

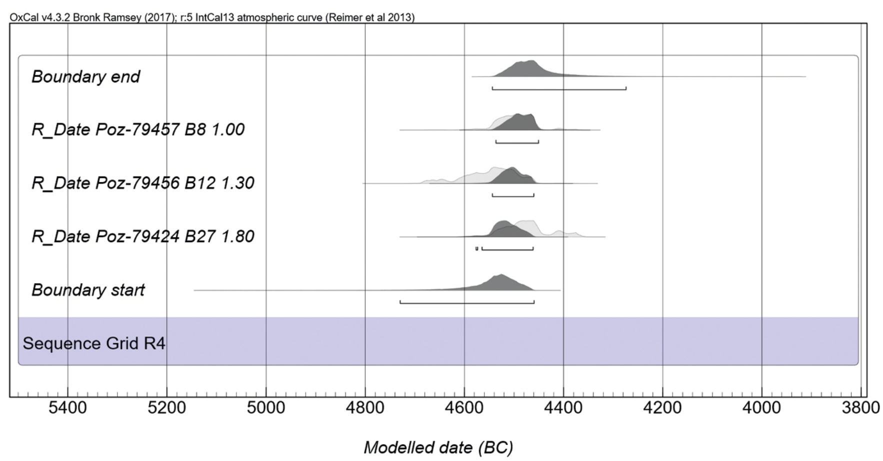

Fig. 7 Modelled AMS results from samples from Junker's excavation grid R4. Dates are shown in calibrated years BC.

the youngest (V) and oldest (I) phases, but without significant detail.[59] The contribution of Hawass et al. includes specific locations within their trenches (WSU and W dates in Tab. 1 and Figs. 4 and 5).[60] Contexts have been considered in terms of depths beneath the surface, as well as being assigned to one (or more, where unknown) of the five phases of the settlement. The most recent samples, which are the first AMS samples for Merimde, were selected by the author from charred plant remains from Junker's excavations (Poznań series in Tab. 1, Figs. 4 and 5, as well as Figs. 6 and 7) and taken from specific contexts. The increased precision of these recent measurements is clear, for example as seen in Tab. 1 and Figs. 4 and 5. Additionally, for the samples from Grids Q4 and R4 of Junker's excavation areas, it has been possible to model these, due to relative depth information (Figs. 6 and 7). It must be added, however, that this is based entirely at present on depth variations and not precise stratigraphic detail. The written documentation is in the process of being examined at the Medelhavsmuseet in Stockholm.[61] In the instance of Figs. 4 and 5 concerning the samples from Grid R4, the modelling of the dates from three burials has proved productive in significantly compressing the ranges for Burials 27 and 12. Two samples from excavation square R5, both at a depth of 0.40 m, a basket and the floor of a house, correspond closely but have not been modelled here (Poz-79455 and Poz-79454 in Tab. 1 and Figs. 4 and 5).

From the previous work – notably the relative phasing of the site – phases III, IV, and V of Eiwanger roughly correspond to Junker's Schicht III, but the phases and Schicht are not interchangeable. The Merimde phases

59 von den Driesch and Boessneck 1985, 2; Eiwanger 1988, 53; Eiwanger 1992, 75.

60 Hawass, Hassan, and Gautier 1988, 31–32.

61 The support and generous assistance of Dr. Sofia Häggman and Ms. Carolin Johansson is gratefully acknowledged.

have been considered to show influence from contacts with different regions, as stated by Eiwanger, and have recently been discussed again by Tristant.[62] Given the differences in the phasing of Junker and Eiwanger, a new stratigraphical model of the site, including environmental and chronological data, will be crucial. Eiwanger suggests that in his phase I there is a blade industry, in addition to artefacts of the Levantine earliest Pottery Neolithic with a series of Epipalaeolithic additions, and also evidence for shells from the Red Sea.[63] Eiwanger's second phase is characterized rather through what he described as an undeveloped nuclear culture, which is not similar to other Egyptian sites of corresponding date, and is described as not being identical to Junker's Schicht II in any way.[64] Eiwanger notes that the black polished ceramics do not appear in Phase II, and that his Phase II does show connections to the Sudanese and southern Saharan Neolithic;[65] his Phase III to V shows a continuous development and can be compared to Junker's. In the youngest phase the hollow-based arrowheads occur, which show a link to the later Fayum Neolithic (Fayum A); at the same time, the youngest phases are also linked with the Levantine sequence.[66] Eiwanger has observed specific areas of the Neolithic settlement where certain phases are not represented, and the phase I–V schematic section published represents the bringing together of these phases, as the five phases have not yet been located within any single area of the settlement.[67]

3.3 Fitting Merimde Beni Salama alongside the new Neolithic landscape

Since the excavations in the 1980s, there has been a wealth of new research, both field and museum-based, with new comparative material from the Nile Valley, Libya, and the Western Desert, as well as the Sinai and the Levant. Furthermore, the discovery of the Neolithic at Sa el-Hagar (Sais), just 70 km north of Merimde has added greatly to our knowledge of the Neolithic of the Delta and has provided much new material of interest.[68] It has been noted that some of the stone types used at Sa el-Hagar in the Neolithic are comparable to the cobbles of the Wadi el-Gamal.[69] As analysis continues on the freshly revealed evidence from Merimde, cross-comparisons will be drawn with the evidence from Sais, and of course that from other sites in a similar environment to Merimde, el-Omari, ca. 60 km southeast of Merimde, and the area around Helwan where the Epipalaeolithic is in evidence also, including the area of Wadi Hof.[70]

Within the phases of Merimde, differences are observable in the presence/absence and relative proportion of species of faunal remains and also plant remains. The new research has already added some new data, although despite modern methods, the increased cultivation around Merimde has not improved the preservation of botanical remains. One area, however, in which progress is not affected by such modern problems, is in the application of scientific methods to artefacts. This has included residue analysis, for which samples have been examined from ground stone implements, including the lower grinder found in context on the Wadi el-Gamal Northeast terraces.[71] A pilot study carried out for organic residue analysis of 10 potsherds from a range of contexts at Merimde yielded very promising results that showed the preservation of residues associated with ruminant and non-ruminant species at Merimde. These were selected from the excavations of Junker, and the analysis conducted by Julie Dunne was made possible by kind permission of the Medelhavsmuseet in Stockholm.[72] This pilot study will provide the basis for a large-scale chronological investigation of diet and subsistence practices at Merimde, with radiocarbon dating potential now existing for the lipids extracted.

62 The characteristics of the assemblage suggest that in the earliest layers there is similarity to Levantine evidence, then Saharo-Sudanese, and later the Fayum Neolithic. See Eiwanger 1980, 69; Eiwanger 1984; Eiwanger 1988; Eiwanger 1992; Midant-Reynes 2000, 108–118; Tristant 2006, 32–37; Rowland and Bertini 2016, 2.

63 Eiwanger 1980, 69. Eiwanger (personal communication) further notes that his Phase 1 is missing in the stratigraphy from Junker's excavations.

64 Eiwanger 1980, 69.

65 Eiwanger, personal communication.

66 Eiwanger 1980, 70.

67 Eiwanger 1982; Eiwanger 1992, Fig. 3.

68 Wilson, Gilbert, and Tassie 2014; Wilson 2006.

69 Rebecca Phillipps, personal communication.

70 Debono and Mortensen 1990; also discussed in Rowland and Bertini 2016, 3.

71 These results will be included within the forthcoming paper concerned with plant remains.

72 The number of samples is too low for wider discussion, but further sampling is anticipated as part of the ongoing project design.

4 Concluding remarks

The idea of Merimde having been a single community from the beginning is probably unlikely. It can be hypothesized that the settlement began as a series of smaller clusters founded by groups arriving in the area looking for suitable places close to water that also had access to shelter and elevated land. The first settlers may have been seasonal, and the lack of finds such as sickle blades within Merimde I, for example, indicates a gradual uptake of the varied aspects of settled, farming life. Over time, Merimde appears to function more and more as a community, with large storage pits lined with basketry, and more robust domestic structures built of mud slabs. The potential street of Merimde was recorded in 1933, and relates to a later period of settlement, when these more durable, mud structures are in evidence (Merimde IV–V).[73] The phasing of Merimde and broad absolute date ranges have been largely accepted in the published literature, however, the more recently discovered areas of Neolithic activity have to be considered within the context of the previously known settlement areas. Examination of the spatial distribution of areas of activity has not been foremost in analysis until now, but should prove fruitful for examining the daily lives of those living in the community, over time. Digital access to finds from former excavations has been enabled by the tireless work of the late G. J. Tassie, assisted by S. Falk.[74] Despite current export limitations and the availability of equipment within Egypt at the time of writing, AMS measurements and analysis of residues within ceramics are restricted to the finds from the Austrian West Delta Expedition that were distributed to a number of museum collections around the world.[75] The results of the first AMS measurements are presented here as a contribution towards reassessing the absolute dating of the site. In combination, these renewed investigations in and out of the field will allow us to start answering the questions of exactly when domesticated plants and animals appeared in the western Nile Delta, and of the absolute timing of fluctuations in the use of particular species.

As shown here, the research potential for excavated material/contexts from current and former excavations is huge. The planned work will add significantly to how we see and understand the development and growth of Merimde, particularly in relation to the local environment and changing climate. Already, by taking a wider perspective in terms of exploitation of the landscape around Merimde, employing now standard geophysical techniques, and environmental coring, a much larger area of use has been uncovered, as has a much clearer picture of the local environment. Further environmental surveys will follow across a longer stretch of the western Delta fringes, to capture what is possible in a fast-changing modern environment. This may have the added result of locating further Neolithic or even Epipalaeolithic findspots.

73 Junker 1933, 58–62.

74 Published online at http://repository.edition-topoi.org/collection/MRMD/metadata (last visited: 07/10/2019).

75 This research was carried out within the framework of the TOPOI Excellence Cluster 264, project A-2-4 'The Neolithic of the Nile Delta'. The objects from Merimde Beni Salama in museum collections that were recorded during the TOPOI A-2-4 can be viewed at http://repository.edition-topoi.org/collection/MRMD/overview (last visited: 07/10/2019). The samples were provided by the kind permission of the Medelhavsmusset in Stockholm, and thanks go to Dr Sofia Häggman and Ms Carolin Johansson. For an example of find types see Larsen 1957; Larsen 1958; Larsen 1959; Larsen 1960; Larsen 1962.

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Revolutions of the Middle Nile – the Dynamics of a Holocene Riverscape

Summary

The early Holocene Nile riverscape differed significantly from today due to higher precipitation, turning it into vast wetlands with numerous cut-off ephemeral lakes. Recent archaeological work on Mograt Island (Sudan) involved soil and stratigraphic studies to reconstruct the dynamics between 9500 and 4000 cal BC and the conditions for plant cultivation. It is argued that arable soils were initially present in dried-up lake sediments at the upper river terrace long before the annual flooding of lower areas was established. Such land use patterns differ from the later river-dependent irrigation that became almost synonymous to the modern notion of agriculture along the Nile.

Keywords: Sudan; Nile valley; Holocene; wetlands; rain-fed cultivation; early agriculture; water storage

Die frühholozäne Nillandschaft unterschied sich aufgrund höherer Niederschläge, wodurch ausgedehnte Feuchtgebiete mit zahlreichen temporären Lagunenseen entstanden, erheblich von der heutigen. Neue archäologische Arbeiten auf der Insel Mograt (Sudan) schlossen bodenkundliche und stratigrafische Untersuchungen ein, um die Dynamik zwischen 9500 und 4000 cal BC und die Voraussetzungen für den Anbau von Pflanzen zu rekonstruieren. Es wird argumentiert, dass fruchtbare Böden zunächst mit den ausgetrockneten Seesedimenten auf der oberen Flussterrasse verfügbar waren, lange bevor die jährliche Überflutung der tiefer gelegenen Ebenen einsetzte. Derartige Formen der Landnutzung unterscheiden sich von der späteren, flussabhängigen Bewässerungskultur, die nahezu synonym zur modernen Vorstellung von der Landwirtschaft entlang des Nils wurde.

Keywords: Sudan; Niltal; Holozän; Feuchtgebiete; Regenfeldbau; frühe Landwirtschaft; Wasserspeicherung

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1 The Holocene Middle Nile Valley

The Holocene constitutes an important period of activity in the long sequence of the Nile Valley formation. This formation finally resulted in the present conditions of the Nile River, with the main White Nile being fed from Lake Victoria and the Blue Nile seasonally adding water from the Ethiopian highlands, as does the most northerly of the Nile tributaries, the Atbara and its main tributary, the Tekezé River (Fig. 1). The Nile then flows without any significant tributary over a distance of 2700 km into the Mediterranean Sea, passing through both Nubia and Egypt.[1] The Nile Valley is a tectono-erosional valley in which the main structure – the riverbed – but also wadis and other tributaries follow linear structures and breaks along the basement.[2] This is most evident in the areas of the six official and other subordinated cataracts that constitute the Middle Nile Valley.[3] While for the late Pleistocene it is assumed that Nile activity had significantly lowered and slowed down,[4] the situation changed with the Holocene. The onset of a period of pronounced rains brought by summer monsoons from 11 500 cal BP onwards – known as the African Humid Period[5] – as well as the overflow of Lake Victoria at 14 700 cal BP and another at 13 100 cal BP[6] resulted in the re-activation of the 'modern' Nile and its palaeo channels, entailing dramatic changes of the Nile Valley geomorphology.

Growth patterns in mollusk shells collected from the Wadi Howar – a now defunct Nile tributary – indicate the presence of two rainy seasons occurring as late as the mid-Holocene.[7] Higher local rainfalls would have sustained a vegetation cover, but also led to a fast and eroding surface run-off via a ramified network of wadis and small khors. From a study of tree and shrub species present in Holocene charcoals, a palaeoenvironmental reconstruction concludes that the woodland savannah extended ca. 800 km to the north of its present limits.[8]

Archaeological sites throughout the Middle Nile Valley are often situated several hundred meters, and even up to a few kilometers, away from the present course of the Nile.[9] This suggests that they could have been related to former palaeochannels, lakeshores, and swamps[10] that no longer function but can be traced by methods of mapping, remote sensing, stratigraphical excavation, and through the study of soils, as well as of faunal and floral indicators. During the 1960s, much attention was paid to the elevation of archaeological sites and their association to certain Nile terrace formations, which could reach heights of up to 40.0 m above the present Nile level in Nubia.[11] In these early works, there arose a major contention about the causes and successive stages of Nile sediment aggradation and recession, which for the Holocene period has largely remained unsolved. It was also believed that there existed congruence between terrace formation and periods of human occupation, however, these two events often prove to be entirely dissociated.[12]

Apart from speculations, there are conspicuously few clues as to when Nile floods started to occur as an annual peak, and when it could have been perceived and anticipated as such by people of the past. As is known from Pharaonic Egypt, the coming of the Nile flood marked the beginning of the year,[13] which would have certainly also been a major event in the perception of the Neolithic people. During the mid-Holocene, when Neolithisation occurred in the Middle Nile Valley,[14] landscapes and the availability of water differed greatly from later conditions, with Nile floods probably being prolonged, whilst also feeding extensive freshwater lakes along the course of the river.[15]

1 Woodward, Macklin, Krom, et al. 2007, 261.
2 Yallouze and Knetsch 1954; Butzer and Hansen 1968, 27.
3 Cf. Ritter 2012, fig. 1.5, 126–137.
4 Said 1981; Woodward, Macklin, Krom, et al. 2007; M. A. J. Williams 2009.
5 DeMenocal, Ortiz, et al. 2000; DeMenocal and Tierney 2012.
6 Woodward, Macklin, Krom, et al. 2007, 271; M. A. J. Williams and Talbot 2009.
7 Rodrigues, Abell, and Kröpelin 2000.
8 Neumann 1989.
9 Marcolongo and Surian 1997, fig. 1; Honegger 2007, fig. 1; Woodward, Macklin, and Welsby 2001.
10 Tothill 1946.
11 Fairbridge 1963; De Heinzelin 1968; Butzer and Hansen 1968.
12 Cf. Dittrich 2011, 35–36, 165–178.
13 Helck and Otto 1986, 832–833.
14 Dittrich 2011; Dittrich 2013; Dittrich 2015.
15 Wickens 1982; M. A. J. Williams, F. M. Williams, et al. 2010.

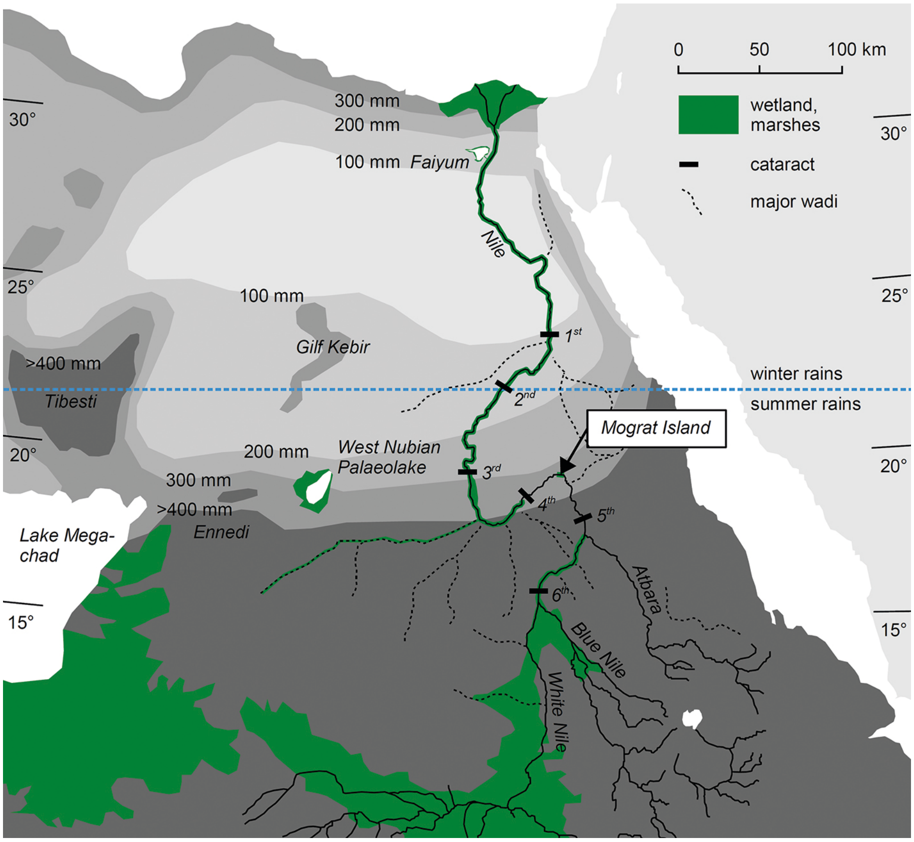

Fig. 1 Map of Northeast Africa and the Nile Valley with reconstructed early Holocene precipitation patterns.

2 Archaeology of flow

Obviously, the complex local sequences of processes of sediment aggradation, human occupation, and erosion pose many difficulties for the interpretation of past human occupation along the banks of the Middle Nile.[16] Combined with the problems above, the layout of the islands and the course of wadis might have changed during each flood event, which makes it even for the present day Nile Valley, difficult to provide a reliable topographical map. Therefore, when studying prehistoric landscapes in the Nile Valley it is not appropriate to map archaeological sites only according to modern realities, the environmental history of each site should be considered as well.

Recently it has been claimed that in local contexts, rivers cannot be studied as static landscape elements or systems but require a more dynamic view – an 'archaeology of flow'.[17] It was postulated that rivers are not only cultural artefacts themselves, but also places where human and river activities intersect. Understanding rivers enables the understanding of this relationship in the past. Furthermore, it was important to include flowing patterns for describing dynamic processes in theories,[18] which would also much apply to the process of Neolithisation. Historically, Neolithisation is a movement resulting from the dynamics of a number of different events, rather than just a mere group of archaeological facts based on material evidence.[19]

3 Conditions of plant cultivation

From recent evidence for Neolithic plant use in the Middle Nile Valley,[20] emerges a picture of a predominant interest in millets, which is in accordance with other regions in Northern Africa.[21] Millets – including *Sorghum*,

16 Cf. Dittrich 2015, 28–42.
17 Edgeworth 2011.
18 Edgeworth 2011, 107–116 and 136–137.
19 Cf. Dittrich 2013; Dittrich 2017.
20 Madella et al. 2014.
21 Barakat and Fahmy 1999; Królik and Schild 2001; Lucarini, this volume.

Pennisetum, *Echinochloa*, *Panicum*, and *Setaria* – are part of the dense grasslands of the tree savanna covering the Sub-Saharan belt. Their growth is facilitated by summer monsoon rains that reached about 800 kilometers further north during the Holocene (Fig. 1). The onset of pottery production in the Middle Nile Valley as early as 7000 cal BC has conclusively been explained by the habit of cooking porridge out of millet, which stands in contrast to the concept of baking bread out of exotic wheat.[22] However, the question could be asked whether this interest in millets is an expression of their cultivation or collection in the wild? Because if seeds of wild grasses were stored – as evidenced in pits and sunken huts at Nabta Playa (Egypt) as early as around 7100 cal BC[23] – they are to be interpreted not only as a food reserve but also as seed storage ready to be potentially sown and grown. This is exactly the point that seems to be crucial in our present definition of Neolithic, which includes a wide range of abstract economic categories but lacks a notion of *performing* agriculture. Just from the fact that it was the seeds that were collected and stored from the available plant parts, people must have learned that in contact with water they will germinate – intentionally or accidentally. There can be no question that millets were subjected to practices of cultivation, at least to a certain degree.

Besides the evidence for African millets, finds of phytoliths of the wheat/barley group suggest that in the large alluvial basins of the Dongola region the cultivation of Near Eastern cereals was introduced as early as 5300 cal BC.[24] Probably, during the mid-Holocene the region received winter rains, as has been postulated for southern Egypt.[25] This climatic circumstance would allow for a growing season for cereals similar to that of the Mediterranean Basin with harvesting in early spring. Therefore, the reliance on either African millets or cereals of Near Eastern origin was largely framed by at least two different seasonal rhythms structured with different cultural practices. Besides the general framework of climatic conditions and the scientific proof of certain plant species, the question could be raised as to the practical conditions of plant cultivation, including knowledge of soils, availability of water, or specific cultivation techniques.

If material evidence is absent, which is most often the case with Holocene plant remains, we may have to rely on indices[26] to interpolate such gaps of knowledge for a meaningful historical view. In the early days of research, it was thought that material evidence for agriculture would include also grinders, digging sticks, hoes, sickles, and even pottery, although this view is nowadays not accepted anymore. Nevertheless, some of these tools such as sickles and hoes today still bear emblematic functions that remind us of, and thus mediate knowledge about, specific tasks in plant cultivation, but not necessarily to that of domesticated species.[27] As a consequence, while equating the Neolithic with agriculture, one could study either the occurrence of related phenomena and events such as the introduction of Near Eastern cereals for which the direct evidence might be lacking or whose social properties might have been exchanged and replaced with that of African millets. A second possibility would be the study of the presence of necessary/sufficient conditions for plant cultivation, requiring a look to indirect hints such as micro traces of soil cultivation. While assuming that agriculture has indeed been *performed* in one way or the other, it could be further asked in which way agriculture has been *conditioned*. Those conditions would not just include the occurrence of emblematic tools or vessels, the discussion of which would gain more relevance, but also of environmental conditions, including the formation of arable soils, the occurrence of rains, and the coming of the Nile flood, as well as local knowledge of soils and cultivation techniques.

4 Case study: Mograt Island

With the example of Mograt Island – the largest island on the Nile – we have the opportunity to study the Holocene shift in climatic conditions and land use patterns in the midst of a cataract landscape.[28] The elongated island is located at the first great Nile bend close

22 Haaland 2007; cf. Dittrich 2017.
23 Królik and Schild 2001.
24 Madella et al. 2014.
25 Linstädter and Kröpelin 2004.
26 Cf. Ginzburg 1989.
27 Dittrich 2017, 90–91, fig. 11.
28 Dittrich and Geßner 2014; Dittrich, Geßner, et al. 2015; Dittrich 2018.

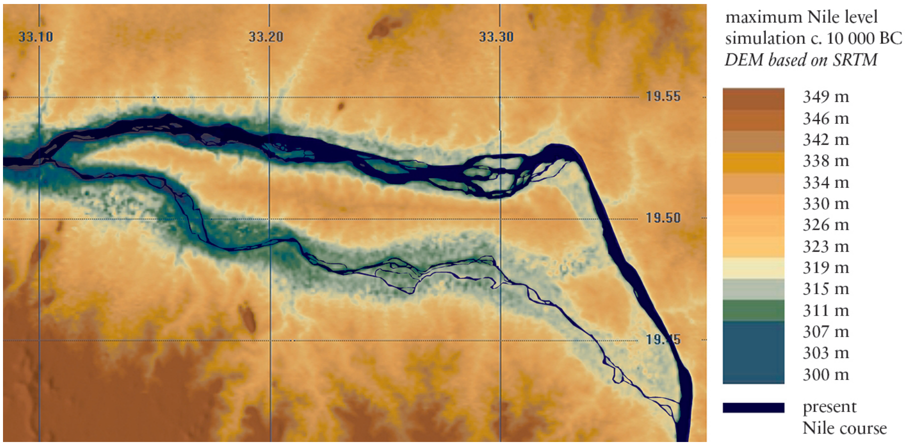

Fig. 2 Mograt Island (Sudan). Digital elevation model indicating the maximum Nile level (ca. 320 m) at the onset of the Holocene; note the division of the eastern part into two separate palaeo islands.

to the town of Abu Hamed (Fig. 1). With a length of 31 kilometers along the east-west axis and a width of up to 6 kilometers, Mograt covers an area of 102 km^2.[29] Mograt's great antiquity is attested by the frequent exposure of the Precambrian basement, while its present surfaces have been stabilized only recently by being covered by stony pavements *(serir, hammada)*, as is typical for desert landscapes. The course of the Nile is mainly confined to the local tectonics, but in some areas the southern and smaller Nile branch has developed true meanders.

Along the main crest of the island, highly dendritic wadi courses indicate the fast drainage of surface water. The lower courses of the wadis have been significantly altered since the Holocene as they frequently cut through Holocene sediments that have accumulated in valley floors, while blocking older wadi courses. These Holocene sediments are of great interest, as they were deposited in more permanent closed-off palaeo lakes that were active during the 10th and 9th millennia cal BC,[30] and in more seasonal swamps that existed until at least the 6th millennium cal BC.[31] Since early to mid-Holocene occupational remains, such as artefacts and ecofacts, have repeatedly been found in the vicinity of these sites, their exact connection to the water bodies is one of the main scopes of current research. Special attention has also been paid to the study of nearby soils and sediments, which often contained calcified roots, humified matter, and other indicators of a former vegetation cover. Depending on the amount of eroded top silts, the highest Holocene Nile level has been assumed to be about 10 to 12 m above the present level, which has been visualized through a digital elevation model (Fig. 2). The livable part of the island would have been limited to its bedrock core that rises another 20.0 m above this level, reducing the landmass to about 40 per cent of its present dimensions. Additionally, by the activation of a palaeo channel, Mograt became divided into two major palaeo islands.[32]

While the more recent Nile alluvium consists almost only of silts, the early Holocene sediments show a mixture with sands, resulting in the presence of silty or sandy loams.[33] Soil formation processes seem to have been well underway, as suggested by limpid clay coatings of particles from a very well-developed 'B' horizon, as seen during the micromorphological analysis.[34] Such features are characteristic of stable and densely vegetated land surfaces. It is assumed that soil fauna, indicated by signs of heavy bioturbation, was most active between the flooding events, when the sediments started drying up. Together the stabilized 'B' horizons and the alluviated floodplain would have provided a naturally and seasonally replenishment of the soil and groundwater system most suitable for cultivation.[35]

Due to high energy fluvial processes that occurred after dry episodes during the mid-Holocene period (ca. 6000–4000 BC), early Holocene deposits have frequently

29 Ritter 2008.
30 Dittrich and Geßner 2014.
31 Dittrich, Geßner, et al. 2015.
32 Dittrich and Geßner 2014.
33 Cf. Rzóska 1976, 159.
34 Dittrich, Geßner, et al. 2015; Dittrich and Neogi 2017.
35 Dittrich and Neogi 2017.

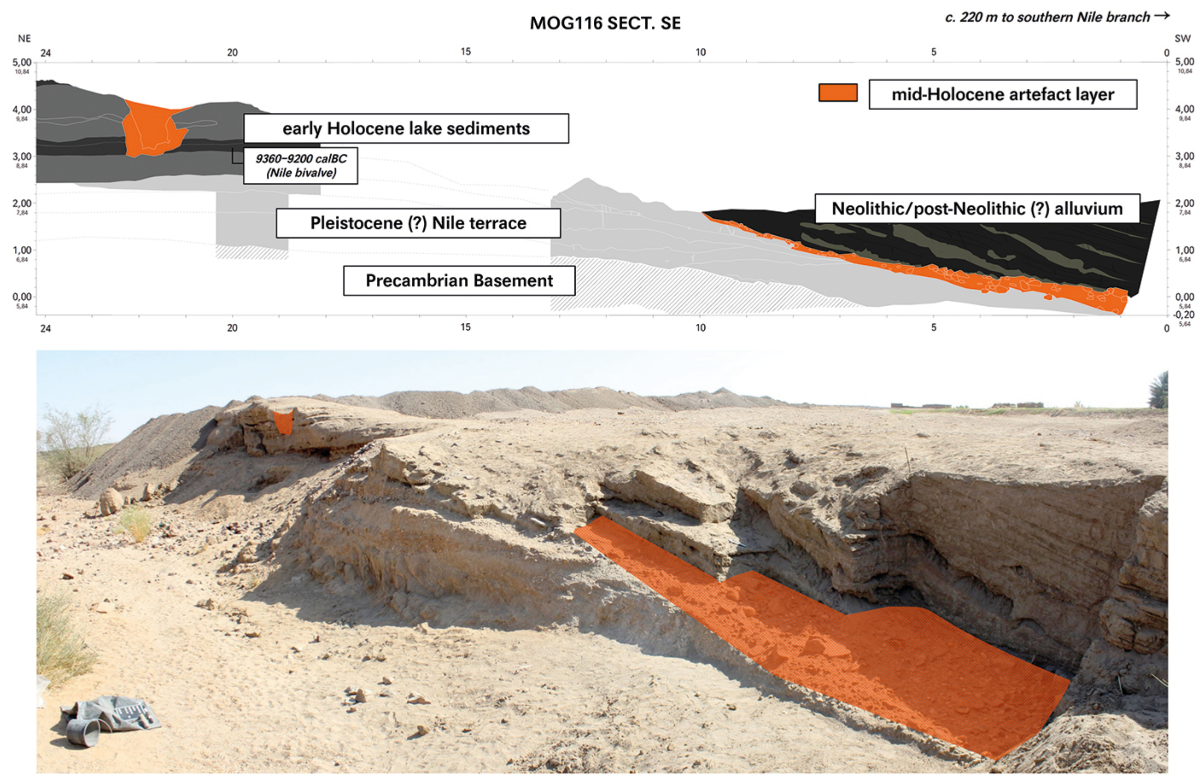

Fig. 3 Mograt Island (Sudan). Sequence of early to mid-Holocene Nile sediments near Gharghara (MOG116).

been destroyed. Through undercutting by the Nile meander, these floods are also responsible for removing most of the former lakeshore banks, as well as for causing landslides along the slopes of the riverbanks (Fig. 3). In one case (Gharghara), this has preserved a mid-Holocene occupation layer *in situ* that must have slipped down and become sandwiched between two different alluvial formations.[36] A similar situation was observed at the site of Khartoum-Hospital,[37] which would point to the dynamic and dramatic effects that affected people on a larger scale in the Nile Valley. Probably as a consequence, settlements were re-located at the highest terraces overlooking the alluvial plain, which transformed from more permanent swamps into a seasonal floodplain.

A further pattern is observed on the central islands' crest where large mid-Holocene surface sites are located around former depressions, which are assumed to have periodically stored rainwater (Fig. 4). The diversity of the gastropod fauna indicates conditions varying from grasslands to swamps between 7100 and 5400 cal BC.[38] The study of soil micromorphology produced evidence for intense earthworm activity, which is characteristic for humic topsoils, as well as evidence for the alteration between wet and dry conditions.[39] Such soils would surely have supported the seasonal growth of savannah grasses, but also of any cultivated plants, although no direct evidence for them exists so far. However, grinding equipment is a common artefact type found on these sites. The high degree of fragmentation of pottery suggests that trampling, for instance by hoofed animals, led to such water ponds for watering.

36 Dittrich, Geßner, et al. 2015.

37 Arkell 1947; Arkell 1949.

38 Dittrich 2018, tab. 1.

39 Dittrich, Geßner, et al. 2015; Dittrich and Neogi 2017.

Fig. 4 Mograt Island (Sudan). Surface depression containing shallow water sediments and faunal relics of a mid-Holocene rain-fed pool.

5 A changing riverscape of the sixth millennium BC

It might be useful to reconsider some of the observations made at the Nile terraces of the Second Nile cataract during the 1960s. Rhodes W. Fairbridge was the first one who was convinced that with the onset of the Holocene:

> A fundamental change in the fluvial regime of the Nile appeared. […] The volume of water increased sharply and severe dissection of the silts was initiated. Not only was the main Nile flood involved, but the side wadis […] showed considerable activity, in flash floods to be sure, but enough to cut down their beds to match the main stream […].[40]

However, he also warned that,

> Care should be taken to appreciate that there were not only general trends (thus the rise and fall of the mean discharge between 10 000 and 6000 b.p. [11 500 and 6800 cal BP]), but there were also very sharp oscillations, of middle and short period, superimposed on the main curve.[41]

To understand the complex interplay of sediment aggradation and recession, of soil formation, erosion, groundwater table, rains, and the local flora and fauna, as well as human activities we still need to build up a precise chronology covering both natural and cultural events at the Middle Nile Valley. As the word 'revolution' in the broadest sense means 'change' or 'alteration',[42] the sharp mid-Holocene oscillations of the Nile as indicators of climatic change surely affected the previous ways of life. From the observations on Mograt Island, it could be inferred that a significant drop of river levels was reached by the 6th millennium BC, triggering in the long-term the shift from the presence of cut-off ephemeral lakes to wide, open alluvial plains (Tab. 1). Subsequently, settlement patterns also changed from

40 Fairbridge 1963, 101.

41 Fairbridge 1963, 101. This view was rejected by Butzer and Hansen 1968, 330–331, and De Heinzelin 1968, who attributed most of the Nile deposits to the Pleistocene period, connecting Nile sediment aggradation – especially of pebbles – to flood events, while they believed the Holocene climate to have been arid to hyper arid. However, as it was discussed by Rzóska 1976, 9, "fall-out of suspended matter occurs whenever current velocity and with it the carrying capacity of flowing water is reduced, regardless of flood or low water conditions. This may be caused by dams or any natural obstacle […]." Furthermore, for the early Holocene period the sediment load and discharge of the River Nile, as well as the impact of local rains on the re-deposition through wadis must be considered separately.

