3 MATERIAL AND METHODS

3.1 Description of the study site

The Selous-Niassa Wildlife Corridor (SNWC) lies in southern Tanzania and is located north of Niassa Game Reserve in Mozambique. The Ruvuma River, the international boundary between Tanzania and Mozambique, separates the Corridor from the Niassa Game Reserve. The Corridor lies within the administrative unit of Ruvuma Region in the two Districts of Songea Rural, now renamed Namtumbo (major western section of SNWC) and Tunduru (smaller eastern section of SNWC). In total the SNWC covers approximately 6,000 – 8,000 km^2 and extends approximately 160-200 km in north-south direction.

The area is mostly covered by miombo woodland and wooded grassland, and there are substantial areas of open savannah, seasonal and permanent wetlands and riverine forests along numerous rivers and streams. The Corridor receives rain during a single period from late November to April and May with an average of 800 – 1,100 mm per year. The Songea-Tunduru road via Namtumbo and Kilimasera forms the watershed between the northern and southern sections of the Corridor. The Mbarangandu River and its tributaries drain towards the north into the Selous Game Reserve towards Kilombero and the Rufiji River system. In the southern section, rivers such as Sasawara, Lukimwa, Nampungu and Msangesi drain into the Ruvuma River.

The landscape consists of plains, valleys, undulating topography and Inselberg Mountains at altitudes between 400 m at the Ruvuma River and 1,283 m in the Mtungwe Mountains. The most important ranges are Mtungwe (1,283 m), Changalanga (901 m) and Kisungule (688 m) mountains; other prominent ranges occur in the southern section of the Corridor.

There are 17 villages in the northern section of the SNWC of which 9 villages are directly linked with the corridor (Table 1) and the rest forms a continuous buffer with the SGR. Most of their land is currently managed by a series of Wildlife Management Areas (WMAs) run by the local people as part of the SGR buffer zone project guided by the Wildlife Division and GTZ's community based conservation (CBC) programme. In the southern section of the SNWC are 13 sparsely populated villages where WMAs do not currently exist and (with the exception of the Sasawala Forest Reserve) other forms of protection are currently not available (Figure 2).