42 Oxford Dictionary of English (3rd ed.). Oxford: Oxford University Press, 2010.

palaeo island/lakeshore to Nile terrace occupation in the long-term. These changes converge with the advent of domesticated species and related novelties in the Middle Nile Valley. Based on the corpus of available radiocarbon dates, most researchers agree that domestic species occurred there from around 5100 cal BC onwards,[43] with only few exceptional claims for an earlier appearance of domestic cattle around 5750 cal BC[44] and of Near Eastern cereals around 5300 cal BC.[45] On the basis of the rich funeral record, dating mainly from the 5th millennium BC, and providing evidence for long-distance exchange both with the Red Sea area and along the north-south axis of the Nile corridor, it has been assumed that people, domestic species, and related ideas followed specific routes of a supra-regional network.[46]

6 Wetlands of the past

Although the early Holocene wet climate is commonly thought of as a climatic optimum, providing plentiful water resources and sustaining a much greater diversity in floral and faunal species, caution was expressed by some authors as to the usability of the wetlands during the past. Parts of the southern Sahara, as well as the Nile Valley, were even considered "too moist and hazardous for appreciable human occupation"[47] during the early Holocene. Furthermore, it was argued that as long as Nile floods had remained high and swampy conditions prevailed, there was no access to arable soils that were suited for cultivation.[48]

However, in a study on American wetlands, Ann Vileisis came to the conclusion that Western culture "has long despised and avoided wetlands",[49] making them a landscape on the periphery. One could further argue that the complex irrigation systems of the Nile banks have long been propagated as an agricultural ideal and a *status quo* against which early agriculture was erroneously measured. Drying up and reclaiming wetlands are common practices today, while prehistoric human-landscape interaction might have been much more differentiated. As the example of Mograt Island shows, on a small and horizontal scale, there was a succession of different landscape elements, such as islands, the high Nile bank standing out and logging off lagoon lakes, swampy basins, elevated grassland, and a tree savannah spotted with rain-fed water ponds. Along with that, a pronounced seasonality would have led to an unsteady riverine landscape, changing from inundated swamps to dried-up plains over the annual cycle. Thus, the alleged harsh conditions should not be generalized. The adaptation to a diversified and seasonal landscape is suggested by the great variety of food resources that were indeed used by early Neolithic farmers and herders in Egypt and Sudan.[50] The recent example of the South Sudanese Nuer illustrates how cattle herders were adapted to the Sudd environment and practiced a number of subsequent seasonal activities, including fishing.[51] Outside the study area, the Marsh Arabs of Iraq are another example of a successful agricultural adaption to marshlands that requires, for instance, the frequent use of boats.

It can be concluded that domesticated species were introduced into the Middle Nile Valley during a climatically favorable period. At that time, the wetlands along the Nile – while demanding an opportunistic behavior – were already important cultural landscapes. By the provision of water and aquatic resources, they offered an enormous advantage over arid regions.

7 Traditional knowledge of alluvial soils in Sudan

In this respect, it might be appropriate to have a look at traditional modes of land use in Sudan that may preserve a specific access to alluvial soils. If the traditional knowledge[52] prior to the introduction of mechanic pump schemes is considered, the soils are classified as:

(1) *gezira*/recent alluvium (includes the currently flooded riverbank called *jarf*, as well as the flooded islands called *gezira*)

43 Cf. Dittrich 2015.
44 Honegger 2005.
45 Madella et al. 2014.
46 Krzyżaniak 1991; cf. Dittrich 2017, figs. 9 and 10.
47 Kuper and Kröpelin 2006, 806.
48 M. A. J. Williams 2009, 11.
49 Vileisis 1997, 10.
50 Wetterstrom 1993; Dittrich 2011, 221–249.
51 Evans-Pritchard 1940.
52 Field 1952, 170–171; Bjørkelo 1989, 57–61.

years calBC	~mean calBP	human presence (+ dated, ○ relics)	Nile terrace (upper) (+ dated)	Nile terrace (lower) (+ dated)	inland high plateau (+ dated)
		○	↑	annual flood peaks	
<5380	<7.4 ka	○	slope erosion	Nile meandering/ downcutting	
5470–5380	~7.4 ka	○	↓	↓	shallow water (+ shells in situ/ in deposits)
5530–5480	~7.5 ka	+			shallow water (+ shells in situ/ in deposits)
5620–5550	~7.6 ka	+			
5830–5700	~7.8 ka	○	(dried up)	swampy floodplain (+ shells in deposits)	
6080–6010	~8.1 ka	○?			shallow water (+ shells in situ/ in deposits)
6480–6410	~8.5 ka			swampy floodplain (+ mature shells in situ)	
				↓	
7450–7320	~9.5 ka	+	—— (downcutting of the Nile river) ——		
			↑		
8300–8020	~10.3 ka	+	periodical lake flooding (+ shells in situ)		
			↓		
9350–8950	~11.4 ka	○?	permanent lake (+ shells in situ) (+ shells in situ)		
>9300	>11.4 ka	○	periodical lake flooding		
			permanent lake		
	? >12 ka		—— boundary to cemented clays and dune sands ——		

Tab. 1 Mograt Island (Sudan). Radiocarbon dated sequence of shifting Holocene Nile terraces with the upper one falling dry before the mid-Holocene (probably due to Nile down-cutting) and of the high plateau, where shallow water sediments indicate periods of increased rainfall.

(2) *sāqiya*/alluvial loam (elevated fertile land along the river that is not flooded by the river anymore but must be irrigated by means of a water wheel called *sāqiya*)

(3) *karru*/heavy clays (land adjoining *sāqiya* land in basins far from the Nile, can be flooded directly through exceptional floods or through the redirection of water from the annual flood or rains); and

(4) *wadi* or *atmur*/sandy dry-bed soils (rain-flooded watercourses called *wadis* or rain-flooded plains and slopes called *atmur*).

It is commonly known that between the recent alluvium and the more elevated irrigated *sāqiya* land, an old allu-

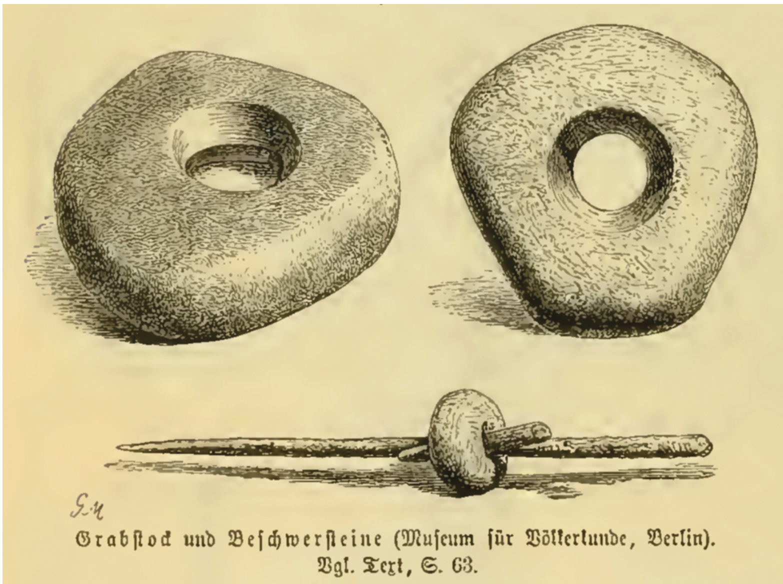

Fig. 5 Digging stick and stone weights, South Africa, 19th century.

vial terrace can often be found that is called *qayf* and consists of fertile *qurayr* soil.[53] In earlier times, this land was irrigated by means of a hand-operated lever with a bucket on a rope *(shadūf)* used to lift water onto less elevated places. In the case of Mograt Island, present cultivation still makes extensive use of mid to late Holocene alluvium, which is sometimes extracted with machines and transferred to remote irrigated fields.

Prior to the use of irrigation systems, the river-flooded land *(gezira, jarf, karru)* and the rain-flooded land *(wadi/atmur)* would have been of predominant interest for what has been called the 'natural flood' and 'basin' cultivation.[54] Especially the *jarf* land, whose shape and extension are subjected to great annual variation, is still sometimes sown by the use of a digging stick (*sallūka*, Fig. 5).[55] The soil is not ploughed, manured, or irrigated; only small holes are made with the digging stick for sowing to retain the moisture (Fig. 6). Usually close to the Nile or the present groundwater table, the plants grow without any additional irrigation (Figs. 7 and 8). It seems very probable that during the mid-Holocene, drying-up swamps and Nile alluvium could have initially been cultivated in the manner of *sallūka*. In fact, it is an opportunistic way to deal with the ever-changing layout of land patterns at the floodplain. Traditionally, the *karru* and the rain-flooded lands are considered for the growth of some great millet types *(dura)* but they may also be quickly overrun with weeds.[56] Thus, unless they are used as pastures, for cultivation they may require weeding, clearing, or firing.

8 Rain-fed cultivation and water management

Beside the practices of irrigation or the opportunistic use of river-flooded lands, rain-fed cultivation was and is still important throughout Africa. A distinction is made between rain-fed cultivation and a combination of rain-fed cultivation with shifting agriculture, called *hariq*.[57]

A number of practices exist to grow plants without further irrigation; for example, special drought-resistant breeds are selected, seeds are sown thinly with the digging stick or are covered with extra soil.[58] In Niger, half-moon shaped pits are dug on slopes to capture and hold back rainwater. Inside the sunken pits, sorghum and

53 Bjørkelo 1989, 57.
54 Burnett 1948, 288–289.
55 Wooden digging sticks, probably weighted by stone rings, have been found at the Palaeolithic site of Border Cave in South Africa, from where one specimen has been directly dated to 39 000 cal BP (D'Errico et al. 2012, fig. 2.25). Stone rings are also known from several Holocene sites in the Sudanese Nile Valley (cf. Arkell 1949, pl. 34 and 35).
56 Bacon 1948; Burnett 1948, 289.
57 Burnett 1948, 292.
58 Bacon 1948, 309–310.

Fig. 6 Southern Darfur (West Sudan), Gidad. Baggara man sowing sorghum by making holes in the ground with a digging stick *(sallūka)* to plant the seeds therein.

other millets are planted.[59] This method is related to the water storage in proper *hafirs,* which are either excavated holes or natural depressions in the ground that hold up rainwater. Their filling is obtained from seasonal watercourses or by hill catchment.[60] Presently, it is not known to which period their artificial digging actually dates back to in the Sudan, but their remains frequently appear along historical migratory routes or close to settlements (Fig. 9). It seems likely that the concept of *hafirs* resemble the phenomenon of early to mid-Holocene rain-fed lakes in natural depressions and are therefore a type of water resource that must have been well-known to migratory animals, as well as to people, during prehistory.[61]

The practice of *hariq* has been described as "unique to Sudan, in which fire set on the old dry grass burns the young green grass which is the potential weed crop of the season. The dura crop is then sown and no further weeding is needed".[62] Before the propagation of western-style agriculture in Sudan, *hariq* was a common traditional system in the low rainfall woodland savannah belt providing an annual precipitation of 450–800 mm.[63] Archaeological evidence for shifted cultivation during the Neolithic in the Nile Valley is still scarce, although spores of *Chaetomium* sp. found in archaeological layers in the Blue Nile region have been interpreted as indicators for repeated events of firing.[64]

9 Conclusions

The early Holocene Middle Nile Valley has to be reconstructed as being dotted with ephemeral lagoon lakes and swamps, like pearls on a string that were fed through the over-flooding of the River Nile. However, since wetlands were probably not marginal places during the past and as an important result of recent archaeological surveying projects, the Middle Nile Valley was almost constantly occupied during that period.

Increased seasonality during the mid-Holocene brought frequent changes between wet and dry conditions, as a prelude to the final phase of the African Humid Period. Humans probably responded to that with opportunistic behavior: the soils of drying-up swamp basins were suited for plant cultivation with the *sallūka* (digging stick) or as pastures. With the return of swampy conditions after the flood, again aquatic resources such as mollusks, fish, and marsh plants might have been of interest. Additionally, surface depressions in the hinterlands provided places for the storage of water from the surface run-off – a strategy that has later been followed up by the construction and maintenance of *hafirs*. Though existing close to the River Nile, this kind of land use would be quite in accordance to what has been observed in other areas in North Africa. Therefore, in this

59 Jones et al. 2013, 36.
60 Jefferson 1954.
61 In the case of Mograt Island, it was quite surprising to find such a migratory scheme of human occupation around rain-fed basins on an island within sight of two Nile River arms.
62 Agabawi 1968, 71.
63 Agabawi 1968, 72.
64 López Sáez and López García 2003.

Fig. 7 Mograt Island (Sudan). View to Kurta Island, note the non-irrigated fresh alluvial patches in the front planted spontaneously with *Sorghum* sp.

Fig. 8 Fourth Cataract (Sudan). Non-irrigated alluvium at the steep banks of an island planted in the *sallūka* manner, photo taken in 2004 before the area became submerged in a huge dam lake.

Fig. 9 Musawwarat es Sufra (Sudan). *Hafīr* dating from the Late Antiquity, after modern dredging and reactivation.

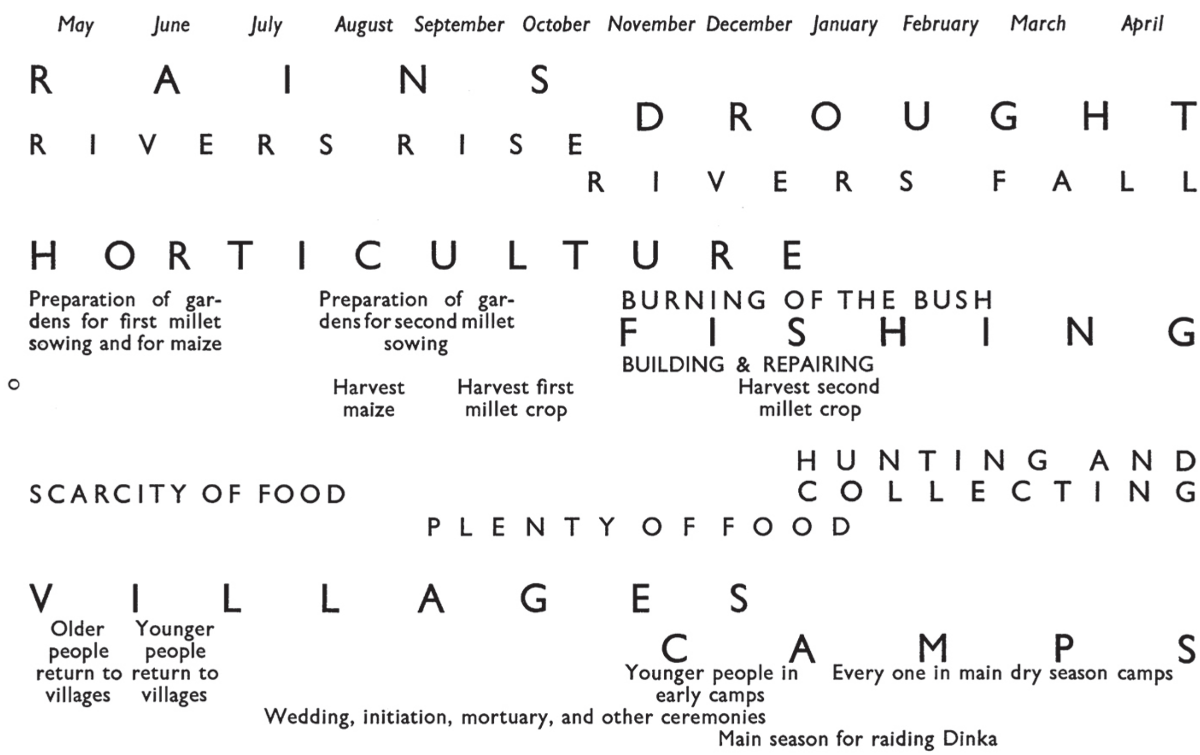

Fig. 10 Seasonal cycle of Nuer activities in South Sudan, as recorded in the 1930s.

respect, the Nile Valley cannot be considered different from other lake landscapes occurring during the early to mid-Holocene.

Maybe it is in this context that early Neolithic food acquiring strategies generally appear as diverse and of the 'immediate return' type.[65] A pronounced seasonality in a changing environment would have fostered an annual cycle of various subsequent activities, including hunting, sowing, fishing, fowling, milking, harvesting, etc. as it is partly practiced until today (cf. Fig. 10). In view of environmental conditions, especially the prevailing presence of summer rains, the cultivation of wheat and barley cannot be seen as the ideal for the Holocene Middle Nile Valley. Therefore, the progress of incorporation of exotic cereals cannot be the scale of Neolithisation in that area, which rather manifested in the incorporation of domestic animals.[66] Conditions were still favorable to the cultivation of indigenous grasses and millets.

However, those forms of cultivation certainly differed from the river-dependence for irrigation – often seen as a prerequisite for any form of agriculture in the Nile Valley – that occurred only later. Rain-fed cultivation is still the most important cultivation method in use in non-arid areas. Two types of land are limited to the Nile Valley: the recently flooded area *(gezira)* and the older alluvium *(sāqiya* and *qayf)*. It is argued that the latter deriving from dried-up early Holocene lake sediments at the higher river terraces was used as arable soil before the annual flooding of lower areas stabilized. The mid-Holocene Nile riverscape must essentially be viewed as an unstable revolving landscape. Only with increasing aridity, the former lakeshore occupation pattern would have slowly developed into a Nile terrace occupation, narrowing the interest from various available water bodies to the apparent constant of the flowing river and its floodplain.

65 Wetterstrom 1993.

66 Dittrich 2017.

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ILLUSTRATIONS: 1 A. Dittrich, palaeoecological data based on Pachur and Altmann 2006, figs. 2.0.1, 5.2.2. 2 A. Dittrich. 3 Photo and graphics: A. Dittrich. 4 Photo: A. Dittrich, 2014. 5 Graphics: (unknown), taken from Ratzel 1885, 62. 6 Photo: G. Haaland, 1973, Inv. UBB-HAA-219. 7–9 Photo: A. Dittrich, 2014. 10 Graphics: Evans-Pritchard 1940, 97. **TABLES:** 1 A. Dittrich.

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Karin Kindermann and Heiko Riemer

From Complex Hunter-Gatherers in the Eastern Sahara to the Early Nile Neolithic

Summary

The beginning of food production in the Nile Valley is a complex and multi-causal phenomenon that coincides with environmental and cultural changes. It can be seen as a long-term, episodic process with various protagonists and changing conditions for cultural contact and exchange. This complexity, and deficient archaeological data, has hampered tracing the basic lines and modes of how, where, and when the 'Neolithic' developed. Viewed from the Sahara, two important phenomena appear: 1) the earliest domesticated animals occur in Saharan hunter-gatherer communities predate the earliest Neolithic on the Nile and 2) in tandem with the beginning climatic trend towards aridity from the late 6th millennium cal BC onwards, Saharan core areas were abandoned and people retreated to more favored landscapes.

Keywords: Egypt; Eastern Sahara; Holocene humid phase; Predynastic; Nile Neolithic; hunter-gatherer; Egyptian-Near Eastern traits

Der Beginn der Nahrungsmittelproduktion im Niltal stellt ein komplexes und multikausales Phänomen dar, das mit ökologischen und kulturellen Veränderungen einhergeht. Dieser Prozess ist als ein langfristiger und episodischer zu interpretieren, mit vielen Protagonisten und sich verändernde Bedingungen des kulturellen Kontakts und Austausches. Diese Komplexität und die wenigen zur Verfügung stehenden archäologischen Daten erschweren es, die Grundlinien und Modi nachzuverfolgen, wie, wo und wann sich ‚das Neolithikum' entwickelt hat. Von der Sahara aus gesehen, sind zwei Phänomene bedeutsam: 1) Erste domestizierte Tiere in jägerisch-sammlerischen Gemeinschaften treten vor dem frühesten Neolithikum im Niltal auf. 2) Zugleich mit dem Klimatrend ab dem späten 6. Jt. cal BC hin zur Trockenheit wurden Kernbereiche der Sahara aufgegeben, und die Menschen zogen sich in ökologische Gunsträume zurück.

Keywords: Ägypten; Ostsahara; holozäne Feuchtphase; Prädynastik; Niltal Neolithikum; Jäger und Sammler; Verbindungen Ägypten-Naher Osten

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1 Introduction

In most parts of the Sahara a full-fledged Neolithic economy, in terms of inventing or introducing agriculture and/or livestock keeping as a primary source of subsistence, never developed. The term 'Saharan Neolithic,' which was widely found in older scholarly literature (and still in some popular works), was to a large extent an archaeological misinterpretation of cultural groups using early ceramics and ground stone items.[1] This scientific point of view was not unfounded for two reasons. The first reason is that the then mainly Eurocentric position viewed the transition from hunter-gatherers to food-producers as a fundamental change ('Neolithic revolution') that was associated with the appearance of a Neolithic package that also included the first presence of grinding stones and polished stone items. The second reason is that there were no such cultural developments in Africa or on other continents that could have demonstrated the wide range of possible pathways from hunter-gatherers to food-producers.

Today, our knowledge of the wide range of hunter-gatherer complexity and technological experimentation, as well as of forager and early food producers' specializations and adaptations – globally, past and present – illustrate that the term 'Neolithic' is often more of a hindrance than a help. Eventually, it might be appropriate to reduce it to the predominantly food-producing farmers and herders, who followed a sedentary or semi-sedentary way of life, saving the term as a phase label in archaeological sequences for communication reasons. Moreover, we will use the term pastoral nomads for all those who fully or predominantly receive their animal products from their livestock (regardless of whether plant food is exchanged with farmers or gathered from wild resources). With all transitional types of early domesticated animals or cultivated plants that found their way into foraging groups, but do not dominate their subsistence, we tend to avoid the term Neolithic. Following this line of argument, the first indications of a Neolithic subsistence in the Egyptian part of the Sahara can be found during Predynastic times in the Nile Valley that was probably already represented in the Fayum Neolithic in Lower Egypt and in the Badarian in Upper Egypt during the 5th millennium cal BC.

The primary aim of this contribution is to focus on the role the Eastern Sahara played in this process, which ended up with early food producing communities that we like to call 'Neolithic.' The Egyptian desert on both sides of the Nile is varied and highly complex, not the least because deserts make up most of the study area (over 95% of the modern territory of Egypt) and, to date, only a few patches have been scientifically explored in detail. Therefore, it is important to treat the desert not as a singular entity, but to highlight the significant differences in climatic conditions and ecological zoning, as well as the various strategies and human trait groups have developed to adapt to these preconditions. Alone, this cannot be viewed as a single map that shows a specific time slice at the advent of the Neolithic in the Nile Valley, but as a complex development over a period of some thousands of years during the Holocene.

It is quite likely that the Sahara only played a periphery role in the elaboration of early food producing strategies, which can be traced back to an Asian origin. Nevertheless, the Sahara as a kind of hinterland of the Nile Valley was neither cut off from external influences nor from Neolithic impacts. Hence, it is of importance to carefully trace such early influences, especially from the Near East, and to investigate how they might have influenced Saharan communities. Moreover, in the course of different migrations, which were caused by the drying trend in the Sahara, people obviously had a substantial impact on the formation of communities in the Nile Valley that first adopted a Neolithic subsistence. As such, the Nile Neolithic cannot be studied without the knowledge of the cultural developments in the deserts framing the river valley.

The Western Desert in Egypt and northern Sudan seems endless in its extension, measuring some 1500 km from the Mediterranean coast to the Wadi Howar in the south, and some 600 to 800 km between the course of the Nile in the east and the borders of Libya and Chad in the west. Compared to this enormous area, archaeology has investigated only a very few pieces of the puzzle, and many regions remain largely unexplored. Despite some early interventions during the 1930s,[2] prehistoric archaeology in the Western Desert was not followed up

1 Klees 1993.

2 Caton-Thompson 1931; Caton-Thompson 1952; Winkler 1938; Rhotert 1952.

until the close of the Nubian salvage campaign, when the Combined Prehistoric Expedition (CPE) set off in 1972 to the desert areas west of the Nile, where they have continued fieldwork until today.[3] Most long-term scientific missions that have followed the CPE are based in the oases of the Western Desert (e.g. the Dakhleh Oasis Project, since 1978; the Italian Archaeological Mission to Farafra, since 1987; and the IFAO survey in Dush and Kharga, since 1994).[4] The data referred to here come from the University of Cologne mission that has followed a decisive geographical approach of a comprehensive survey of archaeological sites throughout the entire Western Desert, carried out during a number of long-term projects (B.O.S. 1980–1993; ACACIA 1995–2007; and Wadi Sura 2009–2015).[5] As a result of this interest in desert archaeology, the past 40 years have seen a tremendous increase of prehistoric data from the Western Desert, which now allows us to draw archaeological maps of some detail for the past 10 000 years (Fig. 1). Most of the data available derived from the time period known as the Saharan Holocene pluvial (or Saharan humid phase) that, after the hyper-arid Pleistocene, offered some 4000 years of savannah-like conditions in an area that is today again a full desert, where human existence is nowadays restricted to the oases.

The following text is divided in two main parts that summarize, firstly, the second half of the pluvial when most of the Sahara was occupied – at least, temporarily – by hunter-gatherers and early domesticated animals began to appear among these groups; and secondly, the beginning of the climate drying and its consequences for the occupation of the Western Desert, its oases, and the Nile Valley.

2 Hunter-gatherer complexity and early pastro-foragers during the Mid-Holocene pluvial (ca. 6500–5300 cal BC)

2.1 Climate and resources during the Holocene pluvial

Today, the Sahara is the largest and most arid temperate zone on earth. This especially pertains to its most continental eastern part in Egypt and northern Sudan, where hyper-arid conditions with mean rainfall of less than 5 mm per year prevail.[6] The deep-lying oases of the Western Desert, which are provided with permanent groundwater by the Nubian Aquifer,[7] are the only localities that are inhabited nowadays. Yet, the Sahara has not always been so harsh (Fig. 1). Before climatic conditions reached those of the present, increased precipitation had turned the Western Desert into a dry savannah-like environment with an annual mean rainfall that has been estimated to have been 50 to 150 mm per year.[8] This so-called 'Holocene humid phase', which set in after the hyper-arid Pleistocene around 9000 cal BC due to global warming and the northwards shift of the monsoonal summer rains into the Sahara, lasted for some 4000 years before arid conditions started to return.[9] Monsoonal summer rains were usually characterized by convectional rainstorms with massive downpours that especially affected the southern half of the Sahara. They created ephemeral wadi runoff and temporary lakes in endorheic inland basins in regions with sufficient terrain gradients, where silty playa sediments still provide evidence their former existence. Moreover, west-wind driven winter rains occurred over the northern part of the Sahara, creating a bimodal rain pattern in central parts of the Western Desert,[10] which are in agreement with geomorphological observations at Farafra Oasis and Dakhla Oasis.[11]

3 Cf. Wendorf and Schild 2001.
4 IFAO is the Institut français d'archéologie orientale.
5 ACACIA is the acronym for a project entitled the *Arid Climate, Adaptation and Cultural Innovation in Africa*. B.O.S. is the acronym for the project ***Besiedlungsgeschichte der Ost-Sahara***.
6 Cf. Griffiths 1972; Henning and Flohn 1977.
7 Cf. Heinl and Thorweihe 1993.
8 Neumann 1989; Kuper and Neumann 1989; Wendorf and Schild 2001.
9 Nicoll 2001; Nicoll 2004; Kuper and Kröpelin 2006.
10 Kindermann, Bubenzer, et al. 2006.
11 Hassan et al. 2001; McDonald 2009, 25–26; Barich and Lucarini 2014a.

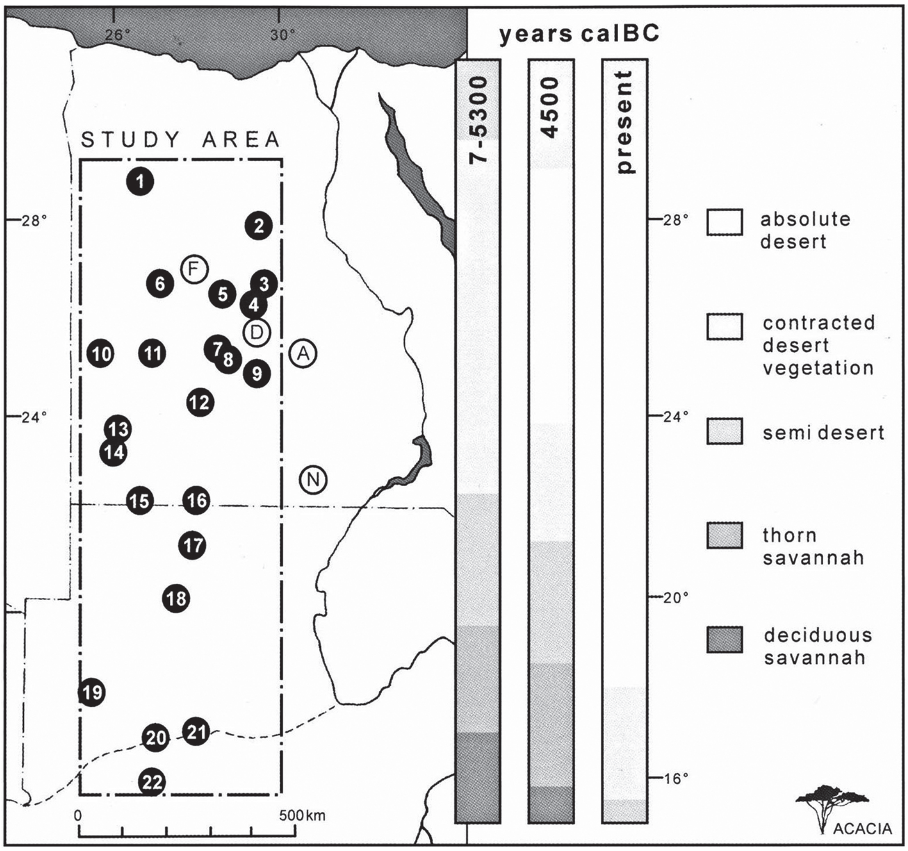

Fig. 1 Most important archaeological sites and study areas investigated in the Western Desert and the suggested change of vegetation zones during the Holocene. Numbers 1 to 22 represent the survey transect investigated by the B.O.S. and ACACIA projects of the Cologne University between 1980 and 2007. Other study regions are: F = Farafra; D = Dakhla; A = Abu Tartur; and N = Nabta Playa and Bir Kiseiba.

For most parts of the Western Desert outside of the areas with permanent access to groundwater, ephemeral wadis and water places formed the most important source for the seasonal rounds and the survival of hunter-gatherer groups. Rich archaeological campsites are often found at such locations. Typical desert and dry savannah fauna, such as small gazelles and antelopes, occupied these landscapes, forming a resource for hunt, such as evidenced in bone records from campsites.[12] Gathering of wild plant seeds, roots, and tubers formed the vegetable food resource,[13] and its processing on the campsites is amply demonstrated by numerous grinding stones.[14] However, the conditions were far from being a paradise. The rainfall estimate reveals an arid environment with a high rainfall variability of some 30 to 50%,[15] expressed in patchy and unpredictable availability of surface water and vegetation. Moreover, there was a scarcity of reliable permanent waters, presented by the spring vents of the oases' depressions, and by the river Nile fed by more independent rainfall in its sub-Saharan headwaters.

These factors created living conditions of high risk and stress for the foragers of the Western Desert. Flexible seasonality resource management and highly variable mobility patterns are likely adaptational expressions of risk minimization, such as are amply illustrated by the distribution of exotic objects, raw materials, and pottery over hundreds of kilometers.[16] A closer look at the ecological zoning of the Western Desert illustrates that oases and mountainous regions constituted the nuclei of retreat areas for occupations during the dry season of the year or during longer-lasting droughts. There are only a few mountainous areas in the Western Desert, such as the Jebel Uweinat and the Gilf Kebir plateau in Egypt's southwest. In its central part, the bow of the Egyptian oases created the retreat areas that mainly follow the geological divide between the Egyptian Limestone Plateau in the north and the Nubian Sandstone formations in the south.

12 Van Neer and Uerpmann 1989; Pöllath 2009.
13 E.g. Thanheiser 2011; Barich and Lucarini 2014a.
14 E.g. Lucarini 2014.
15 Cf. Dubief 1963.
16 Riemer 2007a.

Fig. 2 Map of the Western Desert during the 6th millennium BC showing the generalized distribution of the Bifacial complex with the undecorated pottery of the Dakhla type in the north and the Microlithic complex with the related Khartoum style pottery in the south.

2.2 Hunter-gatherer mobility and patterns of cultural traditions

Ecological zoning, with its vast desert areas dependent on unpredictable seasonal rains, and the few intermitted oases and mountain spots, is not only reflected in mobility patterns but also in patterns of cultural traditions. During the second half of the Holocene humid phase, the material culture in the Western Desert can be clearly subdivided into two distinct traditions (Fig. 2).

This is first indicated by chipped lithic material, both in flaking techniques and in the final modification of tools. Around the beginning of the 6th millennium cal BC, the Egyptian Limestone Plateau as well as its adjacent oases, developed a less elaborate blank production (often fully replaced by the collection of sufficient natural flint or chert blanks) and the invasive or bifacial modification of the blanks into tools. Sites assigned to the Bashendi A and B phases in Dakhla,[17] to the Kharga B and C phases in Dush (Kharga Oasis),[18] or to the Wadi el Obeiyid B at Farafra,[19] as well as those at Djara and Abu Gerara on the Egyptian Limestone Plateau,[20] have yielded evidence of this lithic strategy that gave reason to the establishment of the term 'Bifacial complex' for

17 McDonald 2002; McDonald 2009; McDonald 2016.
18 Dachy et al. 2018.
19 Barich and Lucarini 2014a.
20 Kindermann 2010.

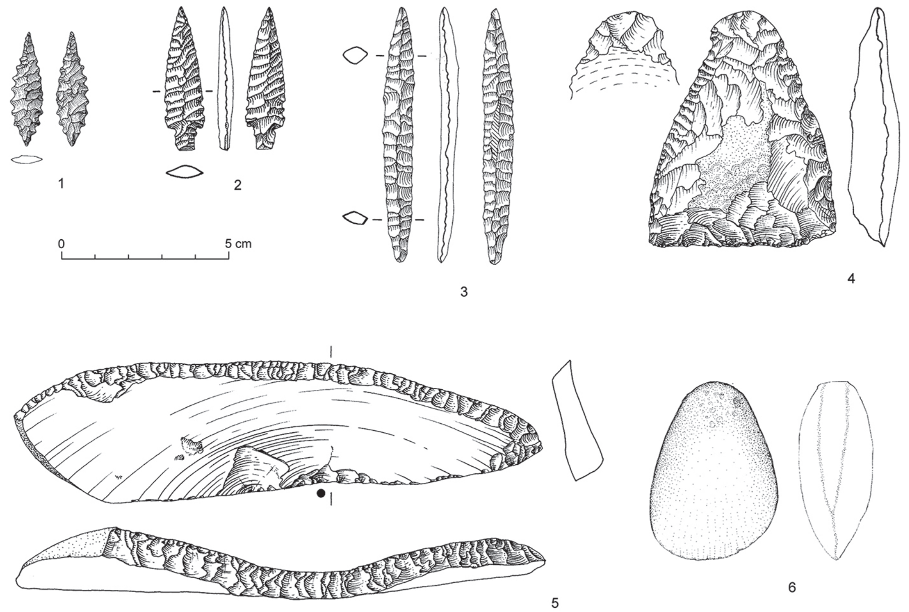

Fig. 3 Characteristic stone tools of the Bifacial complex from Djara: 1 and 2 = bifacially retouched arrowheads; 3 = bifacial drill; 4 = plane; 5 = scraper on side-blow flake; and 6 = ground axe.

this tradition. During the 6th millennium cal BC, this strategy developed a spectrum of distinctive tool types, such as various arrow points, circular and other scrapers, bifacial knives, and side-blow flakes mainly used as side-scrapers (Fig. 3).

The south and southwest of the Western Desert is characterized by a flake industry and the microburin technique to produce arrow insets (triangles, trapezes, and segments) out of elongated flakes or blades (Fig. 4). In contrast to the Bifacial complex of the northeast, this tradition has been described as the 'Microlithic complex' because the most impressive feature is the secondary modification of flakes/blades into microlithic elements.[21]

The distinction of two cultural complexes in the Western Desert is largely reinforced by the occurrence of two pottery traditions (Fig. 5) that strikingly overlap with the lithic traditions in space and time, though it is obviously more centered on refuge areas than on the remote desert regions. From 6500 cal BC onwards, the southern Microlithic complex is accompanied by a well-known tradition represented by Khartoum style decorations, among which the packed dotted zigzag is most common, occasionally combined with dotted and incised wavy line decoration, though the latter is mainly restricted to Egypt's southwest corner and the regions farther into Sudan. Undecorated ceramic vessels can be easily affiliated to the same tradition by shape, wall-thickness, and fabric type.

The northeastern tradition, which can be connected to the Bifacial complex in the lithic material, features undecorated thin-walled small ceramic vessels distinctively different from the Khartoum style pottery.[22] The dating of the vessels is less precisely developed than the Khartoum material, due to the high rate of surface material among them, but it is evident that they predominantly occur in inventories of the 6th millennium cal BC (with growing evidence in its second half). While most vessels of this ceramic tradition have burnished or slightly polished surfaces, there are also red-polished surfaces, some of which indicate early blackened rims and, rarely, a surface rippling.

However, the distribution of this pottery tradition is more restricted because it centers on sites in the Dakhla Oasis and its surroundings,[23] as well as on the southern Egyptian Limestone Plateau at Abu Gerara,[24] with very few examples distributed as far north as the Djara sites, some 250 km north of Dakhla.[25] As a matter of

21 Riemer 2007b; Riemer, Lange, and Kindermann 2013.
22 Riemer and Schönfeld 2010; Muntoni and Gatto 2014.
23 Hope 1999; Hope 2002.
24 Riemer and Schönfeld 2010.
25 Kindermann 2010, 99.

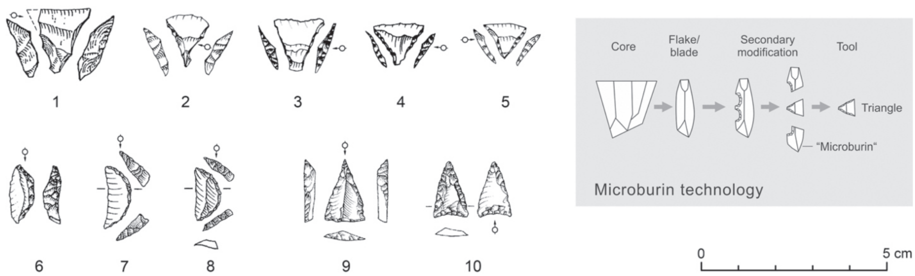

Fig. 4 Characteristic stone tools and technological elements of the Microlithic complex: 1–5 = Transversal arrowheads; 6–8 = segments; and 9–10 = triangular points.

fact, it is unknown from the Farafra region,[26] which still lacks a plausible explanation. However, fragmentary our knowledge of sites in the Western Desert is, Dakhla currently appears as the main center of this tradition (and perhaps as its primary site of production).[27] This pattern obviously parallels the ecological zoning with the oases as the nuclei of retreat, communication, and exchange; while the spread of objects into the episodically occupied desert areas outside is more occasional.

The two regional traditions mentioned above are distinctive in attributes and distribution, but on the archaeological map, they appear with some overlap at the fringes of their distribution (Fig. 2). This contact zone is best evidenced in the Dakhla region and in the Nabta Playa/Bir Kiseiba region where intensive archaeological work has been carried out. Archaeological sites situated in Dakhla and its southern and southwestern margins are dominated by the bifacial tradition in lithics and the thin-walled Dakhla pottery. However, minor intrusions of microlithic elements and Khartoum style potsherds occur as well. The percentages in elements of both traditions shift to the opposite with growing distance from Dakhla to the south and southwest. Most sites from the Chufu region and at Eastpans, some 80 to 100 km out of the oasis proper, reveal a clear dominance in bifacial lithics and Dakhla pottery.[28] The percentages shift to the opposite when entering the Great Sand Sea and the Abu Ballas region. At each of the sites Regenfeld[29] and Mudpans,[30] some 150 to 200 km from Dakhla, the predominance of microliths and Khartoum style pottery is overwhelming; only a very few elements of the bifacial tradition were left there. There is currently no site beyond these locations that has produced reliable evidence of bifacial elements (perhaps with the singular occurrence of a bifacial arrowhead at the southeastern Gilf Kebir site Wadi Bakht 82/17).[31] The distributional pattern summarized above can best be explained by the seasonal mobility of hunter-gatherer groups that covered up to hundreds of kilometers in search of open water pools, vegetation, and game.

2.3 Hunter-gatherer complexity

The mid-Holocene pluvial demonstrates a number of changes and enrichment in material culture, as well as in site structures and patterns which all signals socio-economic relevance. It is a matter of fact that not only the pottery production and use occurs in hunter-gatherer communities, but also the steady increase of grinding stones on campsites throughout the Western Desert. This went with a general trend towards larger camps sites that centered at the water pools in the desert areas. Systematic micro-regional studies at Djara,[32] Abu Gerara,[33] Regenfeld,[34] in the Gilf Kebir valleys,[35] and at other locations prompt the conclusion that – compared to the early Holocene – mobility patterns markedly change towards logistical mobility with larger and more residential camp sites at episodic water pools (playa lakes) that were occupied repeatedly and more regularly over longer episodes during the year; while other resources, such as game, and raw material for lithic production were largely obtained during logistical trips in their vicinity.[36] The accumulation of grinding stones at the campsites reveals that vegetal food resources were

26 Muntoni and Gatto 2014.
27 Warfe 2018.
28 Riemer 2006.
29 Riemer 2009.
30 Kuper 1993.
31 Linstädter 2005, 370.
32 Kindermann and Bubenzer 2007; Kindermann 2010.
33 Riemer 2010; Riemer and Schönfeld 2010.
34 Riemer 2009.
35 Linstädter 2005.
36 Kuper and Riemer 2013, 42.

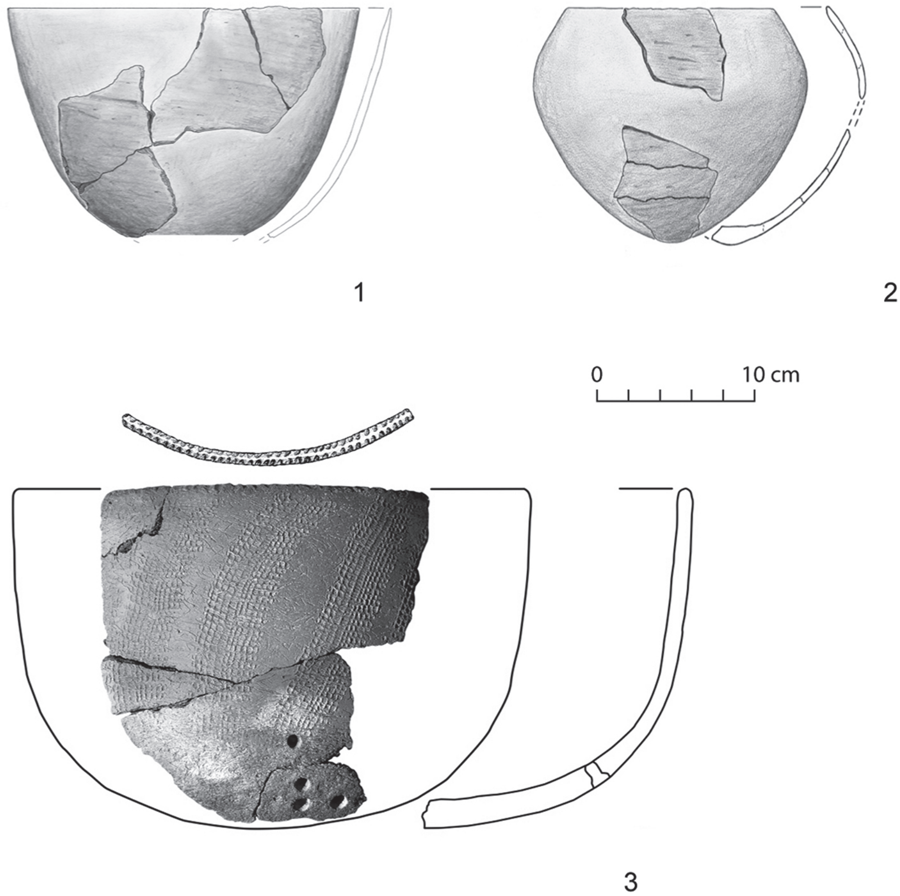

Fig. 5 Mid-Holocene ceramic vessels of the Bifacial complex and the Microlithic complex: 1–2 = Undecorated thin-walled pottery from Djara and 3 = Khartoum-style pottery with rocker stamp decoration from Chufu.

exploited in the surrounding countryside of the camps and preferably processed at these sites, probably by those members of the group who were not involved in hunting parties and other longer logistical trips. Seasonal long-distance movements between the large campsites still occurred, but became less frequent throughout the year, and perhaps covered a smaller territory, as in the early Holocene. Yet, mobility patterns were highly variable, depending on individual landscape configurations and the density and pattern of available resources.

Moreover, research in the oases of Dakhla and Farafra revealed the existence of large complexes of stone slab structures at playa depressions and/or outflows of major wadis during the 6th millennium cal BC.[37] Although their function is not yet sufficiently clear, they indicate a nucleation of campsite activity and a kind of future-orientation at places that provided reliable water and food resources in retreat areas. As such, they are interpreted explicitly as an expression of 'increased sedentism' and 'intensification' of group agglomeration and local resource management.[38] In looking for a rationale to explain this pattern, McDonald points to a number of favorable local factors for the positioning of the sites, such as the water availability and the position at major routes from the lowland onto the plateau (both for humans and game), but also refers to somewhat wetter conditions during the mid-Holocene, presumably fostered by the bi-seasonal precipitation pattern that provided rains during summer and winter.[39] In the same manner, the Nabta Playa area is characterized as an oasis refuge

37 McDonald 2009; Barich, Lucarini, et al. 2014.

38 Only few cultural phenomena appear without forerunners. This also holds true for the early to mid-Holocene transition. Already in the Masara C unit (ca. 8300–7500 cal BC) in the Dakhla Oasis extended slab structures, interpreted as huts, in small well-watered refuges point to 'increased sedentism' during arid intervals with a decreased mobility (McDonald 2009; McDonald 2015).

39 McDonald 2009, 26; Barich and Lucarini 2014a, 467.

featuring water-wells. Here, pits filled with collected edible plants can be interpreted as storage facilities providing "[…] resources that enabled them to stay in the area during the late winter and spring when other food was not available".[40] This example illustrates another facet of early 'low-level food production' of complex hunter-gatherer communities.[41]

Yet, the development in the oases did not occur in isolation from the true desert territories, given the overall connectedness of the different environments and their inhabitants, amply demonstrated by identical material cultures and the fact that the oases created retreat areas during the dry season or during longer periods of drought. The elaborate stone structures and the suggested increased sedentism in the oases is a more pronounced result of the same shift to complexity that occurred in the entire Western Desert, with the oases' sites constituting the stable retreat places of the same (still mobile) groups that ventured to the more ephemeral desert sites in seasons of increased rainfall.

Moreover, McDonald has stressed the point that this kind of intensification during the mid-Holocene "[…] may also have been driven by (or have promoted) increased social complexity […]",[42] which might also be indicated by a number of 'prestige technologies'[43] that emerged during the same time, such as "[…] labrets, carefully-fashioned large arrowheads, the scarce pottery of the time, and marine shell pendants […]".[44] Similar objects, often of exotic origins or unusual materials, also occur in sites elsewhere and illustrate a growing interest in body jewelry. Among them are stone beads, labrets, and the so-called toggles, but also shells of gastropods, such as cowries and land snails (e.g. *Zootecus insularis*), which often show the typical piercing to string them. Such items are not only evidence for far ranging contacts, which in the case of the Red Sea cowries could only be obtained by exchange networks, but also the growing significance of adornment to express group or personal identity, and perhaps an incipient kind of social inequality among group members.[45] As a parallel to McDonald's large bifacial arrowheads (see above), we like to stress the existence of a number of elaborately made bifacial flint knives (Fig. 6) that began to appear in the second half of the 6th millennium cal BC on sites of the Bifacial complex.[46] They indicate a very regular parallel (pressure) flaking of the surfaces, often with the handles carefully worked. The amount of work spent on the production of such show items certainly surmount the investment usually spent for solely utilitarian work tools. Moreover, these items were obviously not (primarily) produced as work tools because the delicate bifacial modification prevents any re-sharpening of the knives without a substantial loss of material.[47] According to McDonald, "[…] prestige technologies are generated in resource-rich environments by 'aggrandizing' individuals, who employ surpluses in a competition for power, prestige and wealth".[48]

2.4 Early domesticated animals

It is not our intention to comment here on the possible autochthonous domestication of the African cattle, as suggested by genetic studies of mitochondrial DNA lineages,[49] nor on the keeping of incipiently domesticated bovids during the early Holocene, as referred to in the study of bone remains from the sites of Nabta Playa and Bir Kiseiba.[50] The bone remains of the early Holocene bovids in question fall into the size range of the Nile Valley wild cattle,[51] and the assessment of their domesticated status is largely built on a number of environmental and ecological arguments.[52] Judging from the analysis of osteometric data provided by the bone material from early to mid-Holocene sites at Nabta Playa and Bir Kiseiba, a marked decrease of body size as indicative for the domestication process in cattle, is – for the first time – evident on bones from site E-75-8, which

40 Wendorf and Schild 2002, 44; cf. Nabta area site E-75-6 (Wendorf and Schild 1980 132-140) and E-91-1 (Wendorf, Close, and Schild 2001, 147-183).
41 B. D. Smith 2001.
42 McDonald 2009, 27.
43 Referring to Hayden 1998.
44 McDonald 2009, 27.
45 Cf. McDonald 2009.
46 Kindermann 2010; Barich and Lucarini 2014b; Riemer, Lange, and Kindermann 2013.
47 Kindermann 2010; Kuper and Riemer 2013.
48 McDonald 2009, 27.
49 Troy et al. 2001; Hanotte et al. 2002; cf. Linseele 2013, 98.
50 Gautier 1980; Gautier 2001; Wendorf and Schild 1980; Wendorf and Schild 1994; Wendorf and Schild 1998.
51 Gautier 2001.
52 Cf. A. B. Smith 1984; A. B. Smith 1986; A. B. Smith 2005; MacDonald 2000.

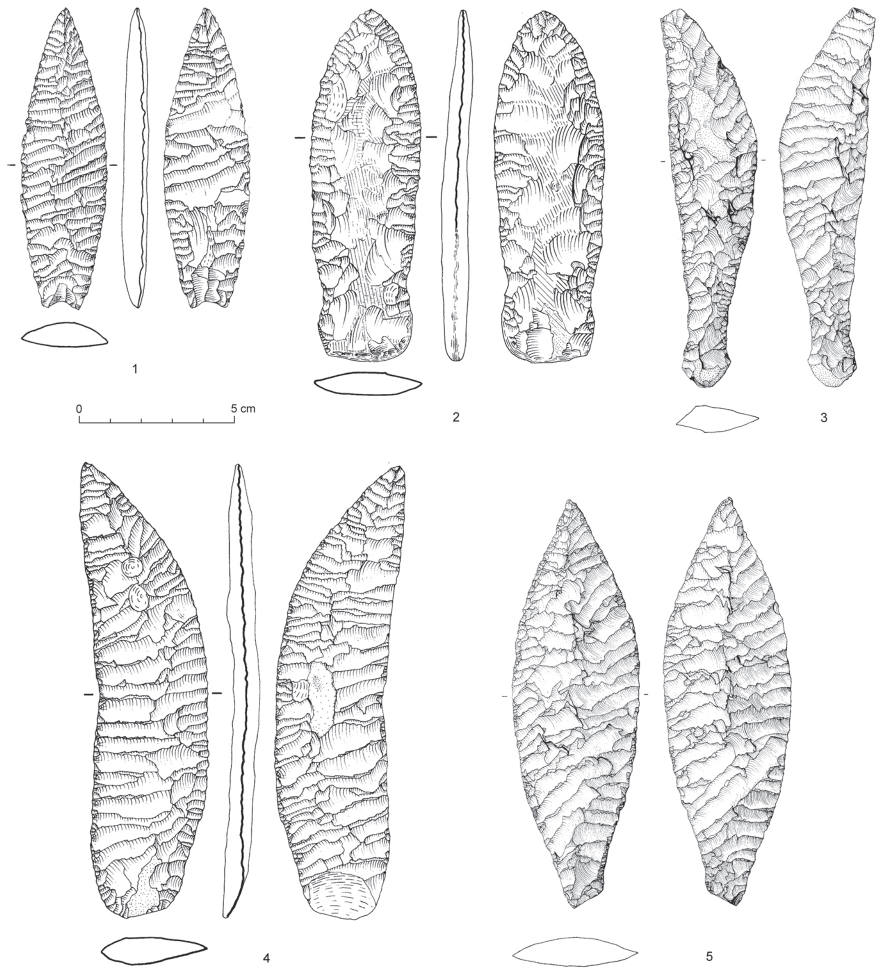

Fig. 6 Flint knives of the Bifacial complex of the 6th millennium BC from Djara.

provided dates between 6000 and 5500 cal BC.[53] Even if we take the domestication status of the early Holocene cattle as granted, it obviously had no substantial impact on other hunter-gatherer communities outside of that region. Rather, it appears that the undisputable keeping of cattle from around 6000 cal BC onwards fully parallels initial attempts to integrate small and large livestock in increasingly complex hunter-gatherer economies elsewhere in the Eastern Sahara (Fig. 7). Although the number of sites that provide evidence for domesticated animals and associated dating information is still small in the Eastern Sahara,[54] the following data allow for a number of general conclusions.

The mid-Holocene hunter-gatherer communities, as outlined in the preceding paragraphs, form the stage against which the early domesticated animals appear in Northeast Africa. It is undisputable that sheep and goat were introduced from the Asian continent because potential wild progenitors do not exist on the African continent.[55] Yet, it is still a matter of debate when this took place, and how and where its introduction into, and spread over, Northeast Africa can be reconstructed.

Initial domestication of ovicaprids has been dated back in the Levant to the 8th millennium cal BC,[56] and their introduction into hunter-gather subsistence of the Levantine arid margins is evidenced until the Late/Final PPNB.[57] The 7th millennium cal BC is regarded as the period when Neolithic activity shifted to previously marginal regions to the east of the Levantine corridor, as well as to the south where contacts with

53 Gautier 2001; Wendorf and Schild 2001.
54 Cf. Riemer 2007b; Linseele 2013; Lesur 2013.
55 Gautier 1980; Gautier 2001; Close 2002; Linseele 2013.
56 Legge 1996.
57 Bar-Yosef 1984; Byrd 1992.

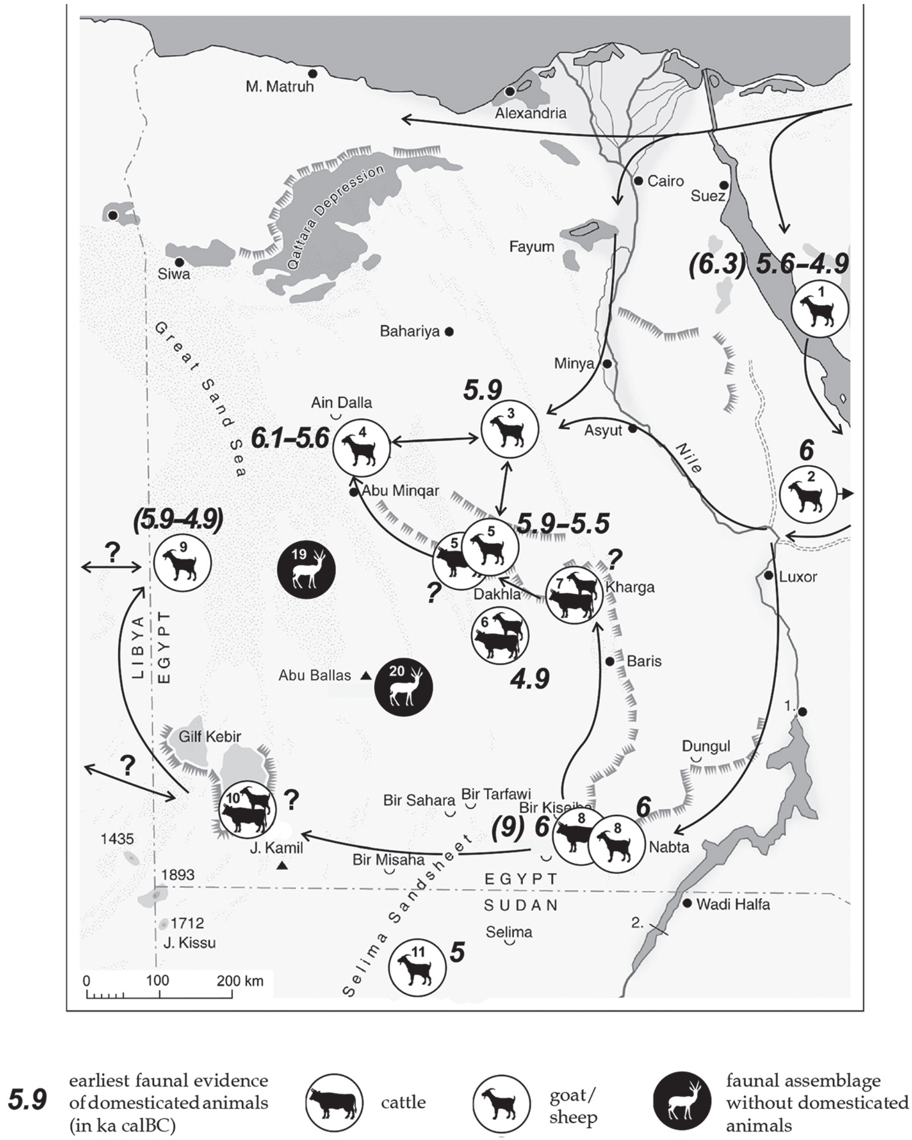

Fig. 7 Introduction and diffusion of early domesticated animals into Northeast Africa/Egypt around 6000 and 5000 cal BC.

African groups were conceivable,[58] although faunal evidence is scarce in the Sinai and Negev region.[59] Bar-Yosef suggests that demographic growth and movements of Levantine groups brought ovicaprids into the Egyptian Nile Valley around the 6th millennium cal BC (Fig. 7).[60]

Potential routes along which early domesticated ovicaprids were brought into Egypt are the northern coastal flank of the Sinai and/or via the southern tip of the peninsula, including a crossing of the Gulf of Suez. The latter is supported to some extent by ovicaprid remains found in the El Qaa region, associated with dates between 6300 and 4900 cal BC.[61] With dates ranging between 6200 and 5300 cal BC, the Sodmein Cave in the Red Sea Mountains constitutes the earliest evidence of ovicaprids in the Eastern Desert,[62] followed by the site of Tree Shelter in the same region with a date around 5600 cal BC.[63] From the Western Desert, the Farafra Oasis currently holds the earliest reliable evidence of small

58 Wengrow 2006.
59 Goring-Morris 1993.
60 Bar-Yosef 2013, 242–244.
61 Close 2002.
62 Vermeersch, Van Peer, et al. 1996; Linseele, Marinova, et al. 2010; Linseele 2013; Vermeersch, Linseele, et al. 2015.
63 Vermeersch 2008.

livestock dating to around 6000 cal BC.[64] In the Dakhla Oasis, small livestock and possibly cattle have been identified from Late Bashendi A sites. Judging from a suite of published radiocarbon dates associated with the site, a possible date range between approximately 6200 and 5400 cal BC is given.[65] An ovicaprid bone fragment excavated from a site at Djara is associated to a date of 5900 cal BC and to lithic material from around the same period.[66] A direct date on the bone centers about the same mean value, but is of minor reliability because of an excessively high standard deviation.[67] A number of other bone finds from cattle and ovicaprids came from surface collections in the Gilf Kebir and the Great Sand Sea. However, they shall not be listed here in detail, due to questionable associations with radiocarbon dates or context material.[68]

Although present data are insufficient to reconstruct variations and exact routes by which domesticated animals spread through the Western Desert, some conclusions can be derived from the aforementioned data: first, the earliest domesticated animals seem to spread out during a relatively short period of time at the beginning of the 6th millennium cal BC in most parts of the Eastern Sahara and its oases.[69] Secondly, although ovicaprids are significantly more frequent among the bone remains, cattle are evidenced for the same time period, at least, from the mid-Holocene onwards in the Nabta/Kiseiba region and in the Kharga Oasis. The lack of cattle remains in the Eastern Desert can possibly be explained by the absence of sufficient surface water and pasture there.[70] Thirdly, while ovicaprids were certainly introduced from the Asian continent, the earliest occurrence (and distribution?) of domesticated cattle during the same time period makes it conceivable that cattle were also introduced from Asia together with the ovicaprids, given that early autochthonous cattle domestication on the African continent is not fully evidenced.[71] Finally, it is evident that early ovicaprids in the Eastern Sahara were introduced to hunter-gatherer communities. It is a matter of fact that this happened around the same time when these communities started to intensify their subsistence and complexity in social patterns.

Yet, it is ambitious to say whether complexity and intensification were initiated by the introduction of livestock, or if livestock was only adopted at a certain point of ideological disposition developed along with social complexity. The latter might be supported by the observation that a number of cultural traits reflecting a beginning of social complexity (such as the increase in grinding stones or the earliest pottery) seem to predate the beginning of the 6th millennium cal BC. Starting from a more theoretical point of view, this interpretation might also be reinforced by the often-cited conservatism of mainly egalitarian foragers, whose ideology of food sharing[72] is opposed to a mentality of future-orientation by food and livestock accumulation, and social inequality.[73] Thus, the introduction of livestock would need a certain substrate of complexity on which stock keeping can grow as a 'delayed return foraging' strategy.[74]

At this point, a word of warning against the oversimplification of archaeological data is needed. There is some recognition that the conditions under which hunter-gatherers lived in the Eastern Sahara illustrate a quite diversified spectrum of ecological niches and their respective living conditions. Likewise, there is some variation in the sedentary tendencies in the different regions under study and that some forager communities adopted and treated livestock in a different way than others. Although the character of the traditional forager economy at sites, where domesticated animals were identified, seems to have undergone no principal change because arrowheads indicating hunting activities still rank high in the lithic tool lists, the proportions in which domesticated animals appear in the bone records show major differences. While sites in the desert landscapes outside of the oases revealed only minimal evidence of livestock, by far surmounted by bones of hunted game (e.g. Djara),[75] or even no livestock in rich bone records of hunted game (e.g. Regenfeld), some of the more favorable oases locations yielded quite substantial percentages of domesticated bones. Although hunting never appears as marginal, bones of domesticated

64 Gautier 2014.
65 McDonald 1998; McDonald 2001.
66 Kindermann, Bubenzer, et al. 2006; Pöllath 2010.
67 Kindermann 2010, 145.
68 See Riemer 2007b.
69 Riemer 2007b; Linseele 2013.
70 Linseele 2013.
71 Cf. Linseele 2013.
72 Lee and De Vore 1968.
73 A. B. Smith 1990; A. B. Smith 1992; Ingold 2000.
74 Woodburn 1988.
75 Pöllath 2010, 844.

animals are at 17% during the early 6th millennium cal BC in the Nabta/Kiseiba record.[76] For the remote desert sites, this picture does not change significantly during the second half of the millennium, reporting a primary hunting subsistence. At Nabta/Kiseiba, however, the percentage of domesticated bones switches to over 30% during the 'Late Neolithic' (ca. 5600–4600), and a similar picture is suggested for the Kharga Oasis sites during the same period of time.[77]

2.5 Traits shared with the Near East?

The potential influence of the Near Eastern Neolithic on African cultural development has biased Saharan archaeological research beyond tracing remains of domesticated animals in Saharan bone records. In this respect, the search for cultural traits revealing parallels between the two continents has also influenced some interpretations of ceramic and lithic objects excavated from sites in the Eastern Sahara. However, traits potentially indicating contacts and infiltrations of knowledge and ideology, as well as of materials and objects, are significantly small, and the overall discussion about the significance of traits is also hampered by the difficulties to draw warranted conclusions from the archaeological material.

According to the current state of research, the oldest *senso stricto*,[78] Neolithic cultures in Egypt – developed during the 5th millennium cal BC in the Nile Delta (e.g. Merimde Benisalâme, el-Omari) – directly reveal an already advanced 'Neolithic set', including cultivated cereals (wheat and barley) and domesticated animals (ovicaprids, cattle, and pigs), pottery, and polished stone artefacts. Recent research from the Fayum, however, has developed a more detailed view on the socio-economic status of the Fayum A cultural unit (5400 to 4500 cal BC). According to Holdaway et al., it shows a diversified socio-economic system combined with a considerable amount of mobility.[79] The latter is especially represented in the exploitation of seasonal abundant fish and game.[80] The Fayum is an extensive mode of resource exploitation adapted to the specific conditions of its habitat sandwiched between the desert and the Nile. Thus, it points to a developed stage on the scale of the low-level food production.[81]

Prior to the 6th millennium cal BC, when a complete Neolithic lifestyle was adopted, no traces of a Neolithic culture could be traced in Egypt. Continuously, it was discussed where the forerunners came from and which influences enabled the Neolithic in Egypt. Can we prove contacts to the Near East, did the Egyptian Neolithic originate from indigenous groups, or was it even more complex, and the Egyptian Nile Valley Neolithic was influenced from both directions, the east and the west?

On the one hand, evidence of domesticated cattle, which was probably domesticated in Northeast Africa,[82] point to clear hints with the indigenous groups of the Western Desert and oases. Whereas on the other hand, domesticated ovicaprids (sheep and goat), as well as proof for cultivated grain, point to the Near East. In any case, a distinctive African pathway towards food production,[83] also termed 'multi-resource pastoralism', can be established,[84] in which livestock keeping became an essential component. However, it also continued simultaneously to exploit different wild plants and animals. Marshall and Weissbrod described it for Africa as:

> [...] a wide range of wild resources in ecodiverse combinations [*were*] continued in use, and mosaics of hunter-gatherers and herders occupied varied regions. Pastoralism developed early in the arid topics whereas the beginning of farming based on domesticated plants was late.[85]

One question still remains, what kind of material culture can be associated with these innovations that showed up for the first time around the 7th to the early 6th millennium cal BC in Egypt? Are there any traits that *support* contacts to the east or to the west and possibly provide more information about the people involved in the

76 Riemer 2007b.
77 Lesur et al. 2011.
78 As defined by Gordon Childe 1936, sedentary farming with domesticated plants and animals.
79 Holdaway et al. 2016.
80 Linseele, Van Neer, et al. 2014.
81 B. D. Smith 2001.
82 Cf. Gautier 1980; Gautier 2001; Troy et al. 2001; Hanotte et al. 2002.
83 McDonald 2013, 176.
84 Kuper and Kröpelin 2006, 805; Marshall and Weissbrod 2011, 408.
85 Marshall and Weissbrod 2011, 408.

Egyptian Neolithisation processes? To try and obtain answers to such considerations, we would like to focus primarily on the two main elements of the material culture that are combined with the first domesticated plants and animals in Egypt, the ceramics and the lithics.

2.5.1 *Ceramics*

The first case to be discussed is the hypothesis of a possible Near Eastern influence on an undecorated pottery tradition in Egypt's Western Desert. The original idea goes back to the excavations carried out at Mudpans, some 200 km south-southwest of the Dakhla Oasis. The stratigraphic examination of potsherds from site Mudpans 85/56 revealed a lower unit that exclusively contained potsherds with a Khartoum style decoration and an upper unit that had Khartoum-decorated pottery mixed with undecorated sherds. The entire sequence covers a date range of some 500 years between ca. 6500 and 5900 cal BC.[86] Although Kuper[87] expresses the idea that:

> […] the appearance of undecorated pottery [from about 6000 cal BC onwards] might well have been imprinted by a Near Eastern influx carrying a new ceramic tradition together with sheep and goat as 'Neolithic' representatives.

He carefully elaborates a number of possible (and also alternative) scenarios:

> (a) meeting and perhaps being influenced by a non-decorating pottery tradition (wherever the origins of this are to be searched); (b) generating out of itself a facies that gave up the mode of decoration; or (c) stimulating people so far without pottery to adopt ceramic technology, who, however, preferred not to ornament their pots.[88]

At that time, some 20 years ago Mudpans actually marked the northernmost dated spread of the Khartoum decorated pottery tradition,[89] while the Dakhla prehistoric ceramics were only cursorily known and barely dated. Moreover, the existence of a Dakhla-centered undecorated pottery tradition that had also spread to remote desert destinations onto the northern Egyptian Limestone Plateau and to the surrounding regions of Dakhla became only apparent with the examination of material collected from sites at Eastpans, Djara, and Abu Gerara after the 1990s.[90]

Confronted with the vast knowledge gained during the past decades on ceramics from the Dakhla Oasis and from various desert regions, the Near Eastern influence on the Saharan undecorated pottery is no longer warranted. The nucleation of a thin-walled undecorated pottery at the Dakhla Oasis and its thinning with growing distance into the surrounding desert regions, clearly supports the conclusion of a local origin of pottery production there.[91] The undecorated pottery found at Mudpans, as well as at a growing number of sites in southern Egypt, is now clearly identified as an undecorated facies of the Khartoum style complex. The latter clearly shows similar recipes and changes in the fabric composition of both decorated and undecorated wares (although often with reasonably finer grain in the impression decorated wares).

2.5.2 *Lithics*

Every now and then, Near Eastern influences on mid-Holocene lithic artefacts from Northeast Africa have been assumed by different scholars, either as a conceivable part of the 'Neolithic package'[92] or as individual elements.[93] In the context of the former, the first occurrence of bifacial technology at the beginning of the mid-Holocene is often quoted,[94] since bifacial stone artefacts are known throughout the PPNA and the PPNB (Pre-Pottery Neolithic A and B, respectively) in the Near East. For the latter, mostly specific types of arrowheads were appointed as proof, documenting contacts between Egypt and the Near East. Shirai, for instance, sees "[…] two successive waves of diffusion of Levantine projectile points […]";[95] for the Pre-Pottery Neolithic Helwan points and for the subsequent Pottery Neolithic

86 Kuper 1993; Kuper 1995, 129.
87 Kuper 1995, 135; cf. Kuper 2002, 5.
88 Kuper 1995, 135.
89 Kuper 1993.
90 Riemer and Schönfeld 2010.
91 Hope 1999; Riemer and Schönfeld 2010.
92 Kuper 2002, 10; Vermeersch 2008, 95; Kuper and Riemer 2013, 37.
93 Gopher 1994, 252–254; Shirai 2010, 311–335.
94 Kuper 2002, 10; Kuper and Riemer 2013, 37.
95 Shirai 2010, 317.

Nizzanim points, Haparsa points and Herzliya points, as well as bifacially retouched sickles are quoted.

However, many researchers emphasize the Neolithic development in the Fayum and the Egyptian Nile Valley as influenced by indigenous traditions and, hence, as derived from Northeast African influences.[96] The characteristic bifacial knives and hollow-base points of the Fayum Neolithic, for example, are also reported from many other archaeological sites in the Western Desert of Egypt (e.g. Abu Tartur,[97] Abu Gerara,[98] and Dakhla[99]), whereas this lithic tradition finds no parallels in the Sinai or the Levant. Bifacial items such as arrowheads, knives, or adzes are numerous during the mid-Holocene in the Egyptian Western Desert. Archaeological inventories with a high proportion of facial retouch are well-known, in particular from the oases region of the Western Desert from the Dakhla Oasis,[100] the Kharga Oasis (Dush),[101] and the Farafra Oasis,[102] but also from the surrounding desert areas, as from Djara[103] or from Eastpans south of Dakhla.[104] During the second half of the 6th millennium cal BC such technology is widespread in the Western Desert.[105]

If bifacial technology is interpreted as a part of a 'Neolithic innovation package' that came together with the earliest evidence of small livestock and undecorated ceramics from the Near East into Northeast Africa,[106] these three cultural elements (bifacial technology, small livestock, and undecorated ceramics) should be observed more or less simultaneously on archaeological sites in Egypt. However, it seems that they appear separately. McDonald consequentially noted that the chronological order of these cultural elements is still a weighty argument against a Near Eastern origin of the bifacial retouch[107] and, hence, sees "[…] the Northeast African mid-Holocene bifacial tradition […] largely of local origin, not part of a package of imports from the Near East".[108]

According to the current state of research, the first occurrence of bifacial technology in Northeast Africa seems to be several hundred years older than the introduction of the first caprids. As noted earlier, shortly before 6200 cal BC, ovicaprids were present in the Sodmein Cave in the Eastern Desert.[109] This evidence can be seen as the earliest proof for caprids in Northeast Africa and, so far, the earliest known from the entire African continent. The use of the cave by mobile stockkeepers seems to concentrate around a time period of 6200 to 5800 cal BC. Vermeersch et al. suppose that these herders probably did not use ceramic at all,[110] whereas the associated lithic tool kit appeared similar to the Bifacial complex in the Western Desert. Only a little reliable evidence of small livestock from later is also known from Egypt's Western Desert, from the Farafra Oasis.[111] All other hints for stock keeping in Egypt are younger and continue with absolute dates of around 6000 cal BC.[112] In contrast, the bifacially retouched artefacts in the Eastern Desert as well as in the Western Desert are dated much earlier (Fig. 8). For Tree Shelter, bifacial technology is documented at around 6600 cal BC (Horizon 4, AH4) or even earlier.[113] For the Western Desert, bifacial artefacts have been present regularly since 6500 to 6400 cal BC, for instance, in the Dakhla Oasis (Bashendi A)[114] and the Djara region (Djara A),[115] while the earliest caprids are verifiable not before 6000 cal BC in Dakhla[116] and around 5900 cal BC in Djara.[117] Considering the entire lithic assemblages of these archaeological sites with the earliest ovicaprids in Northeast Africa, they seem to exhibit more similarities with the assemblages of the Western Desert than with those from the Near East.

From the technological point of view, characteristic stone artefacts of the Levant Middle Neolithic Period (PPNB, PPNB/PPNC), dated around 8500–6250 cal BC,

96 E.g. Butzer 1976, 11; Wenke, Long, and Buck 1988, 47; Kindermann 2010; McDonald 2013.
97 Bubenzer, Hilgers, and Riemer 2007.
98 Riemer 2010.
99 McDonald 2013, 184.
100 McDonald 1999, 118–119.
101 Briois et al. 2012, 183.
102 Barich, Lucarini, et al. 2014.
103 Kindermann 2010, 105–108.
104 Gehlen et al. 2002, 94.
105 Kindermann 2010, 133–134; Riemer and Kindermann 2008.
106 Kuper 2002, 10; Vermeersch 2008, 95; Kuper and Riemer 2013, 37.
107 McDonald 2013; McDonald 2016.
108 McDonald 2016, 192.
109 Vermeersch, Linseele, et al. 2015, 487.
110 Vermeersch, Linseele, et al. 2015, 499.
111 Gautier 2014, 373–374.
112 Linseele, Van Neer, et al. 2014; Riemer 2007b.
113 Vermeersch 2008, 90 and 95.
114 McDonald 2013, 183–185.
115 Kindermann 2010, 105–106.
116 McDonald 2016.
117 Kindermann 2010, 145.

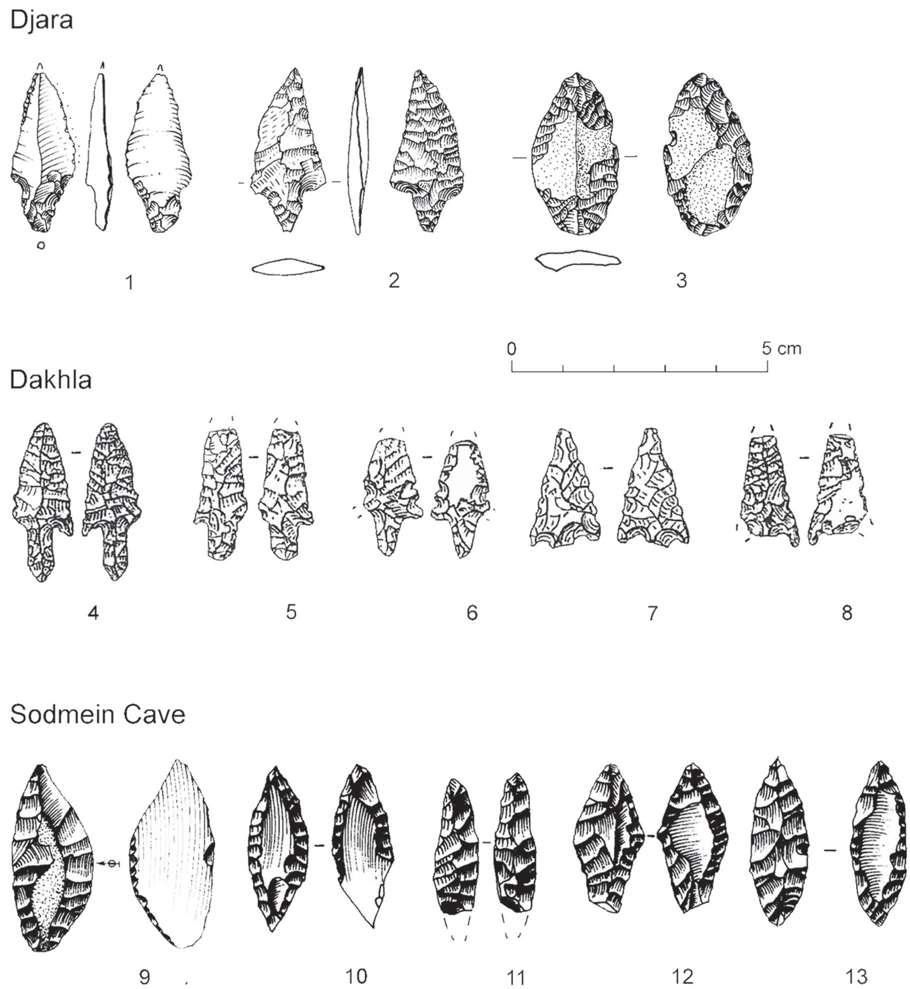

Fig. 8 Early bifacial retouched arrowheads from the Western and Eastern Desert of Egypt: 1–3 = Djara A, Egyptian Limestone Plateau (6500–5900 cal BC); 4–8 = Bashendi A, Dakhla Oasis (6400–5650 cal BC); and 9–13 = Sodmein Cave, Eastern Desert (6200–5800 cal BC).

are made out of long, narrow blades struck from bipolar often 'naviform' (boat-shaped) cores. A complex system of raw material supply and exploitation of highly specialized cores is underlying this.[118] Such naviform cores were already introduced in the northern Levant by the middle of the 8th millennium cal BC, and remained in use until the end of the 6th millennium cal BC.[119] In Northeast Africa a gradual change in technology and blank procurement for tool production is visible from the Epipalaeolithic to the mid-Holocene for many parts of the Western Desert. During this time period, the former elaborated blade and bladelet technology of the Epipalaeolithic was replaced by a flake-oriented production, which was much more pragmatic and less reliant on good raw material resources. Even tabular flint and thermal debris were used for the production of stone tools.[120] Such a flake-oriented tool production and a replacement of the blade technology is observed both on archaeological sites with early livestock in the west, as for example in the Hidden Valley in the Farafra Oasis,[121] and also from a little later time period (around 6300 cal BC) in the Eastern Desert at Tree Shelter and Sodmein Cave. Vermeersch et al. even presumes that the Egyptian North Western Desert seems to share similar cultural traditions with the Eastern Desert.[122]

Last but not least, focusing on the mentioned argument for possible cultural contacts between Northeast Africa and the Near East, the characteristic individual

118 Shea 2013, 221 and 225–227.
119 Gopher 1994, 252.
120 Gehlen et al. 2002; Kindermann 2010.
121 Barich and Lucarini 2014b, 322–323.
122 Vermeersch, Linseele, et al. 2015, 498–500.

lithic elements, is concentrated mainly on one artefact type, the projectile points.[123] A wide variety of different Neolithic projectile points exist in the Levant, which are somewhat the result of a lack of a standardized typology and the substantial variability in the ways lithics are described by archaeologists.[124] The situation is also amplified by the complexity of the Levantine Neolithic and its diversity.[125] Roughly summarized, most Neolithic projectile points are either triangular or bi-conical and vary in their elongation, predominantly between 20 and 100 mm long and are less than 30 mm in width.[126]

The main point of discussion about the spread of projectile points from the Levant essentially turns on the Helwan points (Fig. 9).[127] This projectile point is defined as a triangular point with varying combinations of one or more pairs of bilaterally symmetrical notches and a tang, originating in the Northern Levantine PPNA, but mainly developing in the PPNB around 8200 to 8000 cal BC.[128] Although this projectile point is a characteristic type of the Pre-Pottery Neolithic in the Near East, the name originally derived from the archaeological site of Helwan on the eastern bank of the Egyptian Nile Valley, now part of the modern capital Cairo. To date, this type of point has only been sporadically documented in Northeast Africa, for example at Helwan,[129] at Merimde Benisalâme,[130] in the Fayum,[131] in the Dakhla Oasis,[132] in Wadi Araba in the Eastern Desert of Egypt,[133] and at the Haua Fteah in Libya.[134] Due to the great variability of different forms of Helwan points, it is questionable as to which points are reliably comparable (Helwan points *versus* simple side-notched and denticulate ones). Cauvin argued to abandon the name 'Helwan point' for one specific projectile point because there are so many variants.[135]

Besides a weak definition of Helwan points and the great variety of shapes and sizes,[136] the sporadic occurrence in Northeast Africa and the poor dates pose great problems in such a comparison. Many of these finds are from surface collections and undated. Some of them are roughly dated to the 6th millennium cal BC (e.g. Dakhla Oasis and Haua Fteah). Hence, the significant time gap between the Helwan points of the Levant/Negev and the few dated African side-notched and tanged projectiles must also be explained. Shirai assumes that undated side-notched and tanged projectile points from the Fayum fall in the 8th or early 7th millennium cal BC,[137] which would also leave a significant time gap between their first appearance in the Levant and their first occurrence in Egypt. Gopher expected a diffusion of Helwan points starting around 8000 cal BC from its source area in the Northern Levant, where it first appeared in the late 9th millennium cal BC, to the more southern regions around 7500 cal BC.[138] In any case, the diffusion of Helwan points took place well before the spread of domesticates into Northeast Africa.[139] Further field investigations are necessary and reliable absolute dates are indispensable for achieving progress in the question of how the possible connections between the Levantine and North African Helwan points can be decoded.

There are also similar difficulties with the other cited types of projectile points, which were used to document cultural contacts between the Near East and North Africa.[140] The Nizzanim, Haparsa, and Herzliya points in which Shirai sees a second wave of diffusion of Levantine points, are small versions of the Jericho, Byblos, and Amuq points. Jericho/Haparsa and Byblos/Nizzanim points have tangs, whereas the Amuq/Herzliya points are oval or leaf-shaped in form.[141] Here again, the definitions of these projectile points are broad and need to be more precise and narrowed. In fact, simple tanged arrowheads and oval/leaf-shaped ones can be documented worldwide. Many of these arrowheads are undated; for example, Caton-Thompson's published and unpublished Fayum material, in which Shirai see similarities

123 Gopher 1994, 252–254; Shirai 2010, 311–335.
124 Shea 2013, 222.
125 Gopher 1994, 262.
126 Shea 2013, 238.
127 Gopher 1994; Shirai 2010; Shirai 2011.
128 Gopher 1994, 34–36, 252; Shea 2013, 242–243.
129 De Morgan 1896; Debono and Mortensen 1990; Schmidt 1996.
130 Eiwanger 1984.
131 Seton-Karr 1904; Currelly 1913; Shirai 2002.
132 McDonald 1991.
133 Bissey and Chabot-Morrisseau 1960; Tristant 2010; Tristant 2012.
134 McBurney 1967.
135 Cauvin 1974, 316.
136 Gopher 1994, 34–36; Shirai 2011, 172.
137 Shirai 2010, 324–325.
138 Gopher 1994, 252–253.
139 McDonald 2013, 182.
140 Shirai 2010, 317.
141 Gopher 1994, 36–43.

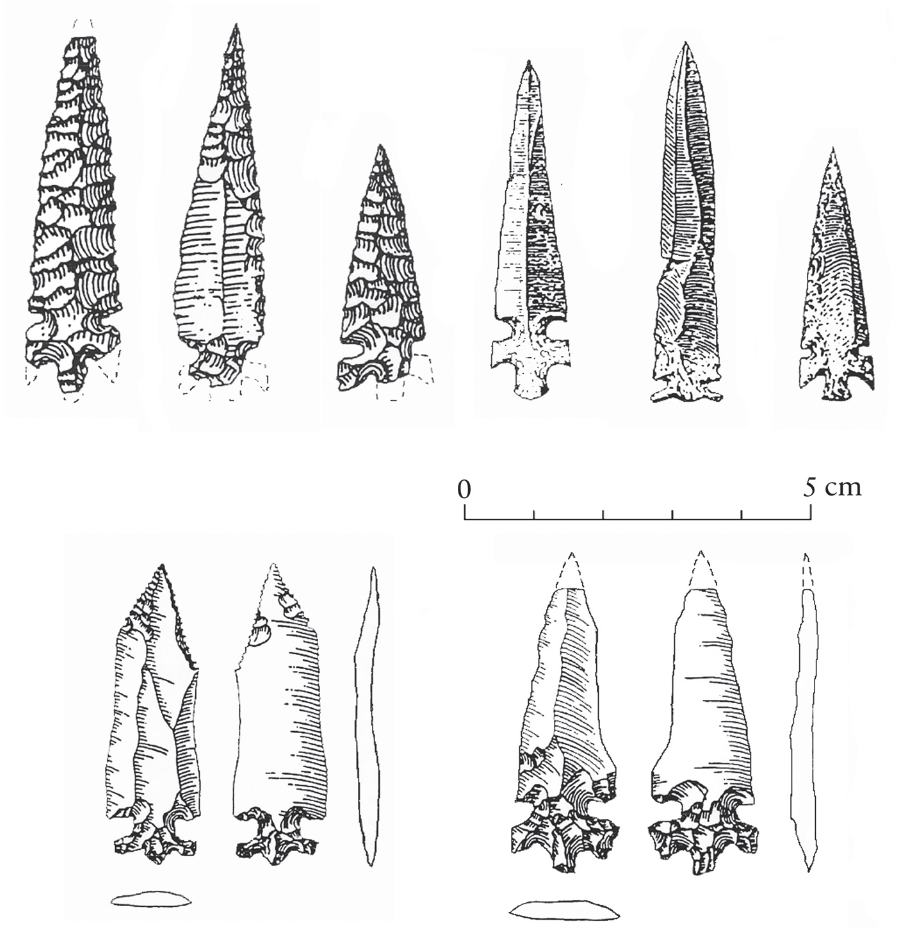

Fig. 9 Helwan points from the eponymous site Helwan in Egypt.

to the aforementioned points.[142] Small bifacial arrowheads show up in the Western Desert of Egypt around 6500 cal BC, in the Dakhla Oasis within the Bashendi A culture around 6400 cal BC[143] and in Djara around 6500 cal BC.[144] There are similar dates for the Sodmein Cave and the Tree Shelter around 6200 cal BC for the Eastern Desert.[145] Therefore, both groups of small bifacial points, the Levantine and the Northeast African ones, appear around 6400 cal BC and seem to be roughly contemporaneous.

3 When the Sahara became a desert (ca. 5300–4500 cal BC)

Certainly, the most important factor of cultural movement and change during the transition from the mid-Holocene humid period to the Early Predynastic along the Nile Valley was the climatic change. This is the time of the depopulation of the Western Desert as a result of the fundamental climatic change in the Sahara. A good proxy for this human occupation history provides the compilation of more than 500 radiocarbon dates from archaeological sites in the Egyptian part of the Western Desert (Fig. 10). A southwards shift of the desert boundary was a gradual, probably staged process[146] with an av-

142 Shirai 2010, fig. 8.7.
143 McDonald 2016, 186–187.
144 Kindermann 2010, 105–106.
145 Vermeersch 2008, 94–95; Vermeersch, Linseele, et al. 2015, 499.
146 Haynes 1987.

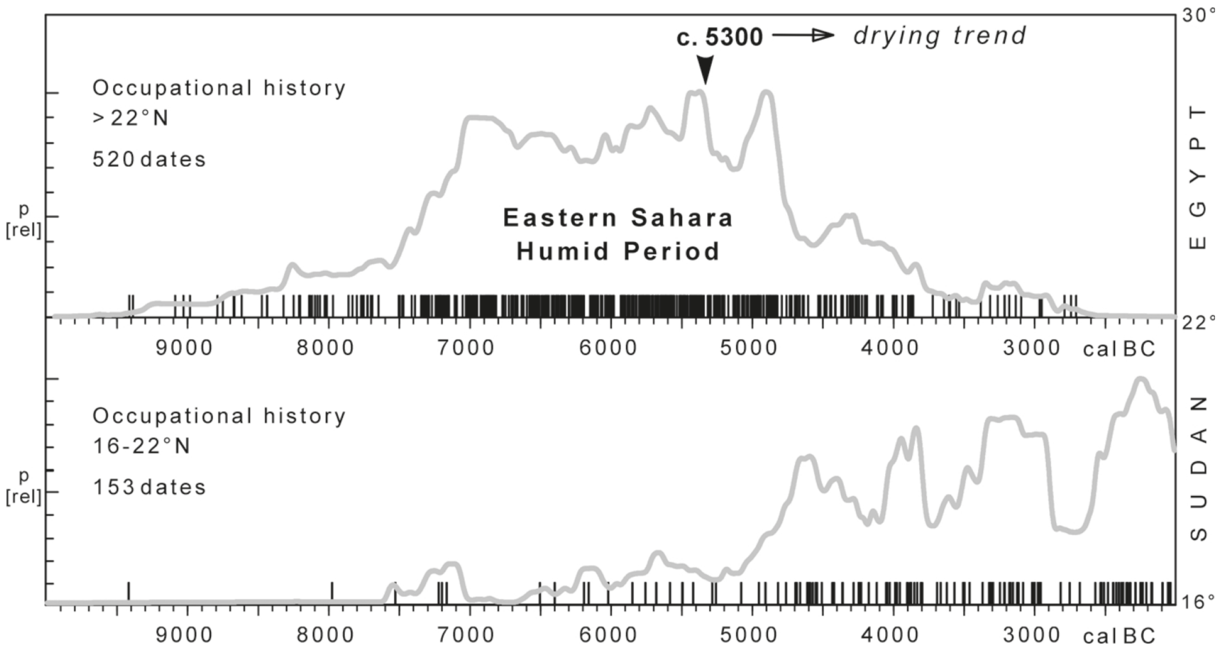

Fig. 10 Time-frequency distribution of 520 calibrated radiocarbon dates from archaeological contexts in the Western Desert of Egypt and 153 dates from the Nubian Western Desert during the Holocene humid phase. The drying spells at 5300 and 4700 cal BC impacted a dramatic depopulation of most territories in the Egyptian Western Desert. In the Nubian Western Desert, chronologies lasted longer because of the moderate retreat of the monsoonal summer rain belt to the south (Frequency histogram computed by group calibration using CalPal calibration and palaeoclimate package, version 2005).

erage of some 35 km in 100 years.[147] The onset of this drying trend can be illustrated by the rapid decrease of settlement activities and radiocarbon chronologies from the most sensitive desert areas far away from any groundwater charge, such as the Great Sand Sea (Regenfeld) and the Abu Ballas region (Mudpans), as well as the central parts of the Egyptian Limestone Plateau (Djara, Abu Gerara). It is probable that most regions in Egypt outside the Nile Valley, the oases, and the few mountain refuges (e.g. Gilf Kebir)[148] were lost to human subsistence. In these areas with only episodic surface water and at a great distance from the areas with permanent groundwater access, the earliest signals for the desiccation trend are marked by a drop off of the ^{14}C-dates connected with archaeological sites around 5300/5200 cal BC.[149] Oases charged by groundwater enabled a continuous or longer-lasting occupation during the following centuries and millennia.[150] This is also the case in the Nabta/Kiseiba region, where the groundwater of the Nubian Aquifer is not far below the surface, though most of the occupation events were obviously rain fed.[151]

The climate-induced abandonment of large areas of the Egyptian Western Desert inevitably resulted in migrational shifts of people into refuge areas and, finally, also into the Nile Valley, as is indirectly inferred by some cultural traits shared by the latest groups in the Western Desert and the earliest Predynastic settlers in the Fayum and along the Nile.[152] The many local desert traditions, such as the bifacial technology, may underline the interpretation that the Early Predynastic dwellers were the descendants of desert people.

A second spell towards dryer conditions is indicated by a rapid decrease in occupation dates during the mid-5th millennium cal BC, which finally led to the complete loss of most desert areas to human subsistence. The rapid decrease in dates and sites that go along with

147 Kröpelin 1993.
148 Linstädter and Kröpelin 2004.
149 Kuper and Kröpelin 2006; Kindermann, Bubenzer, et al. 2006; Bubenzer and Riemer 2007; Riemer, Lange, and Kindermann 2013.
150 I.e. McDonald 2001; Wuttmann et al. 2012; Briois et al. 2012.
151 Wendorf and Schild 2001.
152 Riemer and Kindermann 2008; Riemer, Lange, and Kindermann 2013.

the two aforementioned drying spells can remarkably be paralleled with the beginning of Early Predynastic cultures along the Nile and in the Fayum.[153] While there is no secure evidence of campsites or settlements in the Nile Valley prior to the Predynastic Neolithic (except much earlier dates of the Epipalaeolithic), earliest expressions of the Fayum Neolithic date back to the final 6th millennium cal BC, and dates from Merimde are only slightly later.[154] In Upper Egypt, the Badarian culture, indicated by the earliest absolute dates, emerged during the time of the second spell of desiccation around 4500 cal BC. The remarkable synchrony in timing of the depopulation of the desert, on the one hand, and the beginning of the Early Predynastic, on the other hand, cannot be explained by coincidental circumstances, but most likely illustrates a strong causal relationship, i.e., massive ecological stress in the Western Desert and resulting migrational shifts into the Fayum, the Delta, and the Nile Valley. Such migrations from the desert into the Nile Valley were most likely one of the reasons for a fundamental change of subsistence concepts in the Early Predynastic, among which, herding, intensive fishing and gathering of aquatic resources, agriculture, and a trend towards sedentism and social complexity can be listed as the most decisive elements. These new strategies were, without any doubt, the result of an adaptation in order to cope with the fundamentally different environmental conditions at the Nile Valley and the drastic reduction of the available settlement areas.

4 Conclusions

In view of the foregoing, it must be concluded that during the 6th and early 5th millennium cal BC, hunter-gatherer communities in the Western Desert underwent a number of changes in material culture, site structure, and mobility patterns, as well as in the early appearance of domesticated livestock. All of this signals trends of socio-economic relevance, but eventually do not indicate the adoption of a subsistence dominated by food production.

Sheep and goat were introduced from the Asian continent for the first time around 6000 cal BC. On the basis of the fact that small livestock did not travel alone from Asia to Africa, it can be assumed that they were introduced to African desert hunter-gatherer communities by direct or indirect contact with groups that initially brought them into Africa. It is also a matter of fact that this happened around the same time as when these communities started to slowly intensify subsistence along with technological innovation. Yet, no significant parallels in the material culture between the Near East and the Western Desert of Egypt can be evidenced reliably for this time period, and it seems that the exchange was reduced to the introduction of sheep and goat as small livestock from the Near East into Africa.

Although climatic and ecological conditions did not determine all aspects of the cultural development, they are the framework in which cultural developments and contacts appeared. The deterioration of the Egyptian Western Desert between 5300 and 4600 cal BC can be seen as a trigger for desert dwellers coming into the Nile Valley. They formed the population that intensified stock keeping and adopted agriculture.

153 Kindermann 2010; Riemer and Kindermann 2008; Riemer, Lange, and Kindermann 2013.

154 Riemer and Kindermann 2008.

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The Herding Revolution in the Desert: Adoption, Adaptation, and Social Evolution in the Negev and Levantine Deserts

Summary

Neolithisation in the Levantine deserts, the rise of pastoral societies in the arid periphery of the Mediterranean zone, comprised a patchwork of cumulative adaptations, chronologically and geographically varying according to the specifics of environmental and historical circumstances. These adaptations affected all realms of society, including basic organization, cosmologies, economy and subsistence, and ecology. Neolithisation began with the evolution of small-scale pastoral bands, but culminated in the crystallization of larger groups with deep economic links to the settled zone. It was neither linear, continuous, nor based on any single threshold or defining variable. Like the adoption of farming, it spanned several millennia and included complex formulations of social change.

Keywords: Negev; Badia; pastoralism; nomadism; Neolithisation; desert; Southern Levant

Die Neolithisierung in der Levantinischen Wüste, die Zunahme pastoraler Gesellschaften in der ariden Peripherie der Mittelmeerzone, umfasste ein Patchwork kumulativer Adaptionen mit chronologischen und geografischen Unterschieden, je nach den Besonderheiten der Umgebung und den historischen Gegebenheiten. Diese Anpassungen betrafen alle gesellschaftlichen Bereiche, einschließlich der Organisation, Kosmologien, Ökonomie, Lebensunterhalt sowie Ökologie. Die Neolithisierung begann mit der Evolution kleiner pastoraler Gruppen und kulminierte in der Bildung größerer Gruppen mit tiefen ökonomischen Verbindungen zur jeweiligen Zone. Sie war weder linear und kontinuierlich noch basierte sie auf einem einzigen Schwellenwert oder einer bestimmten Variable. Wie die Übernahme des Landbaus fand sie über mehrere Jahrtausende statt und brachte komplexe soziale Veränderungen mit sich.

Keywords: Negev; Badia; Pastoralismus; Nomadentum; Neolithisierung; Wüste; südliche Levante

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1 Introduction

Reducing a continuous and non-linear process to discrete stages for heuristic purposes, three basic stages in the rise of peripheral nomadic societies and the Neolithisation of the Levantine deserts can be defined:

1. The initial introduction and adoption of domestic herds, primarily goat, into desert societies,

2. The reconfiguration of those desert societies from hunting-gathering to herding-gathering, with all the commensurate social and material tools and knowledge to effect that transition, and

3. The consequent demographic growth and intensification of production and ties to the settled zone, resulting in large-scale tribal groups with deep ties to the developing urban and state societies.

The evolution of these social and ecological adaptations also engendered increasingly evident social divergence from the settled zone. This is evident not only in contrasts in subsistence and architecture, but in changes in iconography, cosmologies and behaviors, and in stylistic traditions, as especially notable in lithic systems.

These processes occurred superimposed on a backdrop of shifting environmental and climatic regimes. This varying backdrop affected the tempo of change, and did so differentially, depending on the specifics of geographic circumstances.

Finally, the evolution of herding societies in the desert did not occur in a vacuum. Interaction with settled society is archaeologically evident in a number of realms (e.g. material exchange, technological and stylistic diffusion, etc.) throughout the long period under discussion; however, these interactions varied in intensity and diversity. They too played key roles in the structure of the transition to food production in the desert.

2 In the beginning

Neolithisation in the core areas of the Near East, the heartland of domestication, has been characterized in a number of ways. From its Childean roots as a revolution in subsistence economy[1] initiated by climatic changes[2] with attendant social ramifications[3], through demographic and ecological adaptations[4], emphasis on the social transformations which brought about sedentarization[5] and immersion in a sedentised geography[6] with evolving economic and political complexity, and on to shifts in ideology and indeed cognition[7], resulting in fundamental changes in world view, Neolithisation in the Near East has been apprehended as deep and all encompassing. Furthermore, this core zone has been seen pretty much as an integrated unit;[8] even if domestication of one species or another did not occur simultaneously in all places within the core, nor did each 'Neolithisation event' occur in a single place or a single moment.[9] The matrix of Natufian/Pre-Pottery Neolithic society was such that attributes and innovations diffused rapidly from one corner of the Near Eastern Neolithic expanse to the other. If we should perhaps not characterize the larger region as homogeneous, the underlying commonalities within this expanse were great enough to enable and facilitate the rapid adoption of a remarkably large range of shared traits. These include physical goods such as obsidian,[10] sea shells,[11] and green stones;[12] technologies and technical paradigms such as architectural types, stone tool technologies and typologies,[13] and pyrotechnologies,[14] behavioral adaptations such as domestications of plants and animals;[15] and even cosmologies.[16] Furthermore, it is clear that beyond this Near

1 E.g. Rindos 1984.
2 E.g. Childe 1951, 66–70; Cohen 1977.
3 E.g. Braidwood 1976, 113.
4 E.g. Binford 1968; Flannery 1965.
5 E.g. Rosenberg 1998.
6 E.g. Hodder 2012.
7 E.g. Cauvin 2000; Mithen 2007.
8 E.g. Bar-Yosef and Belfer-Cohen 1989; Asouti 2006; Gopher 1989.
9 E.g. Fuller, Allaby, and Stevens 2010; Willcox 2005; Naderi et al. 2008.
10 E.g. Renfrew, Dixon, and Cann 1966.
11 E.g. Bar-Yosef Mayer 2005.
12 E.g. Bar-Yosef Mayer and Porat 2008; Wright and Garrard 2003.
13 E.g. Gopher 1994.
14 E.g. Marchal 1984; Gourdin and Kingery 1975.
15 E.g. Zeder, Bradley, et al. 2006.
16 Cauvin 2000.

Eastern PPN expanse, this package did not obtain. If the attributes which characterize the matrix of Near Eastern PPN society ultimately diffused elsewhere, to Europe, Africa, and Asia, there was no integration, no package cultural deal; attributes diffused piecemeal or perhaps in clusters, according to the demands, requirements, and preferences of the recipient cultures.

In a reductionist approach, these processes of Neolithisation might be classed as primary versus secondary, contrasting those societies where Neolithic society evolved *in situ* concomitant with domestication economies, with those societies in other regions that adopted domesticates and adapted the new subsistence system to their local cultures. This would be to miss the point. Once diffused beyond the point of origin, the Near Eastern PPN expanse, Neolithisation is particularistic; the processes of adoption and diffusion varied according to the recipient societies in their respective environments. If on the one hand we see some general similarity in the fact of diffusion, adoption, and adaptation, on the other, if we leave it at that, we lose the immense richness of the process and the uniqueness of each set of circumstances.

3 The Southern Levantine desert expanse in the PPN

For our specific purposes here, the idea of a PPN cultural matrix (Fig. 1) is exemplified well in the rapid spread of domestic goats, and perhaps somewhat later sheep, from a putative source in the Zagros/Taurus, the heartland of wild *Capra aegagrus* and *Ovis aries.*[17] By the early stages of the Middle PPNB, ca. 8000–7900 cal BC, goats have replaced gazelle as the dominant meat species in the faunal assemblages of the incipient villages of the Southern Levant.[18] This replacement seems to have occurred relatively quickly, and within individual sites, in stepwise fashion, not gradually. Even if not all communities jumped immediately on the goat bandwagon, and the replacement of hunting by herding was not a single episode,[19] the change is clear. Furthermore, even if one cannot rule out the possibility that goats (*Capra aegagrus*) were locally domesticated (and the morphological attributes of domestication do not appear for roughly another millennium), the point is that there were hardly more than 200 or 300 years between the earliest evidence for goat *herding* at Ganj Dareh Tepe (as opposed to the morphological changes which mark the endpoint of the domestication process), in the Zagros,[20] and, for example, at Jericho, in the Jordan Valley.[21] Given the deep conceptual contrast between hunting and husbandry,[22] and in the Southern Levant, hunting gazelle and keeping goats, the rapidity of this diffusion/adoption over such a great expanse is remarkable.

In spite of this rapid diffusion, the hunter-gatherer societies of the arid zones of eastern Jordan, the Negev, and Sinai,[23] did not adopt goats (and sheep) into their economies for another millennium.[24] The deserts adjacent to the Southern Levantine PPN village matrix seem to constitute a barrier to the adoption of domesticates, even given the apparent social and cultural connections between the desert and the sown. This is particularly evident in the transfer of such goods as obsidian,[25] shells, green stone[26] and ideas such as arrowhead types and technologies.[27] If the non-adoption of cereal agriculture into the arid zones is obvious due to the harshness of the desert environment, and agriculture was not systematically adopted into the arid zones for millennia, until the development and adoption of run-off irrigation technologies, the large time lag in the adoption of goats is less obviously explicable.

There are two parts to the explanation. First, goat husbandry in the villages of the PPN was not the Bedouin herding we are used to ethnographically. If we are to search for an ethnographic parallel, PPN goats were barnyard goats,[28] perhaps foddered, but certainly not kept in the numbers we associate with pastoralist communities today. If in retrospect, hunting-gathering mobility and pastoral mobility seem somehow similar – they are both mobile – the earliest goat keeping was not attached to a fundamentally residentially mobile society,

17 E.g. Zeder and Hesse 2000; Zeder 2008; Naderi et al. 2008.
18 Horwitz and Lernau 2003; Davis 1982; Peters et al. 1999.
19 Cf. Horwitz and Lernau 2003.
20 Hesse 1982.
21 Davis 1982.
22 Cf. Ingold 1980; Ingold 1987.
23 E.g. Bar-Yosef 1984; Garrard, Hunt, et al. 1988.
24 Martin 1999; S. A Rosen 1988; Betts 2008.
25 Burian and Friedman 1988.
26 Wright and Garrard 2003; Bar-Yosef Mayer and Porat 2008.
27 Gopher 1994.
28 Cf. Arbuckle 2014.

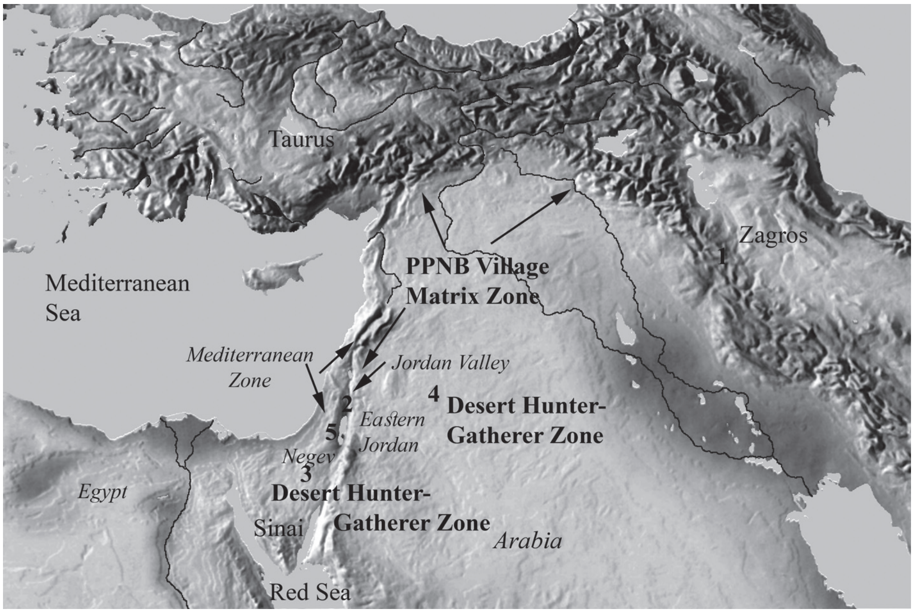

Fig. 1 Map of PPNB Near East with sites mentioned in text: 1. Ganj Dareh Tepe; 2. Jericho; 3. Ramon I, Kvish Harif, Har Harif 45; 4. Azraq; 5. Arad; and Nahal Tsafit (10 km south of Arad).

but to essentially sedentary farming-hunting societies.[29] The connection with mobile societies, in fact, is not intuitively obvious. Second, the PPN hunter-gatherer system was well-embedded in its desert landscape. Adopting herd animals into the well-tuned, well-adapted PPN hunter-gatherer system would require major changes in all aspects of society (changes evident later on). Without some prescience on the part of the hunter-gatherers, it is difficult to make a case that there would be any initial advantage to the adoption of domestic goats into their system. In fact a case could be made, albeit a semantic one, that PPN hunter-gatherers in the Levantine deserts were already Neolithicized, in a process that began with the Natufian and PPNB, seasonal hamlets developed in the desert in much that same way that Neolithisation in the agricultural heartland undoubtedly began with somewhat more sedentary Natufian hamlets and settlements.

4 Pre-revolution, the first goats in the desert – stimuli and responses

The desert-sown system of the Pre-Pottery Neolithic, with complex band level seasonally mobile hunter-gatherers in the desert and aggregate village farmers with domestic household stock in the arable zone, remained intact for more than a millennium, until the general collapse of the PPNB system ca. 6700 cal BC.[30] The causes of that collapse (and the abandonment of a system with 10-hectare aggregate villages must certainly be accorded collapse status) are beyond the scope of this essay. However, the ramifications of that collapse were most surely felt in the desert communities; it can be no coincidence that the earliest evidence for domestic goats in the desert, most notably in eastern Jordan, is found in sites attributed to the PPNC, following the collapse.[31]

Although we reduce social collapse to a single word, obviously system collapse is complex.[32] For the desert hunter-gather communities, we may reconstruct its implications from several perspectives:

1. The collapse of the exchange systems between the desert and the sown meant not only that the flow of goods was disrupted, but would have affected the relative values of different goods, both between the settled and the mobile, but also between the hunter-gatherers in direct contact with the sedentary zone, and those farther removed who received goods second-hand. Revaluation of exchange goods

29 Cf. Kent 1989.
30 Kuijt and Goring-Morris 2002; Rollefson and Köhler-Rollefson 1989.
31 Martin 1999; Martin and Edwards 2013.
32 Cf. Renfrew 1978; Stone 1999.

may affect social relations well beyond the functions of the goods themselves, reordering social status, rendering accessible previously inaccessible items, and leaving others beyond the reach of different groups.[33] The influx of goats into this system may well be partially a result of these disruptions.

2. The perturbations of the settled zone demanded demographic re-organization. In light of the probable end of the exchange foci, such as would have existed most especially at the mega sites of the Jordanian Mediterranean zone,[34] a realignment of exchange networks would have encompassed changes in personnel and locale, changes in goods, and as above, changes in the value of goods. Thus, for example, large flake flint tools (tile knives, bifacial knives) were exchanged into the sedentary zone from the periphery systematically for the first time in this period, following the PPNB collapse.[35] It is reasonable to assume that goats too may have been among the commodities exchanged into the desert, previously limited or unavailable.

3. The abandonment of the mega sites, and many smaller PPNB sites as well, probably also resulted in population dispersals. Goats may have accompanied such populations into the periphery.[36] These new peripheral populations may have served as source groups for the dispersal of goats to the indigenous hunter-gatherer populations, either through exchange or raid.

It is important to note that the archaeology of the PPNC arid zone, like that of the sedentary zone, shows significant continuity with the preceding *desert* PPNB. Few major changes in architecture (continuing desert PPNB curvilinear types, in contrast to the rectilinear types of the sedentary PPNB), lithics, or other aspects of material culture are evident. Goats are important but do not dominate faunal assemblages,[37] and do not seem to constitute the *sine qua non* of these societies. In the Azraq

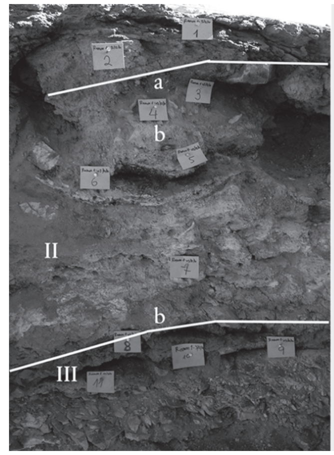

Fig. 2 Ramon I stratigraphy and chronology. All dates based on single standard deviation.

Basin in eastern Jordan, the presence of preserved cereal remains, sickle segments, and grinding stones suggests opportunistic agriculture in the better-watered eastern basins.[38] There is little evidence, in the form of the appearance of sedentary zone attributes, for any massive influx of new population into the desert at this time.

5 Revolution #1: the implications of herding

By the end of the 7th millennium cal BC, systematic off-site herding can be posited based on the presence of a goat (or sheep) dung layer at the Ramon I rock shelter in the Central Negev (Fig. 2).[39] Contemporary occupation sites are known from some 10–20 km away,[40] indicating a specialized goat herding function by this time. It is hard to be precise here given the scarcity of data, but the apparent coincidence of the appearance of systematic herding with the 8.2 kyr cal BP Rapid Climatic Change[41] event suggests that it might be a response to environmental stress.

In the 6th millennium cal BC, that is, just following the rise of systematic herding, fundamental structural changes are evident in the desert societies, reflected in

33 Cf. Sharp 1952.
34 Gebel 2004.
35 E.g. Goring-Morris, Gopher, and S. A Rosen 1994.
36 Cf. Rollefson and Köhler-Rollefson 1993.
37 E.g. Martin 1999; Martin and Edwards 2013.
38 Garrard 1998; Garrard, Baird, et al. 1994; Garrard, Colledge, and Martin 1996.
39 S. A Rosen et al. 2005; S. A Rosen 2015.
40 Vardi, Yegorov, and Eisenberg-Degen 2014.
41 Cf. A. M. Rosen 2007, 9–99.

changes in domestic architecture, lithic technologies and functions, and mortuary and cult sites.[42] Each realm has its specific implications for the transformation from basically hunting-gathering societies that have added goats to pastoral societies whose primary focus is the herd.

The evolution of the enclosure-and-attached-room compound (Fig. 3), replacing the clustered (honeycomb) (Fig. 4) and occasionally solitary structures of the PPNB and PPNC, can be attributed directly to the rise of pastoral societies. The central enclosure has been interpreted by all researchers as a pen, and dung layers have been reported in some of them.[43] However, beyond the presence of herding, and its integration into desert societies, the architecture reflects two other aspects of Early Timnian society, the culture name given this society of early systematic herding in the Southern Levantine deserts.[44] First, we may note the centrality of herding in terms of spatial organization and presumably ideology and, second, a change in social organization seemingly reflecting small bands with internal social relations contrasting with those of the preceding hunter-gatherers. That is, the importance of the goats (and we cannot quite rule out sheep either given the difficulties of species identification) in Timnian society can be seen in the centrality of the enclosures in the site layout; they are not peripheral. The change from clustered to dispersed domestic structures suggests social separation and distinction, perhaps increasing degrees of ownership, not evident in the earlier periods.

Lithic technologies, in terms of the organization of production and distribution, function, and typo-technologies, diverge from those of the agricultural zone. No trends toward specialized production are evident except insofar as the exchange in large flake tools, tabular scrapers succeeding bifacial knives,[45] reflects a kind of regional specialization. The continued use of chipped stone arrowheads, for at least two millennia after their disappearance from the settled zone, constitutes a major divergence in lithic trajectory.[46]

In spite of the continued use of arrowheads in the desert, the decline of hunting is evident in the decreasing proportions of arrowheads in lithic assemblages.[47] Paradoxically, the evolution of desert kites[48] reflects communal hunting; this too marks a different form of social organization. In particular, the integration of corporate construction and advanced planning suggests increased senses of property, investment, and territoriality.

The appearance of centralized and monumental cult sites, often associated with large-scale mortuary sites (cairn fields), contrasts markedly with preceding periods.[49] It marks both the need for public ritual, presumably legitimizing social hierarchies, and the ability to draft labor at a new scale. Complex cosmologies are clearly evident in celestial alignments; if on the one hand complex cosmologies are a human universal, on the other, the construction of large public works reflecting these cosmologies is to fix them and rigidify them. Monumental architecture (especially corporate mortuary architecture) strongly suggests declarations of territoriality.[50] This ties in conceptually to the transition to herding with a more intensive exploitation of the landscape with greater need to control resources.

The role of climatic change should also be addressed in this revolution, coinciding as it does with the 8.2 kyr cal BP Rapid Climate Change.[51] If the transition from the PPNB to PPNC with the collapse of the mega site society cannot be attributed to this global climatic event (the social change pre-dating that of the 8.2 event by about half a millennium) the reverse is true of the earliest evidence for rock shelter stabling evident from the Ramon I rock shelter, which dates precisely to this period. Without more evidence, one can only speculate that the climatic deterioration associated with the 8.2 kyr cal BP event resulted in an extension of herding, due to the need to find increasingly scarce pasturage. This pattern was maintained as herds grew and territoriality expanded.

42 S. A Rosen 2011; S. A Rosen 2015; Goring-Morris 1993.
43 E.g. Kozloff 1981; S. A Rosen 1988; Abu-Azizeh 2013; Abu-Azizeh 2014; Saidel and Haiman 2014; Henry 1995, 360.
44 S. A Rosen 2011.
45 S. A Rosen 1997, 71–84.
46 E.g. S. A Rosen 2011.
47 Goring-Morris 1993; S. A Rosen 2011.
48 E.g. Van Berg et al. 2004; Helms and Betts 1987; Bar-Oz, Nadel, et al. 2011; Bar-Oz, Zeder, and Hole 2011.
49 S. A Rosen 2015; A. M. Rosen 2007.
50 E.g. Renfrew 1984; Kinnes 1982; Kristiansen 1984.
51 E.g. A. M. Rosen 2007, 97–99; S. A Rosen 2017, 83–84; Bar-Matthews and Ayalon 2004; Bar-Matthews and Ayalon 2011.

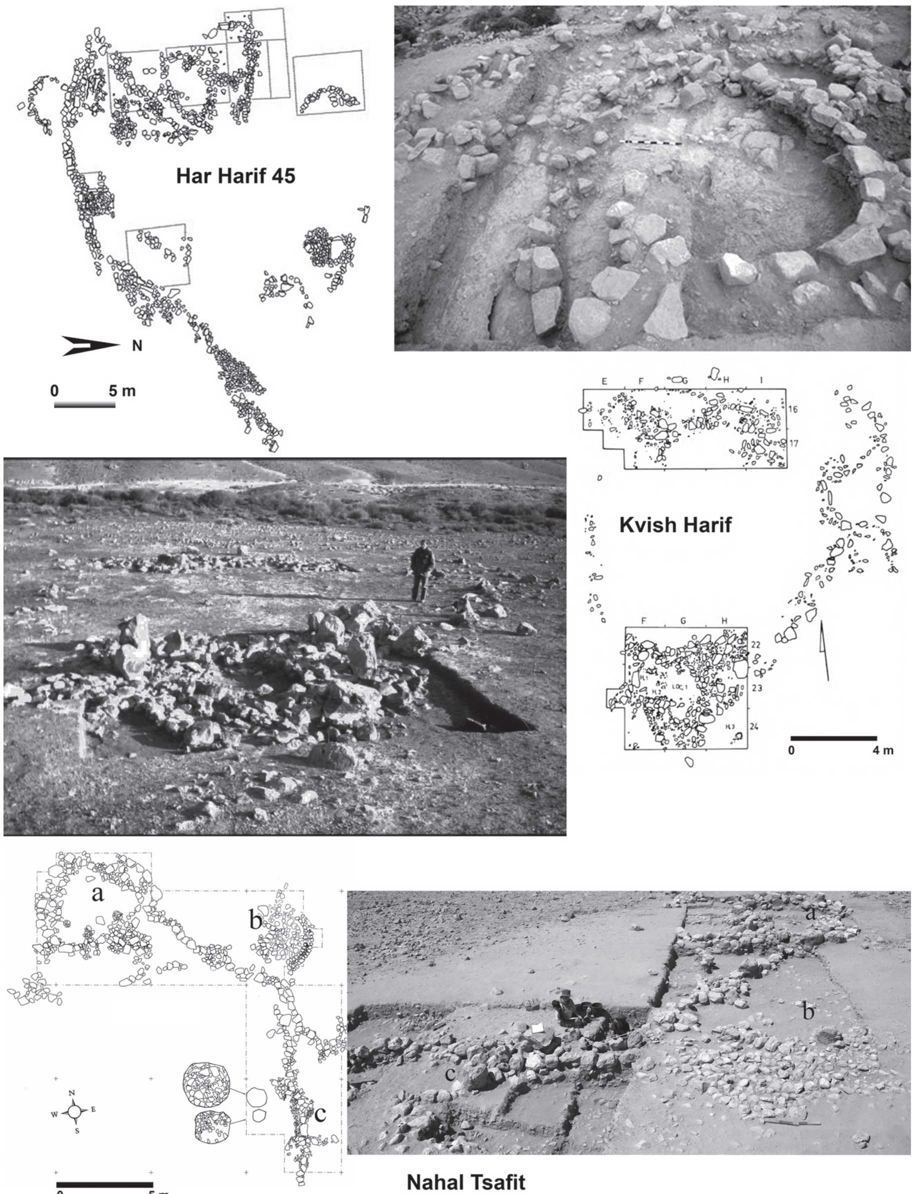

Fig. 3 Timnan enclosure and attached room architecture. Upper: Har Harif 45, 6–5th millennia BCE; Middle: Kvish Harif, late 5th millennium BCE; Lower: Nahal Tsafit, late 5th millennium BCE. All sites located in Central Negev.

6 Revolution #2: the rise of economic asymmetry

Desert pastoral societies in the 6th through 4th millennia cal BC – essentially autonomous herder-gatherers – adapted rapidly to the development of state and urban societies in the late 4th millennium cal BC. If this trend can be traced initially to developing consumption of copper (whose sources are exclusively in the desert) during the late 5th millennium cal BC (Chalcolithic period = Middle Timnian),[52] by ca. 3000 cal BC (Early Bronze Age II in Southern Levantine terminologies = Late Timnian in the desert, ESL4 according to ARCANE),[53] exchange relations between Late Timnian

52 S. A Rosen 2011.

53 S. A Rosen 2011; Regev et al. 2012.

Fig. 4 Desert PPNB clustered architecture. 1. Ujrat el-Mehed, South Sinai (excavated by O. Bar-Yosef); 2. Nahal Issaron, Uvda Valley. Note that more structures on the periphery of the excavation area are evident. (Excavated by A. N. Goring-Morris and A. Gopher). Both photographs show clusters of hut bases with little open space between the huts. The fence around Nahal Issaron was constructed by the excavators to delineate the site.

society and the settled zone diversified to a wide range of goods, extending well beyond the preciosities characterizing the Early and Middle Timnian. Thus, in addition to shells and beads, metals and other minerals (e.g. hematite), milling stones, large numbers of tabular scrapers, pottery (and whatever was in the pots),[54] and textiles[55] constitute physical evidence for exchange across the desert-sown threshold. If ethnography can offer hypotheses, other goods likely included the animals themselves moving from the desert into the settled zone, and grain, moving from the settled zone into the desert.

Beyond the evidence for intensification of exchange, the presence of sedentary zone outposts in the desert, beginning in the early to mid-4th millennium cal BC,[56] but most evident in the Early Bronze Age II (according to material culture attributions),[57] is also strong evidence for intensified relations. The unification and expansion of the early Egyptian State at the end of the

54 E.g. S. A Rosen 2009b.
55 E.g. Shamir and S. A Rosen 2015.
56 E.g. Khalil and Schmidt 2009.
57 E.g. Beit-Arieh 2003; Beit-Arieh and Gophna 1981.

4th millennium cal BC[58] must also have impacted the desert pastoral society, especially in the Sinai where evidence for Egyptian influence is present in the Nawamis tombs.[59] Furthermore, the 10-fold increase in the number of sites in the Central Negev in this period as compared to earlier periods reflects the major economic impact of these intensified relations on the pastoral periphery.[60] Although demographic calculations of mobile societies based on site sizes and numbers are virtually impossible, given the lack of fine resolution chronological control and detailed understanding of seasonal mobility systems, the large relative increase in site numbers, along with an increase in site sizes and the appearance of compound sites, certainly reflects demographic increase in the region. In fact, the low site densities (generally less than 0.1 site per km^2) of all preceding periods suggests a generally low carrying capacity for human populations in the desert, even with pastoral exploitation. The increase in number of sites by roughly an order of magnitude, at least in some areas, indicates external support, that is, a population well in excess of some hypothetical natural capacity. A second revolution thus can be defined at this point, when desert populations are essentially dependent on economic input from the sedentary zone.

Finally, the abandonment of Arad as a gateway city for the desert[61] was accompanied by the collapse of the entire Late Timnian system in the Negev. Such a collapse would indeed be an expected result of a dependency relationship. In Jordan, an equivalent collapse is not evident, at least not yet, and given the continued presence of towns in the Jordanian highlands in the mid-3rd millennium cal BC, this is not surprising.

7 In the end?

Like its agricultural cousins, the pastoral revolutions in the desert are not single events, single thresholds, or single innovations. Ethnographically, peripheral pastoralism has long been understood as an adaptation characterized by short-term flexibility;[62] however, it must also be characterized as a long-term evolution. If Neolithisation should be characterized as a set of inter-related processes, an evolving system with a specific set of potentials and parameters, then the rise of desert pastoralism constitutes a case parallel but not congruent to that of the sedentary zone Neolithic. It developed along a different trajectory, but one that converges with that of the settled zone in the rise of the complex relations between nomads and the State outlined in the 2nd revolution above.

It is important to emphasize further that if the trajectories of the desert and the sown converged, they did not merge. If the frontier between the settled and nomadic peoples of the Levant was always dynamic and porous, it never disappeared. Furthermore, just as desert pastoral societies evolved in the Timnian Cultural Complex from autonomous herder-gatherers to pastoral nomads with complex and asymmetric economic relationships with the settled zone, so did the succeeding desert societies continue to evolve into more complex social orders with dynamic and varying ties to their neighbors. There was no threshold after which desert societies fossilized into a static stereotype; rather, the peoples of the Near Eastern deserts continued to adapt with essential genius to both the desert and its social concomitants.

58 E.g. Klimscha 2011.

59 E.g. Bar-Yosef, Belfer-Cohen, Goren, and Smith 1977; Bar-Yosef, Belfer-Cohen, Goren, Hershkovitz, et al. 1986.

60 S. A Rosen 2009a, fig. 4.8.

61 E.g. Amiran, Ilan, and Sebbane 1997.

62 E.g. Cole 1975, 40–41.

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The Development of Cereal Cultivation and the Evolution of Lithic Technology in Egypt in the Middle Holocene

Summary

The diffusion of the technical know-how of cereal cultivation from Southwest Asia to Egypt and between different regions of Egypt in the Middle Holocene has been insufficiently studied. This article deals with flint sickle blades and concave-based arrowheads in Egypt in this period, and overviews when and where they appeared and how they have developed in evolutionary terms, thereby reconsidering when, where and how cereal cultivation may have begun and developed in Egypt. This overview reveals the utmost importance of the Fayum as a center of the evolution of these specialized tools, and leads to the presumption that the beginning of cereal cultivation in the Fayum is much earlier in date than previously discussed on the basis of botanical data.

Keywords: Egypt; Fayum; Neolithic; cereal cultivation; sickle blades; concave-based arrowheads; cultural evolution

Die Diffusion des technischen Know-How zum Getreideanbau von Südwestasien nach Ägypten und zwischen verschiedenen Regionen Ägyptens im mittleren Holozän ist bislang unzureichend untersucht. Dieser Beitrag beschäftigt sich mit Feuersteinsicheleinsätzen und Feuersteinpfeilspitzen mit einziehender Basis in Ägypten in dieser Periode und gibt einen Überblick, wann und wo sie auftreten und wie sie sich entwickelten, wobei auch berücksichtigt wird, wann, wo und wie Getreideanbau in Ägypten möglicherweise begonnen und sich entwickelt hat. Dieser Überblick zeigt die enorme Bedeutung des Fayyum als Zentrum der Evolution dieser spezialisierten Werkzeuge hatte, und führt zu der Vermutung, dass der Beginn des Getreideanbaus in Fayyum zeitlich viel früher anzusetzen ist als bisher auf der Grundlage botanischer Daten diskutiert.

Keywords: Ägypten; Fayyum; Neolithikum; Getreideanbau; Sicheleinsätze; Pfeilspitzen mit einziehender Form; kulturelle Evolution

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1 Introduction

Previous research on when and how Southwest Asian domesticated cereals and animals diffused from the Southern Levant to different regions of Egypt in prehistory has greatly depended on poorly preserved botanical and faunal remains, but has not paid much attention to the diffusion and development of material technologies which were essential for cereal cultivating and livestock keeping practices in a new environment. As long as botanical and faunal data are used as the sole and decisive evidence, one has to accept the current puzzling situation that the development of cereal cultivation in Lower Egypt and the Fayum was 500–1000 years later than that in Sudan and Morocco, and that the spread of livestock keeping to Lower Egypt and the Fayum was 500–1500 years later than that to the Eastern and Western Deserts of Egypt.[1]

This article deals with flint sickle blades and concave-based arrowheads in Egypt in the Middle Holocene, and overviews when and where they appeared and how they have developed in evolutionary terms, thereby reconsidering when, where and how cereal cultivation may have begun and developed in Egypt. As described below in detail, concave-based arrowheads as well as sickle blades represent the technical aspects of cereal cultivating practices. These flint tools are much better preserved than botanical remains at any archaeological sites in Egypt, and can be used as important clues to the occurrence and development of cereal cultivation even if there is no botanical evidence. Cultural evolutionary studies on technology have become common in the recent decade,[2] and the introduction of a cultural evolutionary perspective to lithic studies in Egypt can give fresh insights into this reconsideration.[3]

2 Sickle blades in the Southern Levant and Egypt

It is reasonable to presume that sickle blades in Egypt derived from Levantine ones, not merely because the diffusion of domesticated cereals from the Levant is unlikely to occur without the transmission of the know-how of growing and harvesting cereals, but also because there was no predecessor of such specialized tools anywhere in Egypt prior to the introduction of domesticated cereals. Egypt has a long history of consuming wild grass seeds since the Early Holocene when the climate became mild and grassland spread in the Egyptian Western Desert. However, no formal sickles were developed locally, and grass seeds are considered to have been usually collected by beating and rubbing.[4]

The early appearance of sickle blades, which are identified by the presence of gloss on their working edge, is well known in the Southern Levant. According to synthetic studies on the development of stone tools in general and sickle blades in particular in the Southern Levant,[5] sickle blades of the PPNA and PPNB in the 9th–8th millennia cal BC were normally made from large blades or blade segments with slight serration on a lateral edge. It was not until the PPNC and PN Yarmukian in the 7th millennium cal BC that one type of sickle blade was made from a blade segment or flake and its lateral edges were sparsely and deeply serrated, though its body surface was not thoroughly flaked bifacially. It was in the PN Lodian culture of the first half of the 6th millennium cal BC that flakes were thoroughly flaked bifacially and their lateral edge was densely and shallowly serrated. Such elaborate sickle blades disappeared in the middle 6th millennium cal BC. In the PN Wadi Rabah culture of the late 6th–early 5th millennia cal BC, serration on one lateral edge of a blade or blade segment without facial flaking became common, while in the PN Qatifian culture of the same period, serrated blades became extremely rare (Fig. 1).

Early formal sickle blades in Egypt are technologically and morphologically most similar to those of the PN Lodian culture found at such sites as Lod, Givat Ha-

1 Barich 2016; Linseele, Holdaway, and Wendrich 2016; Madella et al. 2014; Morales et al. 2016; Out et al. 2016; Shirai 2016a.

2 Boyd, Richerson, and Henrich 2013; Mesoudi et al. 2013; Shennan 2015.

3 Shirai 2013.

4 Lucarini 2008; Lucarini 2014a.

5 Gilead 1990; Gopher and Gophna 1993; Gopher, Barkai, and Asaf 2001; Rosen 1997; Rosen 2012; Shea 2013; Vardi and Gilead 2013.

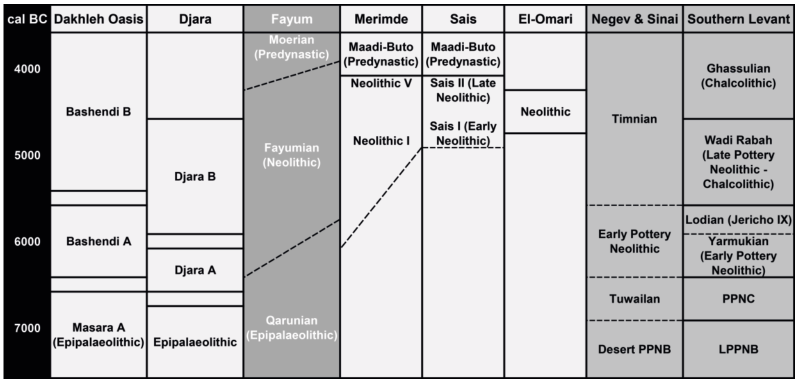

Fig. 1 Middle Holocene chronology of the regions and sites mentioned in the text.

parsa, and Nizzanim on the Mediterranean coastal plain of the Southern Levant.[6] The majority of formal sickle blades in Egypt were made from thin elongated flakes by thoroughly flaking both faces of the body and serrating one lateral edge. They were made either pointed or rectangular in form, and were very rarely serrated bilaterally. Such unique sickle blades have been found at Sais, Merimde Beni Salama, and El-Omari in Lower Egypt, as well as in the Fayum, Seton Hill, Abu Gerara, and Kharga Oasis in the Egyptian Western Desert (Fig. 2).

At Sais, which is approximately 110 km to the northwest of Cairo and located in the middle of the floodplain of the Nile Delta, a few complete sickle blades, which are bifacially flaked and unilaterally serrated, as well as more fragmentary ones have been excavated in a 10 m × 10 m square.[7] Two Neolithic layers (Sais I = Early Neolithic, and Sais II = Late Neolithic) are identified in the square and sickle blades were found from both layers, but no notable technological and morphological differences are seen between those from the two layers. These Neolithic layers are roughly dated to the 5th millennium cal BC on the basis of the comparison of artefact assemblages with those from contemporary sites in the Nile Delta, as radiocarbon dates obtained from these layers are too young apparently because of contamination.[8]

At Merimde Beni Salama, which is approximately 40 km to the northwest of Cairo and located at the western margin of the floodplain of the Nile Delta, a Neolithic site of approximately 400 m × 600 m marked by a concentration of artefacts and ashy sediments was discovered in the late 1920s. Subsequently, two areas of the site were chosen for excavation. One excavation area at the southeastern part of the site is approximately 40 m × 60 m, and another excavation area in the center of the site is approximately 60 m × 120 m. A few dozen complete and partially broken sickle blades were collected on the surface, and at least eight sickle blades were excavated in the area at the southeastern corner. It is noted that three sickle blades (two are pointed and one is rectangular) were found together in an oval structure in the area. The majority of finds in this area are pointed in form.[9] As no photographs or illustrations of finds from other excavation areas have been published, the exact number and detail of finds remain uncertain. However, research on the unpublished finds that are presently stored in museums is being conducted.[10] More information about these finds will be provided in the near future.

In the late 1970s to early 1980s, further excavations were conducted at the site, with a number of trenches opened in the eastern part (approximately 110 m × 150 m), and many bifacially flaked and unilaterally serrated sickle blades were excavated or collected from the surface. Sickle blades appeared first in the second oldest layer (Schicht II) of the stratigraphy. There were 14 sickle blades found in this layer but no complete example of a rectangular form.[11] Sickle blades continued to exist in the subsequent layers, with 14 from Schicht III, 27 from Schicht IV, eight from Schicht V, and five found

6 Gopher and Blockman 2004, figs. 19–20; Olami, Burian, and Friedman 1977, fig. 12; Shirai 2010, fig. 8.1; Yeivin and Olami 1979, fig. 11.
7 Wilson and Gilbert 2012, fig. 3; Wilson, Gilbert, and Tassie 2014, 64–65, 71, pls. 9–11, pl. 37.
8 Wilson and Gilbert 2012; Wilson, Gilbert, and Tassie 2014.
9 Junker 1928, 15, pls. V–VI, pl. XV; Junker 1930, 221, fig. 4-c, pl. IX-a; Junker 1933, 64–67, fig. 5.
10 Rowland, Tassie, and Falk 2014; Topoi A-2-4 2017.
11 Eiwanger 1988, 37, pls. 37–38.

Fig. 2 Map of Egypt indicating regions and sites mentioned in the text.

on the surface. There are only five complete examples of the rectangular form and 11 complete examples of the pointed form. As the rest of the finds are fragmentary, it is difficult to discern whether they were pointed or square-ended unless they have a pointed end.[12] The size and shape of sickle blades varied even within each layer, and it is hard to see any reasonable patterns of change in blade size and shape from the older to younger layers, as shown in the excavator's diagram.[13] The oldest layer (Urschicht) is radiocarbon-dated to ca. 4900–4500 cal BC and the youngest layer (Schicht V) is radiocarbon-dated to ca. 4500–4000 cal BC,[14] with a clear gap between Urschicht and Schicht II in the stratigraphy.[15] These sickle blades most probably fall somewhere in the middle 5th millennium cal BC, and it may be better to consider Schichten II–V as a single cultural unit that lasted for a few hundred years.

At El-Omari, which is approximately 25 km to the southeast of Cairo, 13 bifacially flaked and unilaterally serrated sickle blades made on flakes and 15 unilaterally serrated sickle blades without bifacial flaking of the body were excavated or surface collected in settlement areas named Area A (approximately 25 m × 55 m) and Area BI (approximately 10 m × 15 m), Area BII (approximately 9 m × 13 m), and Area BIII (approximately 25 m × 32 m) on a wadi spur. It is noted that the latter variant of sickle blades appeared later in date.[16] The latter variant is similar to those which were a minority in the PN Lodian culture but became common in the PN Wadi Rabah culture. The site is radiocarbon-dated to ca. 4700–4200 cal BC.[17]

12 Eiwanger 1992, 48–49, pls. 69–73.
13 Eiwanger 1992, fig. 15.
14 Hendrickx 1999, 60.
15 Eiwanger 1992, 8–13.
16 Debono and Mortensen 1990, 45, pl. 18.
17 Hendrickx 1999, 61.

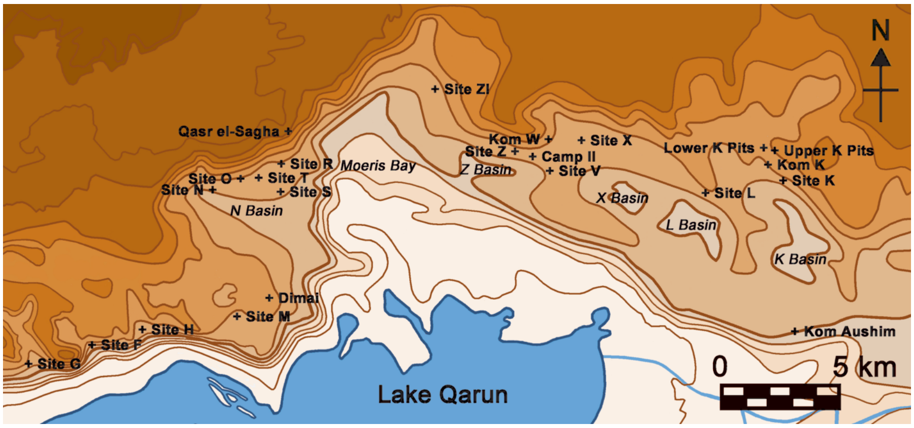

Fig. 3 Map of the north shore of Lake Qarun in the Fayum indicating sites.

The Fayum Depression centered by Lake Qarun is located approximately 60 km to the southwest of Cairo. The distribution of Neolithic sites on the north shore of Lake Qarun is approximately 40 km wide (Fig. 3).

In this wide area, countless numbers of various bifacially flaked and unilaterally/bilaterally serrated sickle blades have been collected on the desert surface by antiquarians and early archaeologists, and partially published in the late 19th and early 20th centuries, but with no information about the exact number and provenance of finds.[18] Subsequently, through the first well-organized archaeological research in the 1920s, more than 150 sickle blades have been collected at a number of undated surface sites on the north and southwest shores of Lake Qarun. In addition, excavations at Kom K and Kom W, which are radiocarbon-dated to ca. 4600–4400 cal BC,[19] have yielded 10 and 31 sickle blades respectively. However, only 53 complete or almost complete sickle blades out of nearly 200 finds collected or excavated in the Fayum were published, whereas the rest were left unpublished (Fig. 4).[20] Since then, different areas of the Fayum have been repeatedly visited by archaeologists and their surface collecting of Neolithic stone tools has been mentioned, but the detailed information about how many and which types of sickle blades were collected has not been published.[21]

Moreover, one well-preserved complete sickle found in a grain storage pit on the Upper K Ridge of the Fayum is worth a detailed description. Two bifacially flaked and unilaterally serrated blades and one serrated blade without bifacial flaking of the body are inserted in line into a centrally placed longitudinal groove on a slightly curved wooden shaft and are held in position by resin (Fig. 5).[22] As two grain storage pits on the K Ridge are radiocarbon-dated to ca. 4500–4200 cal BC,[23] it is probable that this sickle also falls in this period. Serrated blades without bifacial flaking of the body are rare in the Fayum Neolithic.[24] The sickle from the grain storage pit demonstrates the co-existence of two technologically different types of blades at least in that time and place.

Several sickle blades have been found in the middle of the Egyptian Western Desert where there is no permanent standing water and no botanical evidence of cereal cultivation. It is possible that some experiments in cereal cultivation were attempted there. At Seton Hill, which is approximately 150 km to the southwest of the Fayum, a bifacially flaked and unilaterally serrated sickle blade, the tip of which is broken but seems to have been pointed, was collected on the surface. This sickle blade is roughly dated to 5600–5200 cal BC based on associated diagnostic artefacts of the region.[25] In Abu Gerara, which is approximately 400 km to the southwest of the Fayum, at least four bifacially flaked and unilaterally serrated sickle blades, three of which are broken but

18 E.g. Currelly 1913, pl. XXXIV; De Morgan 1897, figs. 314–319; Petrie 1890, pl. XVI; Seton-Karr 1904, pls. 19–20.
19 Shirai 2010, tab. 5.1.
20 Caton-Thompson and Gardner 1934, 29, 39, 71–87, pl. X, pl. XI, pl. XXII, pl. XL, pl. XLVI; Shirai 2017.
21 Puglisi 1967; Wendorf and Schild 1976; Wenke, Long, and Buck 1988.
22 Caton-Thompson and Gardner 1934, 45, pl. XXVIII, pl. XXX.
23 Shirai 2010, tab. 5.1.
24 Caton-Thompson and Gardner 1934, 21.
25 Kindermann 2010, 107–108, 471–472, fig. 302-1.

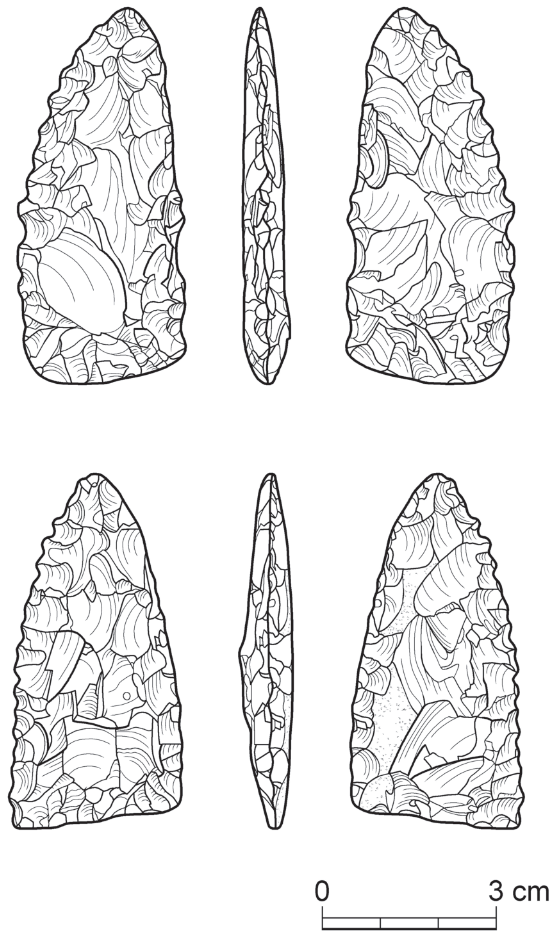

Fig. 4 Unpublished sickle blades from Site Z1 in the Fayum (IoA2015/128 and IoA2015/129 from top to bottom).

seem to have been pointed, have been found at different localities. The localities are roughly dated around 5600–5200 cal BC based on a radiocarbon date and associated diagnostic artefacts.[26] In Kharga Oasis, one bifacially flaked and unilaterally serrated sickle blade of the pointed form has been found on the surface, and attributed to the Peasant Neolithic.[27] Its precise date is uncertain, but other associated lithic artefacts of the Peasant Neolithic are similar to those of the Badarian and Naqada I of the Nile Valley, and this one may be dated to the late 5th millennium cal BC.

In short, the Fayum as a region has produced the largest number of sickle blades in Egypt, even though the scale and manner of excavation and surface collection and the quality of publication are different from region to region and from site to site. All sickle blades found at sites in Lower Egypt fall in the 5th millennium cal BC, whereas those which were found at Seton Hill and Abu Gerara in the Egyptian Western Desert are dated to the middle 6th millennium cal BC. Sickle blades excavated at some sites in the Fayum are dated to the middle 5th millennium cal BC, whereas many others from surface collections remain to be dated. A puzzling thing is that the Lodian type sickle blades appeared earlier in the Egyptian Western Desert than in Lower Egypt, which is geographically much closer to the Southern Levant. However, this may be due to a very small number of Neolithic sites discovered in Lower Egypt. Another puzzling thing is that such sickle blades persisted for a much longer period in the Fayum and Lower Egypt, despite the fast disappearance of their counterparts in the Southern Levant.

3 Evolution of sickle blades in Egypt

The present state of knowledge indicates huge chronological and geographical gaps between Levantine and Egyptian sickle blades and even between Egyptian ones from different regions. Nonetheless, the general similarity between them requires further consideration, particularly with regard to the spread of the know-how of harvesting cereals by using unique sickle blades. It is probable that the know-how of making sickle blades of the Lodian type came from the Mediterranean coastal plain of the Southern Levant across the northern Negev and Sinai, arriving somewhere in the Nile Delta no later than the early–middle 6th millennium cal BC, and then spread southwards. More importantly, the long persistence of such unique sickle blades in Egypt – despite the disappearance of their counterparts in the Southern Levant in the middle 6th millennium cal BC – suggests that the inflow of new ideas about making sickle blades from the Southern Levant to Egypt stopped after the middle 6th millennium cal BC.

In evolutionary terms, the development of sickle blades in Egypt is regarded as an interesting example of a founder effect. Bifacially flaked and serrated sickle blades were separated from a large pool of variation in

26 Riemer 2010, fig. 33-1, fig. 47-1, fig. 70-5, fig. 76-5.

27 Caton-Thompson 1952, 177–182, pl. 109-4.

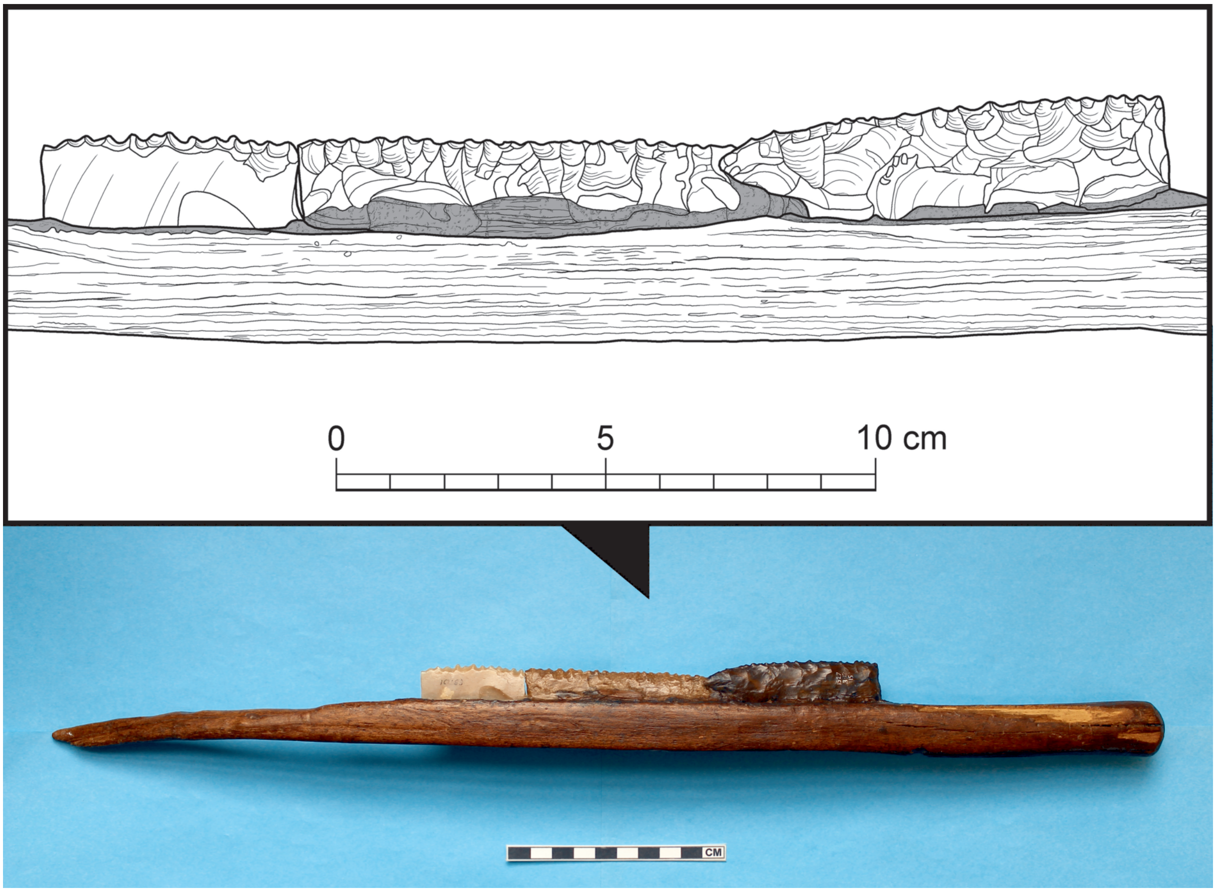

Fig. 5 Sickle from Upper K Pits silo 51 in the Fayum (EA58701).

the Southern Levant by chance and drifted to Egypt, and they determined the trajectory of their subsequent development in Egypt without being rivalled or replaced by other variants deriving from the Southern Levant. It is hard to consider that a large number of Levantine farmers would have continuously migrated into Egypt and have kept contact with their homeland while inviting more migrants. Rather, it is presumed that a small number of Levantine exiles who never returned home or migrants who were hampered from returning home would have passed on domesticated cereals and the know-how of cereal cultivation to indigenous people of Egypt at a certain point in time.

The Jordan Valley and Highlands experienced extreme environmental devastation caused by repeated droughts and torrential rains at the transition from the Late PPNB to the PN in the 7th–6th millennia cal BC,[28] and people in this region probably had to move out to find refuge in neighboring regions. In addition, the rise of the Mediterranean Sea level through the Early to Middle Holocene is evidenced by the submergence of PPNC and PN sites off the northern Carmel coast of Israel,[29] and people in this coastal region probably had to find a new place to live. The coast of the northern Negev and Sinai between the Southern Levant and the Nile Delta is a vast sand sea, but was a possible route of human migration. It may be that this coastal route in the northern Negev and Sinai was also affected by the sea level rise that took place throughout the Early to Middle Holocene. Given that sand dune formation in this sand sea of the northern Negev and Sinai was most active in the Late Pleistocene when the climate was dry and the strong westerlies brought sand from the Nile Delta,[30] the abrupt aridification during the late 7th millennium cal

28 Litt et al. 2012; Migowski et al. 2006; Weninger et al. 2009.
29 Galili, Weinstein-Evron, and Ronen 1988; Galili, Zviely, and Weinstein-Evron 2005.
30 Goring-Morris and Goldberg 1990; Muhs et al. 2013.

BC in the eastern Mediterranean, known as the 8.2 kyr cal BP event,[31] could have temporarily activated the formation and movement of dunes, interrupting the coastal route in the northern Negev and Sinai. This land bridge between the Southern Levant and the Nile Delta could have been a bottleneck for the migration of people. It is most likely that some of the people living in the Mediterranean coastal plain of the Southern Levant migrated to Egypt in the 7th–6th millennia cal BC but lost contact with their homeland afterward.

Given the possible founder effect at the beginning of cereal cultivation in Egypt, the development of sickle blades in Egypt needs to be explained in terms of: 1) the cultural transmission of the know-how of making sickle blades by teachers on the Levantine side and the social learning of the know-how of making these tools by learners on the Egyptian side, 2) the cultural selection and spread of variants made in the process of tool replication by the toolmakers and users in Egypt, and 3) the inheritance of the selected variants as innovation and tradition by the toolmakers and users of the next generations in Egypt (Fig. 6).

It is difficult to specify exactly when and where the cultural transmission between the teachers of the Southern Levant and the learners of Egypt occurred. If there was a language barrier between them, the precise transmission of know-how would not have been easy, even though toolmaking could have been imitated just by observation. If there was a great difference in toolmaking skill level between the teachers and learners, traits of a tool, which were difficult to replicate, may have been omitted or erroneously replicated in the transmission process. Horizontal, peer-to-peer cultural transmission causes greater variants more instantly than vertical, parent-to-offspring cultural transmission does.[32] This must be when and where initial notable variants of sickle blades could have been made. Although a thorough comparison remains to be carried out, Egyptian replicas are generally similar to Levantine originals. As the fidelity of transmission is high, it is assumed that the transmission was not through brief encounters by chance but through constant communication between teachers and learners. It is more difficult to specify exactly when, where and how the know-how of making sickle blades spread among indigenous people in different regions of

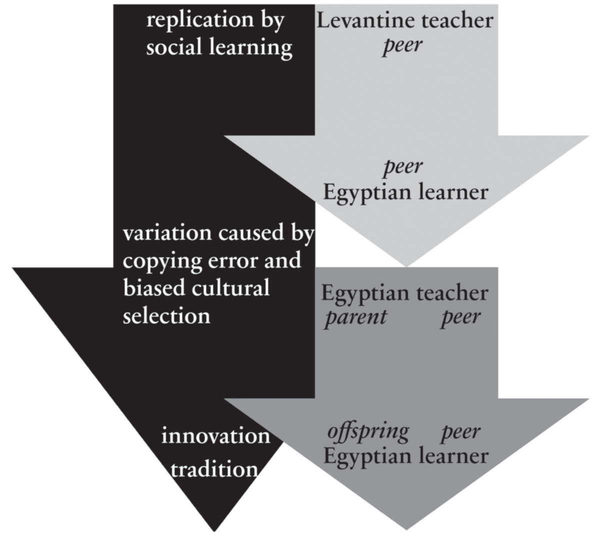

Fig. 6 Cultural transmission of the know-how of toolmaking.

Egypt and how fast the spread was, because both horizontal and vertical cultural transmission and the transmission from one teacher to many learners as well as one learner must have been intricately involved in this process. Nonetheless, it may be possible to detect the accumulation of errors and the presence of selection biases in the replication process at individual sites.

Bifacially retouched sickle blades in Egypt are not homogeneous but vary in size and shape. However, such variants have not been highlighted, except for two major body forms. The predominance of the pointed form over the rectangular form is well known in examples from Merimde Beni Salama and the Fayum, where a substantial number of complete sickle blades have been found. As both pointed and rectangular forms existed in the Southern Levant, it is most probable that these variants in Egypt derived from the Southern Levant. Pointed sickle blades in Egypt can be subdivided into: 1) those whose back is straight but the serrated working edge is convex, 2) those whose back is convex but serrated working edge is straight, 3) those whose back and serrated working edge are convex, and 4) those whose back and serrated working edge are straight. These four variants are seen in the Southern Levant. It is presumed that they derived from there, and that there was little bias in the cultural selection of variants on the Egyptian side. On the other hand, the size, the ratio of body length and

31 Berger and Guilaine 2009; Weninger et al. 2009.

32 Eerkens and Lipo 2005; Eerkens and Lipo 2007.

width, and the working edge serration of sickle blades seem to be more varied from site to site in Egypt. Although the sample number is small, the sickle blades found at Sais and El-Omari seem to be generally wider and more finely serrated than those that were found at Seton Hill and Abu Gerara. The former seems to be the variants that have evolved in Egypt, while the latter are more similar to Levantine ones.

The sickle blades found in the Fayum are most various in body size and shape as well as working edge serration, and include not only all variants seen at other sites in Lower Egypt and the Western Desert but also those which have not been found anywhere else. As mentioned above, the excavation at Kom W yielded 31 sickle blades of various sizes and shapes (Fig. 7), and this is the largest number of finds at a single site in the Fayum.

As the site is radiocarbon-dated to ca. 4600–4200 cal BC, those sickle blades presumably fall in this time range. Although the number of finds is smaller, sickle blades at Kom K, which is approximately 9 km to the east of Kom W and is radiocarbon-dated to ca. 4600–4200 cal BC, are generally similar to those at Kom W in terms of body size, shape, and working edge serration. This may suggest that the households at these two sites have shared the same know-how of making sickle blades through some kind of interactions. On the other hand, other variants of sickle blades that were not excavated at Kom W but found at nearby undated surface sites (Fig. 8) are considered to be dated earlier than the middle 5th millennium cal BC.

Sickle blades are seasonal tools used for harvesting cereals only for a few weeks, at the longest, each year. They are expendable and can be made expediently. However, the elaborate sickle blades of the Lodian type suggest that they may have been used over some length of time. Serrated sickle blades are more durable and effective than unmodified blades.[33] The clear gloss and rough rejuvenation of the working edge of sickle blades and the storage of a sickle in a grain storage pit in the Fayum demonstrate that sickle blades were indeed curated tools that were used over several years.[34] It is probable that such seasonal tools evolve more slowly than those that are easily damaged and frequently replaced.

The greatest variation in sickle blades from the Fayum is considered to be a consequence of human efforts to improve the efficiency of harvesting cereals. Working edge serration may have evolved from coarse to fine through time. This evolution may be substantiated by the fact that those with fine serration have not been found at sites in the Western Desert that are dated to the middle 6th millennium cal BC, whereas those with

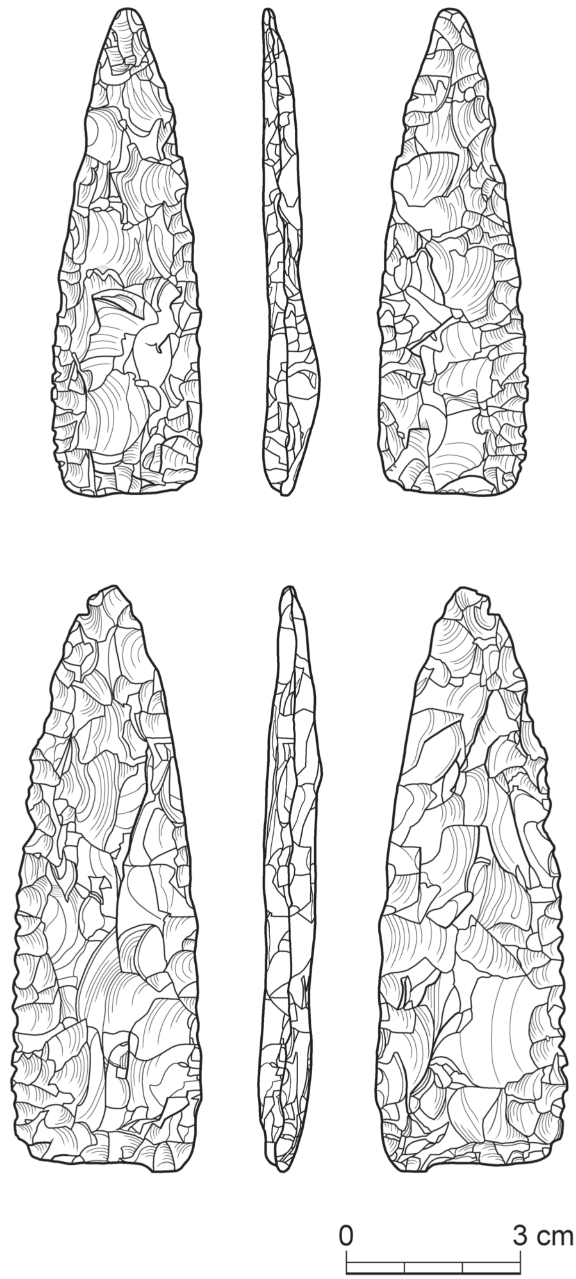

Fig. 7 Sickle blades from Kom W in the Fayum (UC2725 and UC2591 from top to bottom).

33 Quintero, Wilke, and Waines 1997, 279; Unger-Hamilton 1999, 150.

34 Shirai 2016a; Shirai 2017.

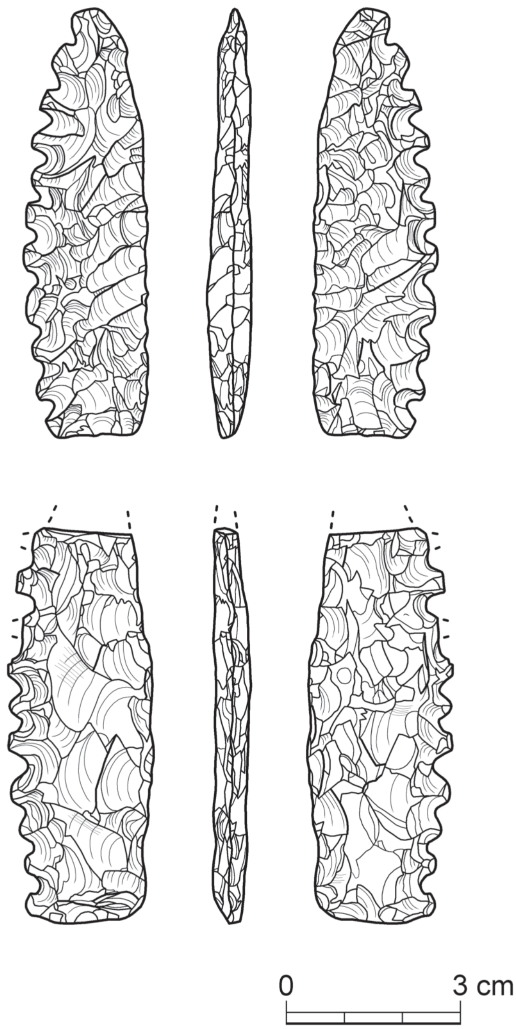

Fig. 8 Sickle blades from Site V and Camp II in the Fayum (UC3221A and UC3308 from top to bottom).

coarse serration are rare to absent at sites in Lower Egypt that are dated to the middle 5th millennium cal BC. The coarsely serrated sickle blades are more suitable for cutting thick, dry cereal culms, whereas the finely serrated sickle blades are more suitable for cutting thin, half-green cereal culms but can also cut thicker ones.[35] Such evolution in working edge serration may suggest that sickle blades had to be modified either for harvesting cereals that did not grow well and became thinner due to climatic and environmental reasons, or for harvesting cereals at an earlier stage of growth in order to avoid loss of yield at a later stage of growth caused by some unknown local conditions. Toolmakers could have made finely serrated sickle blades as variants not necessarily by intention at any point of time. As the versatility of such sickle blades was recognized, the cultural selection of variants in the transmission process would have been biased toward those with fine serration. It is presumed that such an evolutionary process of sickle blades began in the Fayum in the middle 6th millennium cal BC.

4 Concave-based arrowheads in Egypt

Concave-based arrowheads were made from thin flakes by thoroughly flaking both faces of the body, and making a shallow or deep notch at the basal part of the body. The two 'legs' made by the notch are either square-ended, rounded, beveled, or pointed. While the pointed ones could have functioned as barbs, the square-ended, rounded or beveled ones do not seem to be barbs but may have been attached to a shaft and covered by adhesives.[36] In the following, all of these variants are called legs. Moreover, concave-based arrowheads must be distinguished from hollow-based arrowheads whose basal part is only slightly hollowed, as has been defined on the basis of finds in the Fayum.[37]

Concave-based arrowheads have been found by archaeologists at all the Neolithic sites in Lower Egypt mentioned above, though they are not numerous. At Sais, where a small trench was excavated, only three broken examples of similar small size were found in the Sais II (Late Neolithic) layer.[38] At Merimde Beni Salama where different areas have been excavated in the 1920s–1930s and 1970s–1980s, concave-based arrowheads of various sizes and shapes have been found both on the surface and in stratigraphic contexts. Six concave-based arrowheads were found through the initial surface collecting in the southwestern area, whereas in the southeastern area, at least 14 concave-based arrowheads were collected on the surface and at least eight were excavated.[39] The excavations in the eastern area in the 1970s–1980s revealed that concave-based arrowheads appeared first in the second oldest layer (Schicht II), but apart

35 Quintero, Wilke, and Waines 1997, 279; Unger-Hamilton 1999, 150.
36 E.g. Clark, Phillips, and Staley 1974, pl. XVI-3, pl. XIX; Eiwanger 1988, fig. 14.
37 Caton-Thompson and Gardner 1934, 21.
38 Wilson, Gilbert, and Tassie 2014, 64, pl. 8.
39 Junker 1928, 16. pl. VI, pl. XVI; Junker 1930, 219–221, fig. 3, pl. VIII-a; Junker 1933, 63–64, pl. IV-a, pl. VI-b.

from one complete example, another 28 from this layer were incomplete, and 20 out of the 28 are legs only; none of them was of the pointed variety.[40] Concave-based arrowheads continued to exist in the subsequent layers, with one from Schicht III, 33 from Schicht IV, nine from Schicht V, and 14 from the surface. A narrow, elongated body predominates over a wide and short body, and those with pointed legs exist, but are in a minority. It is argued that those with square-ended or beveled legs have been replaced by those with pointed legs at the transition from Schicht IV to Schicht V.[41] At El-Omari, 16 concave-based arrowheads with square-ended legs were found in Areas A and B. They are homogeneous in shape even though there are minor differences in body length and width.[42]

As is the case with sickle blades in the Fayum, countless numbers of concave-based arrowheads have been collected on the desert surface in the large area of the Fayum by antiquarians and early archaeologists, but only part of them were published without the information about their exact number and provenance.[43] Subsequently, approximately 200 concave-based arrowheads were excavated or collected and then published in the 1930s.[44] The illustrations and/or photographs of only 42 out of the 200 concave-based arrowheads have been published, but even this small percentage demonstrates the greater variation in size and shape (Fig. 9), compared with those from other sites mentioned above and below. Only a small number of the concave-based arrowheads were found during excavations at Kom K and Kom W, which are dated to the middle 5th millennium cal BC. It must be noted that most of these examples at Kom W, which vary in size and shape, are abraded and may have been brought there from elsewhere in an already aged state.[45] More concave-based arrowheads seem to have been collected on the desert surface by later researchers, but again the detailed information about how many and which types of concave-based arrowheads were collected has not been published.[46]

Concave-based arrowheads have been sporadically found in the central Western Desert. Several examples found in Dakhleh Oasis have short square-ended legs made by a shallow basal notch. These may be dated to the early 6th millennium cal BC at the latest, and it is argued that such unique arrowheads must have developed first in Dakhleh Oasis.[47] However, the existence of concave-based arrowheads in Dakhleh Oasis seems to have been ephemeral, as no example has been found in the subsequent period. Moreover, besides 11 concave-based arrowheads with square-ended legs found in the 1930s and two concave-based arrowheads with broken legs found in the 1980s in Kharga Oasis,[48] as well as another example with short square-ended legs found in Abu Tartur,[49] no more examples have been reported from contemporary sites in the region. The total number of finds in this region is too small to assume that the development of concave-based arrowheads autonomously occurred there. In the Nabta-Kiseiba region, approximately 300 km to the south of Kharga Oasis, a few elongated, concave-based arrowheads with short square-ended legs have been found on the surface at different sites.[50] These arrowheads look technologically and morphologically distinct among other less elaborate tools at the sites, and would have been brought there from elsewhere. It must be noted that no example with pointed long legs has been found in the Dakhleh and Nabta-Kiseiba regions.

In short, the Fayum as a region has produced the largest number of concave-based arrowheads in Egypt, though the Fayum has been more extensively studied than any other regions in Egypt. The density of finds per unit area seems to be higher at Merimde Beni Salama, but this may be lowered because it was recently revealed that the spatial extent of the site is much larger than previously thought.[51] All concave-based arrowheads found at sites in Lower Egypt fall within the 5th millennium cal BC, whereas those that were found in Dakhleh Oasis may be dated to the early 6th millennium cal BC.

40 Eiwanger 1988, 35–36, pls. 33–34.
41 Eiwanger 1992, 44–45, 52–53, pls. 50–53.
42 Debono and Mortensen 1990, 44, pls. 16–17, pl. 48.
43 E.g. Currelly 1913, pls. XXX–XXXII; De Morgan 1897, figs. 196–201; Petrie 1890, pl. XVI; Seton-Karr 1904, pl. 4, pls. 7–13.
44 Caton-Thompson and Gardner 1934, pls. XXXVIII–XXXIX.
45 Shirai 2016b.
46 Puglisi 1967; Wendorf and Schild 1976; Wenke, Long, and Buck 1988.
47 McDonald 2013, 183–184.
48 Caton-Thompson 1952, 185, pl. 111; Holmes 1992, fig. 3-g.
49 Riemer 2007, fig. 8-1.
50 Wendorf and Close 1984, fig. 10.5-e; Wendorf, Close, and Schild 2001, fig. 8.37; Wendorf and Schild 2001, fig. 13.8-k; Wendorf and Krolik 2001, fig. 17.20-b.
51 Rowland and Bertini 2016.

Fig. 9 Concave-based arrowheads from Site O, Site S, Site N and Qasr el-Sagha (top row: UC3716, UC3663, UC3628 and UC3627 from left to right) and Kom W (bottom row: UC2621, UC2708, UC2625 and UC2626 from left to right) in the Fayum.

Concave-based arrowheads excavated at some sites in the Fayum may be dated to the middle 5th millennium cal BC, whereas many others from surface collections in the Fayum remain to be dated on typological grounds.

A strange phenomenon is that concave-based arrowheads became more common when cereal cultivation and livestock keeping were developing and spreading in Egypt, whereas in the Southern Levant, arrowheads became smaller and fewer as cereal cultivation and/or livestock keeping developed and wild animal hunting declined. It is presumed that concave-based arrowheads in Egypt were made essentially for sustaining cereal cultivation and livestock keeping by eradicating the large predators of cereals and livestock. As two concave-based arrowheads have been found in the skeleton of an elephant and a hippopotamus respectively in the Fayum,[52] it is assumed that concave-based arrowheads were used for hunting these large animals, which are notorious for devastating cultivation plots in present-day Africa. It can be argued that Egypt was not suitable for cereal cultivation in the first place, partly due to the presence of the predators absent in the Levant, and that Neolithic farmers in Egypt overcame this difficulty by developing new hunting weapons.[53]

Another puzzling thing is that concave-based arrowheads have been found in regions where evidence for the existence of such large-sized aggressive animals is scarce. Even in well-watered regions of the central

52 Caton-Thompson and Gardner 1934, 72, 84.

53 Shirai 2016a.

Western Desert like Dakhleh Oasis in the Early to Middle Holocene, the fauna consisted mainly of small to medium-sized animals like hare, dorcas gazelle, and hartebeest,[54] for which large concave-based arrowheads look overdesigned and unsuitable. A study on the frequency of large arrowheads in the Western Desert and Nile Valley in the Middle Holocene has shown that large concave-based arrowheads were extremely rare to absent, even though small arrowheads were present, at most sites in the Western Desert.[55] Given this situation, it is hard to consider that large concave-based arrowheads appeared first in Dakhleh Oasis. It must be considered that these concave-based arrowheads may not have developed locally but may have been brought there from elsewhere as prestige items. It is possible that concave-based arrowheads appeared earlier in the Fayum, where the number and diversity of concave-based arrowheads are outstanding and such a hunting weapon was absolutely needed.

5 Evolution of concave-based arrowheads in Egypt

Concave-based arrowheads are definitely an Egyptian innovation because no similar arrowheads have been found in the Southern Levant in the Neolithic. Nonetheless, concave-based arrowheads probably have their roots in the Southern Levant because such unique arrowheads cannot appear out of nowhere suddenly without any preceding forms. Technology is cumulative in the sense that any change of technology always incorporates previous knowledge. Most technological change is gradual, and any innovation is normally a modification or novel combination of existing elements.[56]

A possible ancestor of the concave-based arrowhead is the Haparsa Point. This small arrowhead is characterized by its isosceles triangular form with a tang and two barbs made by two notches at the basal part.[57] This arrowhead was common in the Southern Levant during the 7th–6th millennia cal BC. Similar examples have been found in the Fayum,[58] Djara,[59] and Farafra Oasis,[60] but have not spread to Dakhleh Oasis.[61] Such an arrowhead is rare to absent at Neolithic sites in Lower Egypt, which are dated to the 5th millennium cal BC. Although very rare, large-sized variants of Haparsa Points have been found in the area between the Fayum and Dakhleh Oasis, including Djara, Farafra Oasis, Abu Gerara, and Kharga Oasis, with some roughly dated to the early–middle 6th millennium cal BC.[62]

It is possible that a concave-based form was initially made by snapping the tang of a large barbed arrowhead for attaching to the shaft in a different manner and/or for reducing the weight of the arrowhead in order to improve its flying performance. As arrowheads are broken or lost easily during use and replaced frequently, the chance of the appearance of variants in the toolmaking process is very high. According to a cultural evolutionary perspective,[63] necessity is not sufficient as the mother of invention. The size, density, and interconnectedness of human populations, in which a variant made by a toolmaker by chance or intention are shared by and transmitted to other toolmakers without being unknown, rejected, or lost, are more important factors to determine the survival of the variant as an innovation. Given the small number of tanged and barbed arrowheads and concave-based arrowheads found in the central Western Desert, it seems unlikely that the evolution from small tanged and barbed arrowheads, through large tanged and barbed arrowheads, to concave-based arrowheads occurred there. It is proposed that such evolution occurred in the Fayum, where all of these types existed in abundance (Fig. 10), suggesting that there were innovation-enhancing cooperative communities in a larger human population.

As mentioned above, the morphometric variation of concave-based arrowheads in the Fayum is greater than that at any other sites in Egypt, and the existence of those with long pointed legs in the Fayum is particularly notable. As pointed legs can be made by carefully trimming square-ended legs, it is reasonable to assume that

54 Churcher et al. 2008.
55 Riemer 2007.
56 Boyd, Richerson, and Henrich 2013; Shennan 2015.
57 Gopher 1994, 41.
58 Currelly 1913, pl. XXVIII; Seton-Karr 1904, pls. 1–6; Shirai 2010, 327–330.
59 Kindermann 2010, 45–46, 68–74.
60 Lucarini 2014b, 279–281.
61 McDonald 2013; McDonald 2016.
62 Currelly 1913, pl. XXVIII; Holmes 1992, fig. 4-c; Kindermann 2010, fig. 104-5, fig. 284-1; Lucarini 2014b, fig. 11/4.7-no. 1; McDonald 2013, fig. 5; Riemer 2010, fig. 70-1; Seton-Karr 1904, pl. 7, pl. 16.
63 Henrich 2010.

Fig. 10 Possible evolution of arrowheads from Camp II in the Fayum (Haparsa Points in the top row: UC3445 and UC3418 from left to right; and concave-based arrowheads in the bottom row: UC3302 and UC3480 from left to right).

the former evolved from the latter. However, concave-based arrowheads with pointed legs were far more prevalent than those with square-ended legs in the Fayum,[64] and it is uncertain whether the former really evolved from the latter. Both seem to have co-existed as functional or aesthetic variants.

The low prevalence of concave-based arrowheads with pointed legs at all other sites in different regions of Egypt may suggest that pointed legs were so difficult to replicate that they were omitted when the know-how of making concave-based arrowheads was transmitted. Consequently, a single variant with square-ended legs may have become fixed. It is possible that the diversity of concave-based arrowheads was lost in the Dakhleh and Nabta-Kiseiba regions due to isolation by distance from the Fayum, even if some may have been made locally. Unlike the case of sickle blades, it is more difficult to study the transmission of the know-how of making concave-based arrowheads because arrowheads are often passed from one maker/user to another user as utilitarian or prestige items and carried over long distances. Therefore, the replication of arrowheads in a distant place may occur not only through imitation (motor actions of toolmaking performed by a teacher are imitated by a learner) but also through emulation (a finished tool is studied and replicated by a toolmaker without formal learning from a teacher), though it is argued that complex artefacts like arrowheads cannot be replicated so easily through emulation.[65] Alternatively, if an interesting cultural evolutionary study on arrowhead variation[66] is taken into consideration, greater variation in concave-based arrowheads in the Fayum and lesser variation in concave-based arrowheads at all other sites may mean that the cultural selection of variants in the transmission process would have been guided toward the products of individuals' trial-and-error in the Fayum but would have been biased toward those made/used by renowned people at all other sites.

A few notable examples of concave-based arrowhead variants have been found only in the Fayum, such as those with serrated lateral edges (Fig. 11).[67] The idea of applying serration to the lateral edges of concave-based arrowheads probably derives from serrated sickle blades. As mentioned above, a novel combination of existing technological elements is always the basis for an innovation. Serrated concave-based arrowheads suggest that there were creative toolmakers who paid attention to or were engaged in multiple subsistence activities like hunting and harvesting. However, serrated concave-based arrowheads have not become common in the Fayum, and have never appeared at other sites in Egypt. This is probably because their functional superiority was not proved in the Fayum and they were not selected as an innovation by other toolmakers and users. This is an interesting example of what happened in the evolution of tools.

64 Caton-Thompson and Gardner 1934, 21, 27–28, pls. X–XI, pls. XXXVIII–XXXIX.
65 Mesoudi et al. 2013, 199.
66 Bettinger and Eerkens 1999.
67 Caton-Thompson and Gardner 1934, pl. XXXVIII-14, pl. XXXVIII-24; Currelly 1913, pl. XXXI bottom row; Seton-Karr 1904, pl. 7, pls. 9–10.

Fig. 11 Serrated concave-based arrowheads from Site V and Site N in the Fayum (UC3219 and UC3629 from left to right).

6 Summary and conclusion

An overview of flint sickle blades and concave-based arrowheads in different regions of Egypt in the Middle Holocene has provided an important basis for considering the possible contrasting evolutionary processes of these specialized tools for the harvest of cereals and the protection of cultivation plots. Both tools most probably derived from Levantine originals, but sickle blades evolved slowly and retained original traits for a long time, whereas concave-based arrowheads evolved rapidly and became incomparably diverse and elaborate. Moreover, this overview has revealed the utmost importance of the Fayum as a center for the evolution of these tools. Although many sites in the Fayum are not securely dated, the great variation seen in the tools from there suggests that the Fayum has a long history of cereal cultivating practices, which may be dated back to the early–middle 6th millennium cal BC at the latest, and that the Fayum has embraced a large population by the middle 5th millennium cal BC. It can be argued that the development of cereal cultivation in the Fayum was realized through the creation and inheritance of technological innovations over many generations, in which countless numbers of toolmakers were involved.

While it is hard to substantiate the interregional cultural transmission of the know-how of cereal cultivation and toolmaking between the Southern Levant and Lower Egypt and between Lower Egypt and the Western Desert, due to the paucity of data, the Fayum provides an exceptional opportunity to study the intraregional cultural transmission of the know-how of toolmaking within a few dozen kilometer radius over millennia. A further explicit cultural evolutionary approach to the lithic study in the Fayum is worthwhile to sort a number of undated tools and to support presumptions mentioned in this article, and will elucidate the beginning and development of cereal cultivation more clearly.

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A Multiple-Scale Approach to the Neolithisation of Lower Egypt

Summary

Although the Neolithic sites of Merimde Beni Salama and el-Omari have been known for over 90 years, explanations for the spread of farming to Lower Egypt have until recently focused on environmental determinism and migrations, or the processes and choices of the local populations. To understand the processes that were taking place, it is essential to relate humans, objects, and environments at multiple scales. The large-scale events that saw farming practices develop in the Levant and spread across Europe and Northeast Africa must be considered, along with the changes occurring at a local-level. However, examining cultural changes over large geographic areas is not sufficient; these changes must be examined over the long- and short-term if cultural change is to be better understood.

Keywords: acculturation; Egypt; Epipalaeolithic; goats; mixed farming; Neolithic; Neolithisation

Obwohl die neolithischen Orte Merimde Beni Salama und El-Omari seit über 90 Jahren bekannt sind, haben sich Erklärungen für die Ausbreitung des Ackerbaus nach Unterägypten bis vor Kurzem auf Umweltdeterminismus und Migration oder die Prozesse und die Entscheidungen der lokalen Bevölkerung fokussiert. Um die Prozesse zu verstehen, ist es entscheidend, Menschen, Objekte und Umgebungen auf verschiedenen Ebenen in Beziehung zu setzen. Großereignisse, bei denen sich die landwirtschaftlichen Praktiken in der Levante entwickelten und sich über Europa und Nordostafrika ausbreiteten, müssen ebenso berücksichtigt werden wie die Veränderungen auf lokaler Ebene. Dabei genügt es nicht, kulturelle Veränderungen in einem großen geografischen Gebiet zu untersuchen, sondern sie müssen über lange und kurze Zeiträume betrachtet werden, um kulturellen Wandel besser zu verstehen.

Keywords: Akkulturation; Ägypten; Epipaläolithikum; Ziegen; gemischte Landwirtschaft; neolithisch; Neolithisierung

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1 Introduction

To understand the advent of mixed farming practices in Northeast Africa, Lower Egypt is a crucial region for study, particularly the Faiyum, Merimde Beni Salama, El-Omari, and Sais. Various questions need to be asked of these sites, such as what were the local environmental conditions that allowed both agriculture and stock keeping to flourish and was there already a population present before the arrival of the domesticates? As there is an interval of some 3000 years between mixed farming developing in the Levant and its arrival in Africa, the economic regimes present in the southern Levant are examined to gain a greater understanding of the timing of the Neolithisation of Egypt. Using all these threads of evidence a clearer understanding of the dynamics involved in the Neolithisation of Lower Egypt is gained and presented here.

The discovery of the Neolithic site of Merimde Beni Salama in the 1927/1928 season by Junker[1] and its investigation throughout the 1930s combined with the scientific investigations of the Neolithic sites of the Faiyum[2] brought to light the earliest evidence for farming in Egypt. The exact dates for these first farming communities are still being refined, as are the actual food-producing activities, but at present it seems that pastoralism started in the Faiyum in the sixth millennium cal BC and mixed farming at Merimde Beni Salama ca. 5000 cal BC and at 4650 cal BC in the Faiyum.

Some of the earliest evidence for food production is to be found in Southwest Asia, in the core area of northern Syria and eastern Anatolia. However, rather than simply emanating out from this core area, the domestication of crops happened slowly in various locations in the southern and Northern Levant, parallel to the developments in the core area, and was dependent on several sociocultural and biological factors.[3] These farming practices however, did not spread immediately across the Negev and Sinai into Egypt, and neither did they initially spread across Anatolia into Europe. This initial Neolithic Revolution was largely confined to the Fertile Crescent, the natural habitat of the domesticates that later spread into Africa and Europe, but it did not include the desertic or Marginal Zone of the Sinai, Negev and into southern Jordan and north Arabia.[4]

In Europe a general westward movement can be observed in the process of Neolithisation; spreading out from eastern Anatolia and the Levant,[5] with both cultural-diffusion and population movements as active carriers.[6] The situation in North Africa is not quite as clear; although a general westward movement of pastoralism can be observed,[7] the same cannot be said for agriculture, which appears to have spread southwards up the Nile, and develops in Morocco at a similar time to its appearance in the Nile Delta. This pattern may partially be an artefact of archaeological research, but also appears to be one of changing environmental conditions.

This delay in the spread of food production and the Neolithic way of life has been a central research question for many decades. Why did it not rapidly move across Europe and North Africa, and why did it start to spread when it did? Another central question is how was the Neolithisation process undertaken, was it a movement of people or ideas? To answer these questions research at both the regional and local scale needs to be considered.

2 People and the environment

Human communities and larger societies respond to the environment as they perceive it, this can vary from group to group, depending on the cultural background, tradition, remembered events or folklore, technology and social aspirations.[8] Humans (and other species) do not just respond to the environment but have been enhancing it through niche construction for tens of thousands of years. Such efforts at environmental modification played an important role in shaping biotic communities and evolutionary processes. In the Holocene humans' rich repertoire of ecosystem and engineering skills led to the domestication of various species in certain areas. However, niche construction did not always lead

1 Junker 1928.
2 Caton-Thompson and Gardner 1934.
3 Allaby et al. 2017; Asouti and Fuller 2013; Fuller, Willcox, and Allaby 2012.
4 S. A Rosen 2011.
5 Bocquet-Appel et al. 2012; Fort, Pujol, and Vander Linden 2012; Özdoğan 2011; Robb 2013; Rowley-Conwy 2011.
6 Fort 2012.
7 Close 2002; Hassan 2000.
8 Evans and O'Connor 1999, 16.

to domestication, just to the better management of wild plants and animals.[9] Niche construction can take various forms and at varying scales, but usually takes place in and around the place of abode. The settlement area constitutes the core of the modified environment, around this is the operational environment, these areas generally constitute the 'site catchment area' from which most of the objects found on the site are derived, and outside these areas is the geographical environment.[10] Therefore, the location of sites was based on both cultural and environmental reasons: what were the resources available in the region, what was its cultural or symbolic significance?

During the early Holocene, there was a whole sequence of socioeconomic transformations coupled with changes in cognition, seemingly brought about by adaptations in the modes of subsistence in response to the environmental changes that occurred during this period. In the various phyto-geographic zones, "people responded to the local conditions by making the most appropriate decisions given the local opportunities, available resources, and their perceptions of the food potentials of specific subsistence modes".[11] However, "It is thanks to human ingenuity, not climatic change, that in responding to environmental crises or endogenous cultural perturbations people tend to make adjustments to sustain their modes of life".[12] Smith[13] has divided the various steps leading up to agriculture into four stages: food procurement – low-level food production without domesticates – low-level food production with domesticates – food production. The second of Smith's stages, the management of wild plants and animals started to occur in both North Africa and Southwest Asia during the early Holocene, whereas in the European Mesolithic there was management of plants through forest clearance and maintenance of open landscapes. This management of wild resources, which in some instances led to domestication, had several false starts and dead ends, and the process could take a couple of millennia, or in the case of sorghum several millennia, for morphological changes only occurred at the end of the process.[14] The manipulation of these wild species took several forms, such as a "general modification of vegetation communities, broadcast sowing of wild annuals, transplantation of perennial fruit-bearing species, in-place encouragement of economically important perennials, transplantation and in-place encouragement of perennial root crops, and landscape modification to increase prey abundance in specific locations".[15]

The climatic shift that occurred at the beginning of the Holocene prompted major environmental changes that had a direct effect upon the human populations throughout Southwest Asia and Northeast Africa; perhaps their most immediate adaptation was the development of new food production techniques that were better suited to the new environmental conditions.[16] During this period, new food processing methods developed to facilitate access to and increase the amounts of digestible nutrients and energy (kilocalories/kilojoules), as well as promoting increased dietary breadth and making possible the production of safer and more stable foods.[17] These advancements in food processing prompted related technological and ecological skills and knowledge.[18] This period was therefore a major turning point in human socioeconomic evolution, and eventually led to one of the greatest socioeconomic transformations in human prehistory, the Neolithic period.[19]

3 Beginnings of food production

There has been extensive research into the initial Neolithic Revolution, which occurred in the Fertile Crescent where primary domestication occurred of goats, pigs, sheep, and cattle, along with wheat, barley, pulses, legumes, flax, and other plants. The domestication of plants was a protracted process, taking thousands of generations of plants, which saw innovations in plant morphology and anatomy that can be correlated with new human behaviors and technologies for harvesting, storage and field preparation.[20] Cultivation and management of various species started prior to the Holocene,

9 Boivin et al. 2016; B. D. Smith 2007; B. D. Smith 2011.
10 Evans and O'Connor 1999, 16.
11 Hassan 2009, 49.
12 Hassan 2009, 41.
13 B. D. Smith 2001.
14 Fuller, Willcox, and Allaby 2012; Marshall and Weissbrod 2011; Zvelebil 1994.
15 B. D. Smith 2011, 836.
16 Broodbank 2013, 148–201.
17 Capparelli, Valamoti, and Wollstonecroft 2011; Wollstonecroft 2011.
18 Wollstonecroft 2011.
19 Zeder 2009, 1.
20 Allaby et al. 2017.

but it was not until there was the major recovery of the oak-pistachio forests of the Levant due to the return of the warmer, wetter climatic conditions after the Younger Dryas event,[21] that morphological domestication of plants and animals occurred in the PPNA ca. 11 700 cal BP (9500 cal BC). However, full mixed farming with a greater range of domesticates only occurred during the middle PPNB 10 300 cal BP (8200 cal BC), although there was not a homogeneous mixed farming economy throughout the region, and early farming practices were quite varied.[22] The complete 'Neolithic package' did not emerge until late in the Neolithic, with reliance on domesticates perhaps beginning in the late PPNB 9500 cal BP (7520 cal BC).[23]

Although there has been less research into the Second Neolithic Revolution, the Neolithisation of Europe has had far more attention than that of North Africa. Indeed, apart from Egypt, the use of the term Neolithic for North African societies has been questioned. Although the economy, ecology, technology, and settlement strategies are important in defining the Neolithic, socio-cultural, cognitive and ritual aspects are also important elements. In the last 20 years, research has shown that some North African societies were manipulating both plants and animals in the early to mid-Holocene, particularly from the late ninth to the eighth millennium cal BP and by the seventh millennium cal BP had complex belief systems and societies, with semi-permanent settlements in well-watered regions.[24] Although the pathways to food production in the two continents seem to be very different on the surface,[25] both were part of the large-scale changes that occurred throughout the countries that border the Mediterranean Basin.

At the beginning of the Holocene, new plants and animals started to inhabit former desertic regions of North Africa as the climate warmed, with lakes starting to form ca. 11 500 cal BP. There was a rapid demographic shift to the former desertic regions of the Eastern Sahara at 10 500 cal BP as the carrying capacity of this region increased.[26] To make these new plant foods more edible, communities started to process them in various ways, including grinding and boiling in order to make porridge and other nutritional meals.[27] During the early Holocene, communities in various parts of North Africa began manipulating and possibly cultivating wild plant remains (i.e. sorghum and millet). These processed foods were supplemented with meat from wild animals, fowl, fish and mollusks.[28]

At Nabta Playa, domesticated cattle are definitely attested by 6100 cal BC at several sites, possibly earlier.[29] The bones of cattle from the El-Adam (8600–7570 cal BC) site of E-75-9 have been studied by several scientists; however, a much larger sample of cattle bones of the same date has now been collected from E-06-1 and E-08-2.[30] As opinions differ wildly on the original cattle bones, these new bovine bones need to be examined closely by various scientists. The genetic evidence is not conclusive; although indicating the major domestication of taurine cattle took place in the Fertile Crescent, it does not rule out a minor domestication event in Africa or minor captures of aurochs in Africa. It is possible that a small number of Levantine cows could have been bred with captured and managed aurochs creating distinctive African cattle breeds.[31] Larson and Fuller[32] suggest that cattle were introduced into Africa at the same time as goats and sheep, although at present there is no evidence for cattle in the Sinai or Eastern Desert during the seventh millennium cal BC. Cattle pastoralism then seems to have spread westward across North Africa,[33] accompanied and possibly aided by the introduction of goat husbandry.[34] Pastoralism then remained the primary form of food production throughout much of North Africa for several millennia.[35]

21 Bar-Yosef 2011; N. Roberts et al. 2018.
22 Asouti and Fuller 2013; Fuller, Willcox, and Allaby 2012; Tassie 2014.
23 Finlayson 2013, 134.
24 De Faucamberge 2016; Garcea 2016; Garcea, Karul, and D'Ercole 2016; Kherbouche et al. 2016; Linseele, Holdaway, and Wendrich 2016; Linstädter, Broich, and Weninger 2018; Lucarini 2013; Mercuri et al. 2018; Morales et al. 2016; Mulazzani et al. 2016; Shirai 2016; Tassie 2014.
25 Garcea 2004; Garcea 2006.
26 Kuper and Kröpelin 2006; Manning and Timpson 2014.
27 Haaland 2007.
28 Lucarini et al. 2016; Mercuri et al. 2018; Tassie 2014.
29 Brass 2018; Linseele, Van Neer, et al. 2014; Linseele, Holdaway, and Wendrich 2016; Tassie 2014.
30 Jórdeczka et al. 2015.
31 Brass 2018; A. B. Smith 2013; Stock and Gifford-Gonzalez 2013.
32 Larson and Fuller 2014, 125.
33 Hassan 2000; Hassan 2002.
34 Close 2002.
35 Broodbank 2013, 204–212.

Goat, sheep, wheat, and barley, along with other domesticates were introduced into Egypt from the Levant.[36] This introduction of domesticates seems not to have been one event, but occurred in at least two waves, the first being that of ovicaprines ca. 6000 cal BC and the second the introduction of domesticated flora and more domesticated fauna ca. 5000 cal BC.[37] Ovicaprines seem to have crossed from the southern Sinai to the Red Sea coast of Egypt in the region of Ras Issaran, Garf, and Gebel Dara (where Neolithic tools have been found), and made their way south to the Tree Shelter and Sodmein Cave before turning west and spreading throughout the Western Desert.[38] The route of the second wave is uncertain, but may have been across the northern Sinai. These animals and plants had to adapt to a new environment, and the people to new work regimes to make these new economic activities successful.[39] Although many of the tools used during the Neolithic of the Nile Valley were already in use in the Western Desert during the sixth millennium cal BC, they were adapted and modified and new tools created for tree cutting, cereal harvesting and predator eradication to ensure cereals and livestock thrived.[40]

During the Last Glacial Maximum (24 000–21 000 cal BP) much of northern Europe was covered by glaciers, but as these started to retreat in the post-glacial period, plants and animals started to colonize previously glacial regions. Communities of Mesolithic hunter-foragers spread throughout Europe; in 7000 cal BC, the whole continent practiced a Mesolithic lifestyle. These Mesolithic groups began landscape management as a "promotional strategy to increase the productivity of nut and fruit trees and shrubs, wetland plants, and possibly native grasses".[41] However, by 6500 cal BC mixed farming had reached the western coast of Anatolia and spread through Greece, and into the Balkans by 6000 cal BC.[42] Mixed farming reached France by 5000 cal BC and Great Britain by 4000 cal BC. This was not one monumental Neolithic wave spreading across Europe bringing a "homogeneous, stereotypical 'Neolithic package' of sedentism in villages, domesticated animals and grains, pottery, axes, and grinding technologies", this only "comes together later in the Neolithic and seems to be a *result*, not a cause, of the transition".[43] The focus of previous studies on an indivisible package has made it hard to understand the diversity of the processes taking place in economy, society and ideology at different rates and combinations in various locations in North Africa and Europe, over an extensive area and time.[44]

4 The spread of food production

What caused the spread of the Neolithic from the Fertile Crescent? What were the changes that happened in the ninth and eighth millennia cal BP in the Levant and elsewhere to facilitate the spread of the Neolithic?

In the late PPNB (9500 to 8800 cal BP) several mega sites evolved in the Levant, such as 'Ain Ghazel, Basta, es-Sifiya, Wadi Shweib, and others, reaching up to 14 hectares in size and consisted of densely packed rectilinear mud-brick architecture. Some of the structures in these settlements showed evidence for two storeys and a new attention to planning the separation of residential and non-residential buildings, and further evidence for increased craft specialization and social complexity.[45] The damage done by these mega sites to the local environment is illustrated by recent computer modelling, which suggests that the more distributed Pottery Neolithic settlement pattern, possibly with a greater variety of site types (i.e. farmsteads, hamlets), would have been less damaging to the environment.[46] This decline of the PPNB koine was further precipitated by the organizational structure of the late PPNB, for these communities appear to have had a heterarchical social organization based on aggregation of extended families within a communal organization with a focus on religion and ritual as a means of social cohesion and a lack of clear leadership. This social structure was unable to cope with these interrelated problems, which finally resulted in the demise of PPNB society. Breakdowns in social interactions were also brought about by the rise in contagious

36 Linseele, Holdaway, and Wendrich 2016.
37 Linseele, Holdaway, and Wendrich 2016; Tassie 2014.
38 Close 2002; Montenat 1986; Tassie 2014, 151–179.
39 Shirai 2016; Tassie 2014.
40 Shirai 2016.
41 Zvelebil 1994, 35.
42 Düring 2011; Robb 2013; Rowley-Conwy 2011; Schier 2009.
43 Robb 2013, 659.
44 Finlayson 2013, 134.
45 Finlayson and Warren 2010, 68–70; Watkins 2010.
46 Barton, Ullah, and Mitasova 2010; see also Banning and Gibbs 2010.

diseases and interpersonal violence, possibly reflected by the increase in multiple burials during the late PPNB.[47] Throughout the ninth and eighth millennia cal BP rainfall lessened and became more seasonal[48] and the socioeconomic organization of these late PPNB societies was not able to adapt to the changing environmental conditions and led to their final dispersal. After the collapse of the late PPNB at 8800 cal BP (6900 cal BC) there was a steady decline throughout the PPNC and final PPNB in the Levant resulting from over-exploitation of certain niches of groundwater soil, revealed in reduced settlement size and the abandonment of labor intensive building in mud-brick and plaster.[49]

With the onset of the 8200 cal BP event starting ca. 8550 cal BP[50] the environment of the Northern Levant changed from open woodlands to one of marquis and in the southern Levant there were more olives in the period from 8200–6800 cal BP, which roughly corresponds to the Pottery Neolithic (6500–4900 cal BC).[51] There was a move to the Marginal Zone of the Negev and Sinai and along the Mediterranean coastal plain, particularly in the Lebanon and Syria and eastward into Mesopotamia and Iran, which led to further regional differentiation.[52], 25. These communities were small enough to be able to make autonomous group decisions at regular community meetings, probably held in public spaces and influenced by charismatic or respected people.[53] This allowed these communities more freedom, and it seems unlike the previous PPNB, these communities were not so attached to place, and could more easily move their settlement to a new location. There was also a de-standardization in artefacts produced, with the interaction pools for learning different kinds of behaviors and techniques taking place on different scales and in different contexts; some were learnt more locally others regionally. This resulted in more design effort being put into pottery, spindle whorls, sickle blades and adzes.[54] It appears that it was during the Pottery Neolithic that an integrated set of crops and animals, combined with optimal farming strategies developed in the Fertile Crescent.[55] The increasing drought conditions from 8550 to 7900 cal BP (6.6–6.0 kyr cal BC) resulted in the need for increasingly managed and artificial growing conditions to make the cultivation of a standard set of crops (cereals, pulses, flax) possible, particularly in small plots on which a range of crops were grown.[56]

The period of rapid climatic change (8550–7900 cal BP) that surrounds the 8.2 kyr cal BP event has been associated with the demise of the PPNB and with the Neolithic expansion. However, this event, although causing global sea level rise and bringing a cold climate to the Mediterranean postdates the end of the PPNB (8800 cal BP), but coincides with the beginning of the Pottery Neolithic in the Levant at 6500 cal BC.[57] At several Yarmoukian sites (6500–6000 cal BC), particularly in southern Jordan, rubble slides have been noted. Weninger et al.[58] see the cold arid conditions that prevailed, combined with the northerly position of the ITCZ and cold Siberian winds that interacted with the moist Mediterranean air masses as being major factors in creating the flash floods that caused several sites to be abandoned. The exact relationship of this period of rapid climatic change to the spread of the Neolithic into Europe is still under debate; there does seem to be a correlation in the timing, with some farming communities being established in Turkish Thrace, Greece and Bulgaria from 6500 cal BC, although the major movement was not until ca. 6000 cal BC.[59]

At Çatalhöyük, the social, religious and economic changes and final abandonment of the east höyük (tell), along with the occupation of the west one some 200 years later, is seen by Weninger et al.[60] as being the result of the communities response to the worsening environmental conditions caused by the period of rapid climatic change. Other scholars have a more multi-causal approach, citing the addition of crops and animals better adapted to temperate climates and forested regions and the possible integration of crops and animals in garden agriculture. These actions combined with the addition of dairy products to the agricultural

47 Belfer-Cohen and Goring-Morris 2011, 215.
48 A. M. Rosen 2007.
49 Wengrow 2006, 25.
50 Rohling and Pälike 2005, *passim*; Rohling, Casfor, et al. 2002, 41.
51 A. M. Rosen 2007.
52 Rohling, Casfor, et al. 2002, 42; Verhoeven 2004, 259; Wengrow2006
53 Banning 2010.
54 Banning, Rahimi, and Siggers 1994, 162; Banning and Gibbs 2010.
55 Düring 2011.
56 Boggard 2005; Weninger, Clare, Gerritsen, et al. 2014.
57 Weninger, Clare, Gerritsen, et al. 2014.
58 Weninger, Clare, Rohling, et al. 2009, 30–33.
59 See Vander Linden et al. this volume.
60 Weninger, Clare, Rohling, et al. 2009, 33.

economy and the breakup of large agglomerate communities in individual households into smaller segments in which multiple households became more autonomous, are seen as the main reasons for the Neolithic expansion. These changes in economy and household-related practices built a more portable and artificial ecosystem and created a social environment that could more easily spread. These socioeconomic changes indeed led to a continued expansion of population on the Konya Plain, but when combined with the cold dry conditions caused by the rapid climatic change (that affected western Anatolia more severely than central Anatolia) led to an expansion of the Neolithic through the previous static boundary.[61]

In Northeast Africa, the onset and the aftermath of the 8.2 kyr cal BP event may have been a contributing factor in the spread of ovicaprines. The Timnian herder-gatherers of the Negev, Sinai and southern Jordan developed ca. 6000 cal BC or slightly before, and rapidly moved to the Red Sea coast of Egypt and then spread throughout the Western Desert.[62] However, the 8.2 kyr cal BP event predates the advent of the Lower Egyptian Neolithic and the introduction of mixed farming practices by several hundred years. The catalysts for the spread of this second wave of food-production, transferring wheat, barley, lentils, peas, pigs, cattle, sheep and goats, seems to be the changes in farming technologies in the Levant, enabling them to be practiced in different ecological zones combined with social factors (i.e. Anatolia). The more dispersed communities of the Pottery Neolithic lived in settlements of a more modest size and with a focus on household level economies. This allowed them to operate more independently than in the late PPNB and allowed the various agents greater choices in their actions. The local actions that certain of these farmers took led to unintended continental consequences resulting in the spread of the Neolithic. Some of these decisions to expand out of the Fertile Crescent were undoubtedly influenced by the worsening environmental conditions surrounding the 8.2 kyr cal BP event, but it was the changes in socioeconomic practice (which seem also have originally been an adaptation to changing environmental conditions) that made this movement possible.

Current research involving genetic and isotopic studies, artefactual analyses, and the fact that previously uninhabited islands began to be settled suggest that the Neolithisation of Europe was a mixture of a movement of people, objects and ideas.[63] In Europe Neolithisation occurred in a 'mosaic' way, with quite diverse pathways evident not only between regions but also within any moderate-size region. Many scholars concur that the Neolithisation of Europe was "spread through a combination of a few rapid, 'enclave migration' population movements (principally the Impressed/Cardial Ware in the Mediterranean and the LBK in the northern European Plain) and local forager acculturation in most other places".[64] Groups could travel by sea, probably up to 150 km, or by land, with mountains having only a negligible effect on the spread.[65] This spread in food-production is sometimes referred to as the Second Neolithic Revolution.[66] As Robb[67] notes, once the Neolithic way of life and material culture was taken up, it was hard to reverse the process.

5 Neolithic prelude in Northeast Africa

That goats, sheep, and possibly also pigs and cattle, along with wheat, barley, pulses and flax were introduced into Northeast Africa from the Levant has long been recognized.[68] Although domestic cattle were already present in southern Egypt by the seventh millennium cal BC, it does not prevent more coming in with the Levantine farmers at this period. One of the main questions is whether the Neolithisation of Lower Egypt was by chain migration of people from the Levant, enclave movement of people within Egypt, or local hunter-gatherer acculturation? At present, there are only a few sites or areas in the lower Nile valley to examine the spread of the

61 Brami 2017; Düring 2013.
62 Close 2002; Close and Minichillo 2010; Linseele, Holdaway, and Wendrich 2016; Tassie 2014; and see Rosen this volume.
63 Bocquet-Appel et al. 2012; Fort, Pujol, and Vander Linden 2012; Özdoğan 2011; Robb 2013; B. W. Roberts and Vander Linden 2011; Rowley-Conwy 2011.
64 Robb 2013, 659.
65 Fort, Pujol, and Vander Linden 2012.
66 Düring 2011.
67 Robb 2013.
68 Holdaway, Phillipps, Emmitt, et al. 2016; Tassie 2014.

Neolithic; these are Faiyum, Merimde Beni Salama, El-Omari, and Sais.[69]

Some of the Epipalaeolithic hunter-fisher-gatherer communities in Northeast Africa had already begun to practice broad-spectrum subsistence patterns, economic intensification, and increasing sedentism since before the beginning of the Holocene, and increasing further with the development of ceramics with impressed or incised designs.[70] During this period, grinding stones were used for processing wild grasses and cereals that grew in the wetter regions of the green Sahara and Sudan. In the Western Desert and oases during the seventh millennium cal BC, this was often accompanied by food storage and the beginnings of ritual behavior, all activities that could be seen as a prelude to the process of Neolithisation. Although the cattle found at some of these sites may not be morphologically domesticated, they were probably being managed in the early to Mid-Holocene. The plants that were being tended during this period, such as sorghum and millet, also did not result in morphological changes. These various groups may be seen as being pre-adapted to food production, occupying the middle ground between hunting and gathering and mixed farming activities.[71]

Phylogenetic research indicates that inherited cultural traits predominately take the form of language and material culture tradition, although economic and descent rule systems are inheritable traits, which can be transmitted through inter-group exchange or by diffusion.[72] Aspects of foreign cultures removed from their original contexts within temporally and spatially distinct traditions and the mixing of them with the indigenous Nilotic culture, resulted in significant transformations. Particular kin groups or communities may have retained aspects of their more valuable traditions and symbols, although in a very different form from their original ones, in both structure as well as context of occurrence. This would explain the reappearance of techniques and traditions whose origins can be traced to different areas and time periods.[73] Stylistic elements of the material culture and symbolic codes were likely re-arranged within the new community to the extent that they render any attempt to pinpoint an original 'homeland' for the immigrants highly implausible and largely futile. However, certain elements can be assigned to general regions and time periods, and there is a view that human culture is phenotypic and that human cultural transmission is an inheritance system and source of variation.[74]

Prior to the sixth millennium cal BC there was no pottery in northern Egypt (north of Farafra Oasis), but by at least 5000 cal BC Egypto-Levantine pottery was to be found at Merimde Beni Salama, the Faiyum, and Sais and by 4600 cal BC at El-Omari.[75] Burnished unpatterned thin walled Libo-Nubian pottery started to appear between 6000–5500 cal BC in both Nubia, at places such el-Barga and in Egypt, at Dakhla Oasis and elsewhere.[76] By 5000 cal BC, black topped red ware pottery with ripple decoration is found in the Abkan sites and elsewhere in Nubia and into southern Egypt, and in the late Neolithic Badarian sites by 4400 cal BC.[77] The Egypto-Levantine pottery is distinct in form and manufacture from the burnished or polished Libo-Nubian pottery found in the south of Egypt and Nubia at this period.[78] Although the idea of pottery making could have emanated from the south, as the types of pottery with its decorative elements found in northern Egypt had no precedent in Africa and show greater affinity with that from the Levant, particularly in the early stages, the Levant seems the more probable origin.

Another artefactual element associated with the Neolithic, bifacial technology, started to appear in the form of bifacially retouched formal points after 8350 cal BP (6400 cal BC). By 7950 cal BP (5900 cal BC) bi-facially worked tanged and concave-based points and other bifacial elements had spread throughout most of the Western Desert, either through human migration and/or expansion of exchange networks induced by the changing climate as well as available resources, eventually leading to a complete change in the lithic toolkit of the northern part of the Eastern Sahara.[79] Small leaf-shaped

69 Research at the three Neolithic sites in the East Delta will also greatly help in understanding the Neolithisation process.

70 The sites in the Nabta Playa region and Western Desert are often termed Neolithic, but the term Early Saharan Ceramic is preferred here, as the economy and lithic technology from the eleventh to the ninth millennium cal BP were more akin to the Epipalaeolithic than the Neolithic, Tassie 2014, 80.

71 B. D. Smith 2001.

72 Holden and Shennan 2005.

73 Asouti 2006, 117.

74 Holden and Shennan 2005; O'Brien and Lyman 2005.

75 Tassie 2014, 183–185.

76 Tassie 2014, 160–175, 183–185.

77 Honegger 2014, 22; Tassie 2014, 254–256, 293–294.

78 Tassie 2014, 183–185, 287–289.

79 Kuper and Kröpelin 2006, 805; Shirai 2006, 356–357.

and tanged points are associated with the early part of Bashendi A, whereas larger concave-based and tanged points are associated with the latter part of Bashendi A and Bashendi B.[80] Riemer[81] calls this the (bi)facial techno-complex, the origins of which lie in the Levant.[82] Various elements of the bifacial techno-complex can be found in the late Bashendi A and Bashendi B of Dakhla Oasis, Dabadibian A in Kharga Oasis, Farafra B-C phase, the late Djara A and Djara B phase of the Abu Muhariq Plateau, the Late Baris Unit of Kharga Oasis, the Lobo and Chufu sites in the Great Sand Sea, in the Siwan of Siwa Oasis, Bahariya Oasis, and in the Haua Fteah cave in Libya.[83]

In the southern part of the Eastern Sahara was the Microlithic or Khartoum techno-complex with a transition zone in the region of Nabta Playa in the southeast, and Chufu and Meri in the center of the Western Desert extending south into the Sudan. Although there is still regionalism within these complexes, certain tool classes such as stem and leaf-points, bifacial knives, tranchet adzes, side-blow flakes, and side scrapers are typical of the bifacial-techno-complex, whereas transverse arrowheads, lunates and stemmed and triangular points are more typical of the Khartoum techno-complex.[84] During the period 6500 to 5400 cal BC, the similarity in tool classes at sites in Haua Fteah, Siwa, the Faiyum, Bahariya Oasis, Djara, Farafra Oasis, Abu Gerard, Abu Minqar, Dakhla Oasis, Kharga Oasis, and Abu Tartur indicates an extended interaction sphere in this region.[85]

During this period, there were sporadic occurrences of the side-notched and tanged projectile points on Northeast African sites. These arrowheads were particularly good for hunting small game, such as hare and gazelle. In the Levant, Helwan points are associated with the PPNB, in Egypt their appearance is probably prior to food producing economies, and hence usually associated with Epipalaeolithic or transitional hunter-gatherfishers, who were using bifacial technology. Unifacially and bifacially retouched side-notched and tanged (Helwan) points found at Dakhla Oasis, Abu Gerara, Chufu, and Haua Fteah are roughly dated to the sixth millennium cal BC.[86] A slightly earlier date in the seventh millennium is postulated for the none to slightly retouched ones from Ayn Buerat in the Wadi Araba,[87] which like the ones from Helwan are associated with scalene bladelets, backed triangles, and lunates. Side-notched and tanged points have also been found in the Faiyum and Sinai, but not in great numbers. These points probably indicate the existence of interregional networks of material, artistic, and cultural exchange during the seventh to sixth millennium cal BC, although most points appear to have been made in Egypt.[88] As Shirai notes, some of the various types of points found during this period indicate a Levantine origin,[89] and it is probable that a small but steady flow of these Levantine points arrived in Egypt and thereafter were imitated as novel and prestigious items.

Polished axes, which take the most time out of any of the stone tools to produce, but also have greater tensile strength lessening the likelihood of chipping and breakage, appear in the Western Desert during the Ru'at el-Ghanam Period (5900 to 5500 cal BC) at Nabta Playa, and in the Bashendi B phase at Dakhla Oasis and Abu Gerara by 5500 cal BC.[90] At Tagalagal, in the Central Sahara, axes and adzes with polished cutting edges appear around 6500 cal BC, whereas complete polished axes were already being used in the Levant during the latter part of the PPNA, ca. 9500 cal BC.[91] These polished celts although being prestige items were also functional and could be formed as axes to chop trees and shrubs, hoes to till soil or adzes to shape wood. This change in the lithic toolkit, from the Red Sea coast to Nabta Playa and Siwa Oasis indicates a general change in hunting and mobility tactics, and prestige lithic objects, whereas the difference in techno-complexes may reflect the climatic gradient. Therefore, although new lithic tools and techniques may have been introduced from the Levant, along with the domesticates, the major inspiration for the bifacial tools found in the Neolithic of Lower Egypt and the Faiyum probably originated in

80 Shirai 2006, 356.
81 Riemer 2006.
82 Kuper and Kröpelin 2006, 805.
83 Hassan and Holmes 1985; Holmes 1991; Lucarini 2013; Shirai 2006, 356.
84 Riemer 2006, 521; also see Holmes 1989, Tab. 11.2.
85 Riemer 2003; Riemer 2006; Riemer, Lange, and Kindermann 2013, fig. 3.
86 McDonald 1991; McBurney 1967; Riemer 2003; Riemer 2006.
87 Tristant 2012.
88 Shirai 2011, 80.
89 Shirai 2005.
90 Riemer 2003, 87.
91 Le Quellec 2006; Verhoeven 2004; Roset 1996.

the Western Desert, possibly brought with refugees escaping the increasing aridification. Exaptation of already familiar tools and technologies, particularly the bifacial element, allowed the communities to more easily adapt to the new farming tasks.

Both Hassan and Kaiser suggest that groups moved into the Nile Valley from both the Western Desert and Levant to escape worsening climatic conditions and mixed with the original Nilotes.[92] Although some groups may have emigrated to the Nile Valley due to the 8.2 kyr cal BP event, occupation in the Western Desert really started to fall-off around 7350 cal BP (5400 cal BC) toward the end of the African Humid Period and the onset of more arid conditions, with another depopulation event between 6800 to 6500 cal BP (4850 to 4500 cal BC), followed by a brief demographic recovery and a final and irreversible depopulation event between 6300 to 5200 years cal BP (4350 to 3255 cal BC), as the conditions became too arid to support human and animal life.[93] This seems to have been caused by a southward shift in the ITCZ and a northward shift of the Mediterranean rains. Increased mobility and investment in herding, milking and meat consumption was one of the cultural strategies adopted by North African populations during these more arid periods of the middle Holocene.[94] In Libya a full pastoral economy with dairying appears at the beginning of the Middle Pastoral (5200 cal BC), a thousand years after domestic cattle first appeared in North Africa. This dairying economy had spread into the Central Sudan by 4600 cal BC.[95]

Many groups of the Pastoral Neolithic in the Western Desert and oases (6100 cal BC to 3950 cal BC) show cultural convergence with the Tasian from ca. 5000 cal BC,[96] which has been identified at sites such as Deir el-Tasa, Gebel Ramlah and Wadi Atulla.[97] In the Upper Egyptian Nile Valley, primary pastoral communities such as the Badarian started to appear ca. 4400 cal BC, probably composed of both Nilotes and people escaping the increasingly arid conditions of the Western Desert. These groups seem to have appeared slightly earlier in Nubia, with domesticated cattle represented by a skull on a burial in the el-Barga cemetery at 5800 cal BC, although pastoral communities did not appear until ca. 5000 cal BC.[98] Segments of these groups practiced seasonal mobility, taking the herds out to pasturage, while others remained in the Nile Valley. As the desert was drying, these movements covered increasingly larger areas, occasionally meeting with other groups, resulting in increasing cultural convergence across a large region comprising of Upper Egypt, Nubia and the surrounding deserts.[99] These primary pastoral groups were low-level food producers with domesticates, complementing their pastoral activities with some cereals and other domesticates, along with fishing and some gathering, activities mainly practiced in the Nile Valley.

In the Levant at ca. 7450 to 7350 cal BP (5500 to 5400cal BC) Rosen records a very warm, moist phase coinciding with the water level in the Dead Sea rising.[100] Although there were climatic oscillations, this period was generally favorable to human occupation in the southern Levant.[101] This climatic amelioration also caused the core of the Sinai Desert to gradually contract, leaving pastoral land around the perimeter and in other areas of the Sinai.[102] With the southward shift of the systematic agricultural frontier reaching its fullest extent at ca. 7450 cal BP (5500 cal BC) coinciding with a greening of the perimeter of the Sinai, the peninsula became more favorable for the herder-gatherer Timnian population of the region, providing larger areas of pasturage.[103]

It also appears that it was during this period of the mid to late sixth millennium cal BC that mixed farming communities moved across the Sinai, possibly being pulled by the promise of the rich Nile Delta environment, a period that may have been optimal for Nile flood based agriculture.[104] These migrants, probably from the Wadi Raba cultural unit,[105] found suitable ecological zones in the Delta for both their crops and animals. This was not large-scale demic diffusion, rather

92 Hassan 1988; Kaiser 1956; Kaiser 1985.
93 Manning and Timpson 2014; Riemer 2003; Riemer, Lange, and Kindermann 2013; Shanahan et al. 2015.
94 Dunne, Evershed, et al. 2013.
95 Dunne, Lernia, et al. 2018.
96 Wuttmann et al. 2012.
97 Tassie 2014, 266–282.
98 Honegger 2014, 27; Wengrow et al. 2014.
99 Wengrow et al. 2014.
100 A. M. Rosen 2007, 73, 98.
101 Vernet 2002, 52.
102 Rossignol-Strick 2002, 165.
103 S. A Rosen 2009.
104 Williams 2009.
105 Tassie 2014.

the movement of a few families. There were no political borders, with the only barriers to movement of people being the different ecological zones and tribal territories. This eastern region of the Delta and Sinai was a dynamic region that people had been moving across and through for thousands of years. Although the Mediterranean rains had shifted north, there was still sufficient precipitation over the Faiyum to support rain-fed agriculture up to about 4000 cal BC.[106] As illustrated above and highlighted by Holdaway et al., the Neolithisation of Egypt – and North Africa as a whole – was a complex process, that was neither rapid nor involving a coherent whole package, for there were temporal and geographic differences in the timing of the arrival of its constituent parts.[107]

Although there was cultural convergence in the Libo-Nubian sphere of influence of Upper Egypt/Western Desert and Nubia, with the pottery showing many similarities in the fifth millennium cal BC, the lithics in these two regions emerged from different techno complexes of the sixth millennium cal BC. In the Nile Delta, although being part of the Egypto-Levantine sphere of influence with regards to pottery in the fifth millennium cal BC, the lithics may have been influenced by the earlier Western Desert bifacial techno-complex. This indicates a complex set of cultural dynamics in force during this period, with overlapping spheres of influence, immigration, geographical proximity to neighboring regions, the climatic gradient, differences in economic strategy, and original inherited cultural traditions all being factors in the observed regional differences during the Neolithic.

6 The Neolithic of the Nile Delta and Faiyum

The amount of fourth to early third millennium cal BC sites recorded for Lower Egypt is nearly 100, although the number of sites per period increases through time until the end of the Early Dynastic Period.[108] Whereas, only six sites dating to the fifth millennium cal BC (Neolithic) are attested in the region: the major sites of Merimde Beni Salama, El-Omari and Sais, along with Minshat Abu Omar (MAO), Tell el-Samara (TeS), and Tell el-Sanyura. However, if the more ephemeral find spots of Neolithic remains from the Faiyum are included the number rises to several tens of sites.

The majority of the known Predynastic sites are located in the East Delta, with only a few discovered in the west, such as Buto, Ezbet el-Qerdahi, Kom el-Qanater, el-Qatta, Merimde Beni Salama and Sais.[109] At the latter, two of these sites substantial Neolithic remains have been recovered. At only three of the numerous East Delta Chalcolithic sites: Minshat Abu Omar, Tell el-Samara, and Tell el-Sanyura, have possible Neolithic remains been located. The recently identified Neolithic remains in the East Delta (see Fig. 1) may suggest that the most likely route for emigrants moving into Egypt would have been via the Sinai and through the East Delta. Bar-Yosef argues the possibility that people sailed down the coast of the Levant and passed round the Delta and came up one of the western branches; but goes on to say that traversing the Sinai on foot would probably have been more manageable.[110]

At Minshat Abu Omar, located in the northeast of the Nile Delta by the Tanitic branch, a drill-core collected material that provided a date of 5720 + 80 bp (4730 to 4360 cal BC) from the layer of organic rich mud above the deposit containing non-diagnostic Neolithic rough-ware potsherds.[111] This is from a relatively low position on the turtleback, around 6.0 m below the current ground level. The fourth millennium cemetery site is located at a much higher elevation upon the *gezira*. This is because the deposit of Nile alluvium that built up around the turtleback necessitated communities moving to higher elevations in order that both the settlement and cemetery stayed clear of the annual inundation. The site of Tell el-Samara is located about 20 km west of MAO, in the large group of sites that includes Kom el-Khilgan, Minshat Ezzat, Tell el-Farkha, and Tell el-Rub'a situated between the Mendesian and Tanitic branches.[112] Like MAO, TeS is located on a sand *gezira* or turtleback and has both Chalcolithic and Early Bronze Age I-II occupation phases ranging from the early fourth

106 Phillipps, Holdaway, Wendrich, et al. 2012.
107 Holdaway, Phillipps, Emmitt, et al. 2016.
108 Jucha and Mączyńska 2011; Tristant 2004; Tristant 2005.
109 Dębowska-Ludwin 2013; Jucha and Mączyńska 2011.
110 Bar-Yosef 2013.
111 Krzyżaniak 1992; Krzyżaniak 1993.
112 See Tassie 2014, fig. 110.

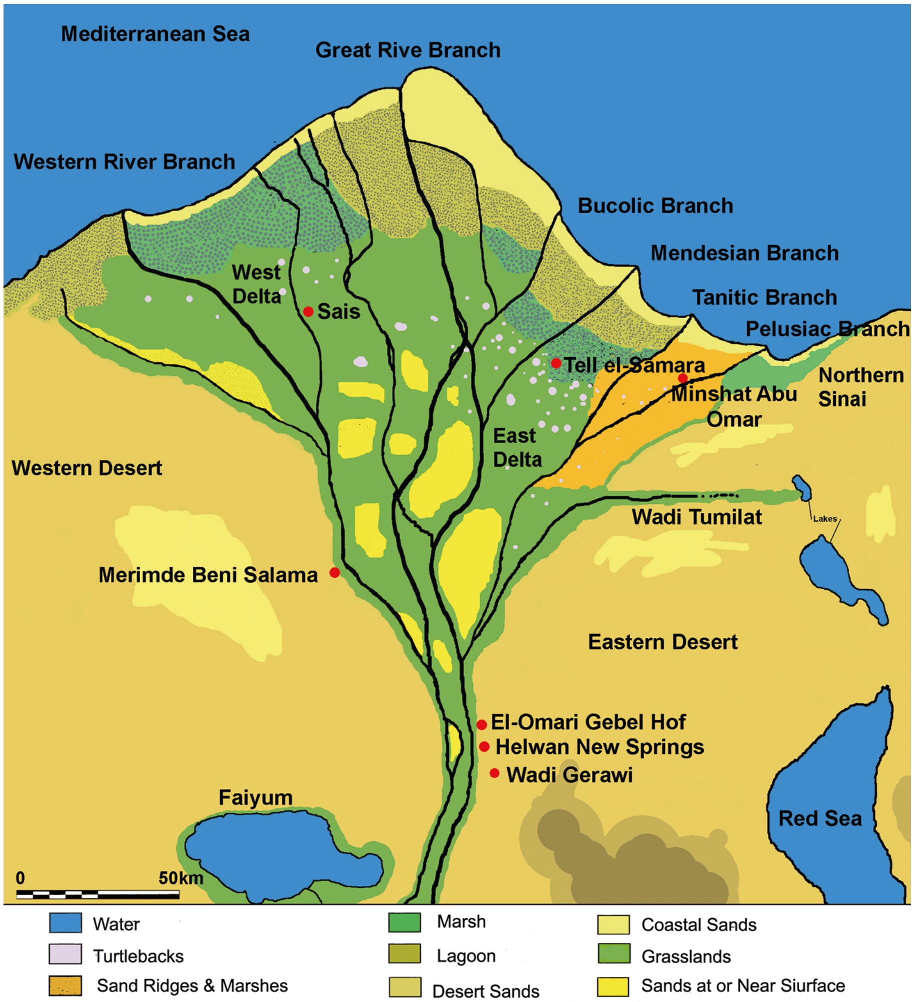

Fig. 1 Map of the Nile Delta in the fifth millennium cal BC showing the location of Neolithic sites.

to early third millennium cal BC, although the Chalcolithic occupation starts earlier at TeS. The earliest levels of occupation at TeS (Phase 1) are located directly on the natural surface of the gezira. These remains consist of a large oval pit (1.50 m long by 0.30 deep), which is connected by a step down to a smaller pit, possibly remains of a shelter made of reeds and branches. Located nearby was a cylindrical pit or silo of 0.84 m diameter containing a large quantity of animal bones and another smaller pit. Some of the pottery from this phase is similar to that recovered from the earliest levels at Tell el-Iswid South, dated to Buto I. However, other potsherds show great similarity to vessels found in the Late Neolithic levels at Merimde Beni Salama, El-Omari and Sais. The lithics include bifacial denticulated sickles, typical of the Neolithic.[113] This may be a transitional phase between the Neolithic and Chalcolithic dating to the end of the fifth and beginning of the fourth millennium cal BC. Tell el-Sanyura, like the other two sites is located on a large turtleback, 0.5 km west of the Predynastic to Early Dynastic site of Tell el-Masha'la located on the same turtleback. Although there is nothing published on this site at present, the potsherds and lithics are similar to those found at Merimde Beni Salama.[114] These findings indicate that more survey and excavation work is needed at the lower elevations of the sand gizeras, levees and other

113 Guyot 2016.
114 Sabrina Rampersand recently conducted research at this site, which is being excavated by the local Ministry of Antiquities under the direction of Mr Nashat and Mr Magdy Saad.

high places not only in the east but also throughout the whole Delta.

Changes in the Nile's discharge combined with alterations in the activity of the various branches, seems to have had an impact on the settlement pattern during the fifth and fourth millennium cal BC.[115] These environmental changes created more favorable conditions for farmers. Many of the Chalcolithic to Early Bronze Age sites in the Nile Delta are located on turtlebacks or ancient levees. This was to keep them, particularly the cemeteries, above the waters of the inundation. These settlements underwent various changes in their characteristics over time and not all the distinguishing features of Neolithic occupation are consistent across all sites, although some similarities are very clear.[116]

The Delta environment has not always been as it is today, the rich alluvium that is today characteristic of the Delta landscape started to be deposited in the early to mid-Holocene, ca. 8900 cal BP, and more rapidly from 7000 to 6000 cal BP due to the decrease in sea level rise. During the Last Glacial period, there was a broad, sandy, minimally vegetated plain, with seasonally dry anastomosing channels.[117] From the post-glacial warming period, higher insolation in the northern Hemisphere caused the ITCZ to shift northwards, and the initiation of a period generally referred to as the African Humid Period (14.8 to 5.5 kyr cal BP). These two environmental phenomena changed the morphology and dominant sediments of the Nile Delta, by covering the dry, sandy plains between the former anastomosing channels with alluvium creating floodplains, wetlands and marshes, and brackish water lagoons in the outer part of the Delta, and this high-energy shoreline migrated landward (southward).[118] In the eastern Mediterranean as a whole these climatic conditions led to a sapropel (S1) – the deposition of organic-rich sediment layers – between 10 500 to 6100 cal BP.[119] The Delta environment of the late Pleistocene and early Holocene could have supported a hunter-gatherer lifestyle, such as practiced by various Epipalaeolithic groups. However, any Epipalaeolithic remains are likely to be buried beneath 10 to 25 m of alluvium. Therefore, Epipalaeolithic remains will only be found in the central Nile Delta under very exceptional circumstances.

During the early Holocene, there was a rapid rise in sea level, particularly due to the 8.2 kyr cal BP event, which altered the degree of slope of the Delta, making it a gentler gradient. This resulted in a "high rate of in-channel aggradation, little to no lateral channel migration, multi-channel networks, frequent avulsion, continuous crevassing, fast floodplain aggradation, poorly drained swampy and wetland landscape formation, little or no large-scale soil development, and accumulations of complex flood basin sediments varying substantially both laterally and vertically",[120] this may be termed a large-scale crevassing environment. The ecosystem at this period was brackish and there were salt marshes and lagoons at the coast, with farther south freshwater swamps and marshes; this was a nutritionally rich, varied and heterogeneous wetland environment.[121] It was during this period that the Neolithic sites of Merimde Beni Salama, El-Omari and Sais flourished, with aquatic resources, in particular fish, comprising a very important wild nutritional source, although domestic animals were already the major provider of animal protein. Hippopotami were the major game animal hunted in the Delta, although aurochs and hartebeest remained important hunted species.[122] There was a deceleration in sea level rise that occurred during the seventh millennium cal BP. This initiated further changes in the Delta, with a transition to a meandering riverine landscape during the sixth millennium cal BP, with lower in-channel aggradation rates, substantial lateral migration of channels through sweeping and point-bar deposition, single-channel networks, slow floodplain aggradation, less crevassing, enhanced soil-formation, and simpler floodplain sediments, wedging out laterally from the channel.[123] The ecosystem at the coast was very similar to the period before, but farther south woodland, shrubland and grassland dominated; this was a nu-

115 Butzer 2002; Pennington, Bunbury, and Hovius 2016; Pennington, Sturt, et al. 2017.

116 Phillipps, Holdaway, Emmitt, et al. 2016; Rowland and Bertini 2016.

117 Muhs et al. 2013; Stanley, Jorstad, et al. 2008; Stanley and Warner 1993.

118 Muhs et al. 2013, 42–43; Shanahan et al. 2015, 1–4.

119 Grant et al. 2016.

120 Pennington, Bunbury, and Hovius 2016, 195.

121 Pennington, Bunbury, and Hovius 2016, 203; Pennington, Sturt, et al. 2017, 213–215.

122 Linseele and Van Neer 2009.

123 Pennington, Bunbury, and Hovius 2016, 196; Pennington, Sturt, et al. 2017, 224–227.

tritionally homogeneous environment with sparser resources than previously.[124] As the wetland areas of the Delta reduced in size, fish became less important in the diet of the Chalcolithic communities, and there was an increase in the importance of agro-pastoralism.

The situation in the Faiyum is quite different to that of the Delta, particularly to the north of Lake Qarun, where various beach deposits can be found corresponding to both the Epipalaeolithic and Neolithic. These beaches, often marked by diatomite deposits, are now way above the level of the lake, for although the lake levels have fluctuated over the course of the Holocene,[125] it is presently at a very low stand. The Neolithic settlement remains in the Faiyum are very ephemeral, consisting of surface scatters, hearths and storage pits (some lined with pottery vessels, others like the K-Pits with basketry), but with no evidence of structures.[126] This suggests that people were moving around and through the landscape, possibly gathering around the seasonally filled basins. There may have been fields, possible around the edges of the basins, which allowed for rain-fed agriculture.

Research in the Faiyum has shown that there was a thriving early to mid-Holocene Epipalaeolithic population. Although originally there was a perceived gap between the Epipalaeolithic Qarunian unit (7530 to 6090 cal BC) and the Early Faiyumian Neolithic (5550 to 4650 cal BC; Late Faiyumian 4650–4200 cal BC), this is now being shown to have been a result of the previous research strategies and the limited number of radiometric samples.[127] Shirai suggests that a late non-food-producing Epipalaeolithic culture, which had some bifacial elements along with flakes in their lithic tool kit, inhabited the Faiyum.[128] New radiocarbon dates for the Faiyum, particularly around E29H1 have now bridged this 500-year gap between the two periods.[129] Fish remains dominate in the early and mid-Holocene faunal assemblage, a small amount of ovicaprines and cattle appear to have been added in the Early Faiyumian and these were joined by domesticated flora and more fauna (in particular a few pigs) in the Late Faiyumian.[130]

Epipalaeolithic populations were present in the Helwan region where the late Neolithic El-Omari settlements are located.[131] However, unlike in the Faiyum there seems to have been a hiatus in occupation between the Epipalaeolithic and Neolithic. Unfortunately, there are no radiocarbon dates for the Epipalaeolithic in the Helwan region, although it seems on typological grounds that they span both the late Pleistocene and the early to mid-Holocene, ranging from the transitional Mushabian to a phase probably roughly contemporary with the Qarunian.[132] At present no early Neolithic remains have been found in the area only the late Neolithic Omarian (4600 to 4000 cal BC), although it is possible that they remain to be discovered. The Neolithic settlements of El-Omari are located at the strategic position of the ancient apex of the Delta (see Fig. 1) in and around the Ras el-Hof, a hilly area cut by wadis overlooking the floodplain in the area of Helwan.[133] The inhabitants made great use of the various active wadi systems, leaving potsherds and lithics behind, whilst generally avoiding the floodplain, although this was the probable location of their fields.[134] Similar material has been found all the way down to Wadi Gerawi.[135]

The main site or cluster of sites at Merimde Beni Salama, the core of the modified environment cover(s) ca. 24 hectares of the Wadi el-Gamal fan, which overlooked the Nile floodplain. There was settlement shift over both space and time on this wadi fan resulting in five distinct chrono-stratigraphic layers; these have been divided into three phases (Layer I – Phase 1, Layer II – Phase 2, and Layers III-V – Phase 3, which cover the whole of the fifth millennium cal BC).[136] The rich environment of the Nile floodplain was a location where pigs could be herded, wildlife hunted, plants gathered, and agricultural fields located. However, the Wadi el-Gamal – located just to the southwest of the main site – appears to also have been part of the operational environment, where raw materials and plants were collected, ovicaprines herded in semiarid pasture lands and wild animals hunted amongst the wadi vegetation. In this larger

124 Pennington, Bunbury, and Hovius 2016, 203–204.
125 Hassan, Tassie, et al. 2006; Phillipps, Holdaway, Ramsay, et al. 2016.
126 Holdaway, Phillipps, Emmitt, et al. 2016.
127 Holdaway, Phillipps, Emmitt, et al. 2016.
128 Shirai 2012; Shirai 2015.
129 Holdaway, Phillipps, Emmitt, et al. 2016.
130 Linseele, Holdaway, and Wendrich 2016, 9.
131 Tassie 2014, 107–109.
132 Tassie 2014, 107, 110.
133 Tassie 2014, 221–227.
134 Tassie 2014.
135 Tassie 2014, 220.
136 Eiwanger 1992.

modified area that includes the slopes of the Wadi el-Gamal, there where semi-permanent structures, hearths, pits, and graves. Therefore, the Neolithic settlement seems to have consisted of a core area gradating into the operational environment, which form the "site catchment area" from which most of the objects found on the site derived. Outside of the site catchment area was the geographical environment. This more marginal area on the floodplain and Wadi el-Gamal would have been more sparsely used, and may have been utilized/settled by a segment of the community either during certain periods of the year, or possibly to undertake certain activities throughout the year. The catchment area of Merimde Beni Salama covers at least 50 to 60 hectares.[137]

As with the earliest Neolithic occupation at Sais, Merimde Layer I has a high blade index. Recent survey work undertaken in the nearby Wadi el-Gamal has indications of a late Epipalaeolithic industry, possibly dating to the second half of the seventh millennium to the first half of the sixth millennium cal BC consisting of blades, bladelets, flakes and microburins.[138] However, more work remains to be done in this area of the Wadi el-Gamal to define further this industry, as it is also possible that it is another, earlier expression of the Phase 1 Neolithic industry. The finding of a Helwan point, usually associated with Epipalaeolithic industries[139] in Merimde Layer I[140] strengthens the likelihood of an Epipalaeolithic presence in the region, for this side-notched and tanged point, like the Middle Palaeolithic Levallois point found by Junker in Grid Square S7 at a depth of 2.20 m (now in the Medelhavsmuseet in Stockholm (MM12107)), may have been collected by the Neolithic inhabitants from the terraces of the Wadi el-Gamal.[141]

The site of Sais is located in the west central Delta, with the Neolithic settlement situated on a sandy silt hill with a river branch just to the west. This location would have been above the annual flood. Although no Epipalaeolithic finds have been made at Sais, the Early Neolithic (Sais I) has a high blade index,[142] which seems to indicate that it evolved out of a local culture, rather than being brought in by Levantine Pottery Neolithic emigrants. The material remains found at Sais resemble those of Merimde Beni Salama, and includes Egypto-Levantine pottery, including some with herringbone design, bifacial concave-based arrowheads, polished axe heads, and denticulated bifacial sickle blades. Settlement remains include postholes, hearths and pits in Layer IB, whereas IA seems to be a fish bone midden, the analysis of which indicates fish exploitation in different seasons.[143]

Although all the Neolithic sites in Lower Egypt are located in different areas and within different environmental settings, the one thing that they all have in common is that they are located on elevations higher than the waters of the annual inundation, although the settlements may have shifted due to changes in the local environment. Wilson suggests that other Neolithic sites may be found on the large sand ridge in the center of the Delta.[144] For this ridge would have provided an excellent location above the floodplain. At all these sites heavy core tools, such as polished axe heads, bifacial axe heads, bifacial hatchets, hammer axes, and bifacial hoes attest to environmental modification or ecological engineering. Also found at all the sites are heavy quartzite grinding stones, both upper and lower.[145] The major source for quartzite is Gebel el-Ahmar (14 km north of El-Omari), although other sources exist in the Western Desert,[146] and Caton-Thompson and Gardner suggest that the Faiyum examples could have come from the local scarp.[147] However, although shared cultural traits are indicated by artefact types, if a shared origin for the quartzite could be demonstrated, this may indicate a greater interconnectedness between the Neolithic sites than previously thought. Elemental analysis has indicated that there was also probably movement of pottery or clay between the sites.[148] Another instance of interconnectivity is indicated by the source of flint used to make tools at Sais appears to be the Western Delta edge, possibly in the region of Merimde Beni Salama. Both longitudinal and a transverse movement through

137 See Rowland this volume, and Rowland 2020, 73.
138 Rowland and Tassie 2014.
139 Shirai 2002; Shirai 2011.
140 Eiwanger 1984, I.1106.
141 Rowland and Tassie 2017.
142 Wilson 2006; Wilson, Gilbert, and Tassie 2014.
143 Wilson, Gilbert, and Tassie 2014.
144 Wilson 2006, 111.
145 Caton-Thompson and Gardner 1934, 87; Debono and Mortensen 1990, pl. 30–31; Eiwanger 1984, pl. 67–69; Rowland 2015, 39; Wilson, Gilbert, and Tassie 2014, 85–90.
146 Aston, Harrell, and Shaw 2000, 53; R. Klemm and D. D. Klemm 2008, chapter 6.
147 Caton-Thompson and Gardner 1934, 87.
148 Emmitt 2017.

the Delta by waterborne transport would have been relatively easy due to the multichannel, anastomosing character of the Nile during this period.[149]

In the Faiyum, and Helwan (El-Omari), it appears that there was an Epipalaeolithic population present in the areas before Neolithisation occurred, this was also possibly the case at Merimde Beni Salama as well.[150] The high blade index in the early Neolithic of both Merimde and Sais, and probably the Faiyum[151] seems to indicate that it was local forager acculturation, rather than an influx of Levantine farmers or enclave migration. This does not mean that a few Levantine farmers did not live at these sites, but that the majority were originally local foragers. The Omarian in the Helwan area was probably the result of enclave migration as there is no early Neolithic phase and the mixed farming practices seen at the site are fully developed. Domesticated ovicaprines appear in the Early Faiyumian;[152] this could be the result of the indigenous population meeting bifacial using herder-gatherers coming in from the Western Desert who were escaping the increased aridity.[153] Groups from the Western Desert may already have seasonally been visiting the Faiyum and places in the Nile Valley and so were familiar with the locales and people. The result was that the late Epipalaeolithic population became low-level food producers with domesticates, thus optimizing their subsistence strategies that until then had been primarily based on hunting, fishing and foraging.[154] The transition to herding is not just a matter of incorporating a few animals into the daily activities of hunter-gatherers, but a change in the mind-set from one of trust and being part of nature to one of control and care of animals.[155] The late Faiyumian may have been the result of the unforeseen transformative effects caused by using bifacial tools and herding animals, for when they came into contact with people using mixed farming practices, they were more willing to accept these new practices and incorporated the small-scale cultivation of wheat, barley, and flax and also added a few pigs.

The sites of Merimde Beni Salama, El-Omari and Sais all have a high proportion of pigs in the faunal remains.[156] The presence of pigs, along with a high percentage of domestic crops, seems to indicate that the communities at these sites were sedentary mixed farming communities.[157] Although there were activities that required a percentage of the community to be mobile (e.g. stone collection, seasonal foraging), it appears that their lifestyle was one that involved a year-round cycle of productive activities. Although pigs are recorded in the Late Faiyumian, they occur in lower percentages, which seem to reflect the less permanent and more mobile nature of the occupation in the Faiyum Depression. High percentages of piscine remains have been found at all the Lower Egyptian sites, but particularly in the Faiyum and Sais. This is not surprising as they were all located close to large bodies of water, and so continued some of their hunter-gatherer-fisher economic activities. The Faiyum Neolithic community can best be described as low-level food producers, utilizing subsistence strategies that included aspects of both food procurement and food production.[158] Wild mammals only constituted a small percentage of the animal remains at all the sites, which indicate that it was only a minor activity.[159] Although a degree of mobility is recognized at all these Lower Egyptian sites, mobility and sedentism are not dichotomous states. All groups to certain extents utilize both strategies at some scale, and as such, they should be seen as complementary, rather than oppositional strategies.[160]

Lower Egypt was not colonized by Levantine farmers who transported their whole way of life into the deltaic environment, including their rectangular mudbrick houses. The Neolithisation process consisted of a small movement of people and a staggered flow of objects and domesticates. Northeast African architecture of the fifth millennium cal BC and before generally consisted of round dwellings constructed of wooden posts with the walls and roofs made of organic material, such as reeds, or hides. Seasonal settlements have been found at Kerma that comprise a series of postholes, pits and hearths, which belonged to a pastoral community

149 Pennington, Bunbury, and Hovius 2016, 203.
150 Rowland and Bertini 2016.
151 Holdaway, Phillipps, Koopman, et al. 2017, 96.
152 Linseele, Van Neer, et al. 2014.
153 Shirai 2013.
154 Phillipps, Holdaway, Wendrich, et al. 2012.
155 A. B. Smith 2013.
156 Wilson 2006; Wilson, Gilbert, and Tassie 2014; Yokell 2004.
157 Linseele, Van Neer, et al. 2014, 19.
158 Holdaway, Phillipps, Emmitt, et al. 2016.
159 Linseele, Van Neer, et al. 2014; Yokell 2004.
160 Stone 1999.

Fig. 2 A pit in test trench K1b at Merimde Beni Salama and examples of objects from the settlement, but not from this context. The change to a semi-sedentary or sedentary Neolithic lifestyle and economy required several adjustments, but there was particularly a reliance on a wide resource base in the early phase. Clockwise from top left: a bone awl, concave-based arrowhead, tanged arrowhead, and a catfish vertebra.

dating to ca. 4500 BC.[161] Slab structures made from stone have been found in some of the oases, such as Dakhla and Farafra, but evidence for similar structures are absent in the Nile Valley.[162] Series of postholes indicating circular structures have been found at all the Delta sites, although not in the Faiyum.[163] At Merimde Beni Salama, the largest of the Delta sites (given the current state of evidence), there were both permanent and semi-permanent circular and oval dwellings, rubbish pits, mud and basketry lined silos, large pottery vessels placed in pits, hearths, and possible threshing floors consisting of shallow circular depressions lined with spiral matting (see Fig. 2). Some of these structures appear to have been organized in streets.[164] In the upper layers packed mud oval structures, probably with a reed or hide upper section appeared.[165]

Many Neolithic sites in the Levant were located in the alluvial mouths of wadis and had rectangular structures built with mud-bricks; they also consisted of pits and hearths, and had many grinding stones, along with other typical Neolithic objects. The repeated rebuilding of settlements in these favorable locations soon led to the build-up of mud-brick remains mixed with mud-brick wash, alluvium and other sediment, creating in some instances huge tells.[166] During the middle PPNB (10 300 to 9500 cal BP) many large sites emerged, growing to between seven and 12 hectares, mainly in the eastern part of the southern Levant, although there were smaller sites of between 0.1–0.5 hectares, located in the steppe and near the coast, however most sites only covered three to four hectares.[167] Compared with the site of Merimde Beni Salama, the core settlement area of which covers 24 hectares and the operational area 50 to 60 hectares, these sites cover a relatively small area. At present, it is uncertain if it was one large community settlement or several aggregated communities, although the latter seems more likely. The earliest settlement is unlikely to have covered the entire area, as it is only encountered in certain parts of the site. There appears to be settlement shift over time, where burials were placed in disused areas of the settlement.[168] Two types of abandonment could cause this: community abandonment or household level abandonment, and this may be seen as a strategy of resituating, both socially and ecologically, and perhaps even ideologically. The changes that occur in households can be due to changes in the domestic set-up or demographic shifts, which make it advantageous to change the architectural units in which they lived. Unlike rectangular buildings, which can have rooms added on to them when sons or daughters start their own family, circular

161 Honegger 2001.
162 Tassie 2014.
163 See Phillipps, Holdaway, Emmitt, et al. 2016; Tassie 2014.
164 Tassie 2014, 208.
165 Tassie 2014, 200, 205, 208, 215.
166 Verhoeven 2004.
167 Goring-Morris and Belfer-Cohen 1997, 83–85; Verhoeven 2004.
168 Tassie 2014, 202.

dwellings require a new or a whole new group of residential units to be built, possibly recycling old building materials from the previous structure. Environmental reasons may also make it expedient for whole communities to move, not necessarily very far, just far enough away from the threat.[169] At Merimde, this dispersed village grew horizontally, as well as vertically, but due to the typical African nature of the villages – both socially and architecturally – the build-up of the settlement layers was not as dense and thick as those found in the Levant.

Unlike Nubia and Middle Egypt, large separate cemeteries with well-provisioned graves have generally not been located in Lower Egypt. Although the graves of these Lower Egyptian communities generally did not contain numerous grave goods, at Merimde Beni Salama, *Aspatharia* sp. shells occur in adult burials, and amulets have been discovered in graves of children. However, at El-Omari several separate cemeteries (usually in disused areas of the settlement) were discovered, and grave goods were more common, including the earliest scepter. Over and around some of the graves there appears to have been organic structures built, and in one of the earliest cemeteries large stone tumuli were built over the graves. The variations in the grave goods at El-Omari seem to indicate an early form of social inequality and ranking.[170]

The decisions made by the Lower Egyptian Epipalaeolithic communities had a range of unintended consequences that changed their range of choices – a process of emergent causation – so that once-optional additions to the hunter-gatherer lifestyles became obligatory parts of farming.[171] In these sedentary mixed farming communities in the Delta, there was an emergence of a new sense of place, arising through the various subsistence activities, with convivial and emotional engagements between people, things, and landscapes. Communal ceremonies and rituals took place that bound the groups together and gave them a sense of identity, leaving behind objects such as the Merimde head (Cairo Museum, JE97472). Polished axe heads and mace heads appear from the earliest levels at Merimde Beni Salama, and increase over time and although these could also be utilitarian objects,[172] the use of miniature polished axe heads as pendants emphasizes their role as prestige items (see Fig. 3). Long-distance exchange networks helped to bring in objects that also promoted the development of social inequality.

The timing of the process is still being refined, with the current radiocarbon dates suggesting that mixed farming practices started at Merimde Beni Salama ca. 5000 cal BC and in the Faiyum at 4650 cal BC.[173] The radiocarbon determinations for the Faiyum are modern AMS measurements with low $^{14}C + 1\sigma$ variances,[174] whereas those for Merimde were, until recently, only based on conventional radiocarbon measurements, often reported with $+ 1\sigma$ counting variance of $< 100+$ years.[175] The lithic toolkit from Merimde Layer I when compared to that from the Faiyum and elsewhere seem to indicate that the current dates of ca. 5000 cal BC are probably too young. Although new AMS dates have been obtained, a complete stratified sequence of dates needs to be taken, and this will hopefully refine the current dates.[176]

7 Conclusions

Although the process of Neolithisation and the use of the term Neolithic has been questioned when using it in an African context,[177] as Barker notes, it is a useful term to describe the socioeconomic transformations that occurred in the early to mid-Holocene,[178] particularly as nobody has proposed a better terminology. Recent research is showing that there was a great variety of ways that the various communities in North Africa became food-producers.[179] Although many of the food-producing communities in North Africa do not fit comfortably under the normative term Neolithic, they were food-producing societies well-adapted to the North African environments, often using the Neolithic tool kit of pottery, polished axe heads, bifacial arrowheads and certain objects of bodily adornment.

169 Stone 1999.
170 Tassie 2014, 195–241.
171 Robb 2013.
172 Eiwanger 1992, fig. 21.
173 Tassie 2014.
174 Wendrich, Taylor, and Southon 2010.
175 See Rowland, this volume.
176 See Rowland this volume.
177 See A. B. Smith 2013.
178 Barker 2013.
179 Garcea 2004; Lucarini 2013.

Fig. 3 Power objects: left= polished axe head from Merimde Beni Salama (Medelhavsmuseet MM11803); right= pear-shaped mace head (Medelhavsmuseet MM15538).

The process of Neolithisation in Northeast Africa can be compared to that of Europe in many ways. The timing and the original causes are very similar. It was not until changes in farming practices had occurred in the Fertile Crescent that a greater number of domesticates started to spread from their core area. The different societies in both North Africa and Europe had to be amenable to accepting new economic regimes (although often supplemented by hunting, fishing, and gathering) and the plants and animals had to be adaptable enough to thrive in the various environments. In Africa the introduction of the different components of the Neolithic appear to have been phased, for herding seems to have been the earliest food producing activity in the Eastern Sahara ca. 6100 cal BC, followed later by mixed farming in Lower Egypt and also in northern Morocco (probably introduced from southern Spain) ca. 5000 cal BC. This Second Neolithic Revolution was aided by changes in the climate around the Mediterranean Basin. However, the different environmental and sociocultural conditions present in Europe and Northeast Africa resulted in the adoption of Neolithic things and techniques in various ways. In the Nile Delta domesticates only arrived after the riverine regime became more favorable to the Neolithic way of life. The means by which it spread through the two continents took many different forms and had many differing socioeconomic motivations. The process of Neolithisation was not a transplanting of a complete way of life, Levantine Neolithic villages did not spring up in either North Africa or Europe, but elements of the Neolithic steadily spread, whether they were organic or inorganic. These objects were initially subsumed into already existing socioeconomic systems; through continued use of the objects and the care of domesticated animals and plants, these original systems irrevocably changed.

Recent research into human genetics is showing that there were several migrations from the Levant into Europe, with a constant flow of people and practices on a local level, but the actual amount of immigration from the Near East was minor in the seventh and sixth millennia cal BC, and there was substantial adoption of farming by indigenous groups in many parts of Europe.[180] This is very similar to the results of archaeogenetic research into Levantine movements of people into Northeast Africa, which show that there were multiple migration events, including a steady trickle of people in the seventh and sixth millennia cal BC. However, it appears that there was a considerable adoption of agriculture and pastoralism by the pre-Neolithic Northeast African populations.[181]

Although the Second Neolithic Revolution would not have been possible without the first, it was this second revolution that spread food-producing practices across a larger geographical area, and arguably had a greater impact on subsequent sociopolitical developments throughout the Mediterranean Basin. The Neolithic subsistence strategies of much of North Africa were based on pastoral activities, particularly the herding of cattle and ovicaprines. However, the Neolithic of

180 Hassett 2017; Robb 2013; Soares et al. 2010.

181 A. B. Smith 2013.

Lower Egypt shows greater similarities with that of the Near East and Europe. The development of these primary agricultural communities in northern Egypt was probably due to their proximity to the Levant. However, there were contacts between the distinct societies of the north and the south, and these meetings included the exchange of materials and technology that facilitated the construction of new social environments and the southward spread of new agropastoral subsistence strategies, and this was a key factor in laying the foundations for the sociopolitical developments observed in the fourth millennium cal BC. However, as Stevenson[182] notes, there was no neat, linear evolutionary trajectory that lead to the formation of the first nation state ca. 3060 cal BC, but it should be seen as a more syncopated phenomenon, characterized by periods of political experimentation and shifting social boundaries. Although there was increasing inequality from at least 5000 cal BC, there were "overlapping clusters of development, the location and nature of which ebbed and flowed across the centuries as the scale and, significantly, the orientation of social assemblages was negotiated".[183]

182 Stevenson 2016.

183 Stevenson 2016, 425.

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1 Adapted from Butzer 2002, 4.5; Bunbury et al. 2017, 78. **2** The images on the left are Courtesy of the Egyptian Collection, Heidelberg Center for Cultural Heritage (University of Heidelberg, top 1062, bottom 3190) and on the right Courtesy of the Medelhavsmuseet, Stockholm (top MM15673, bottom MM32881). The image of the pit is courtesy of J. Rowland/Egypt Exploration Society. **3** Medelhavsmuseet, Stockholm.

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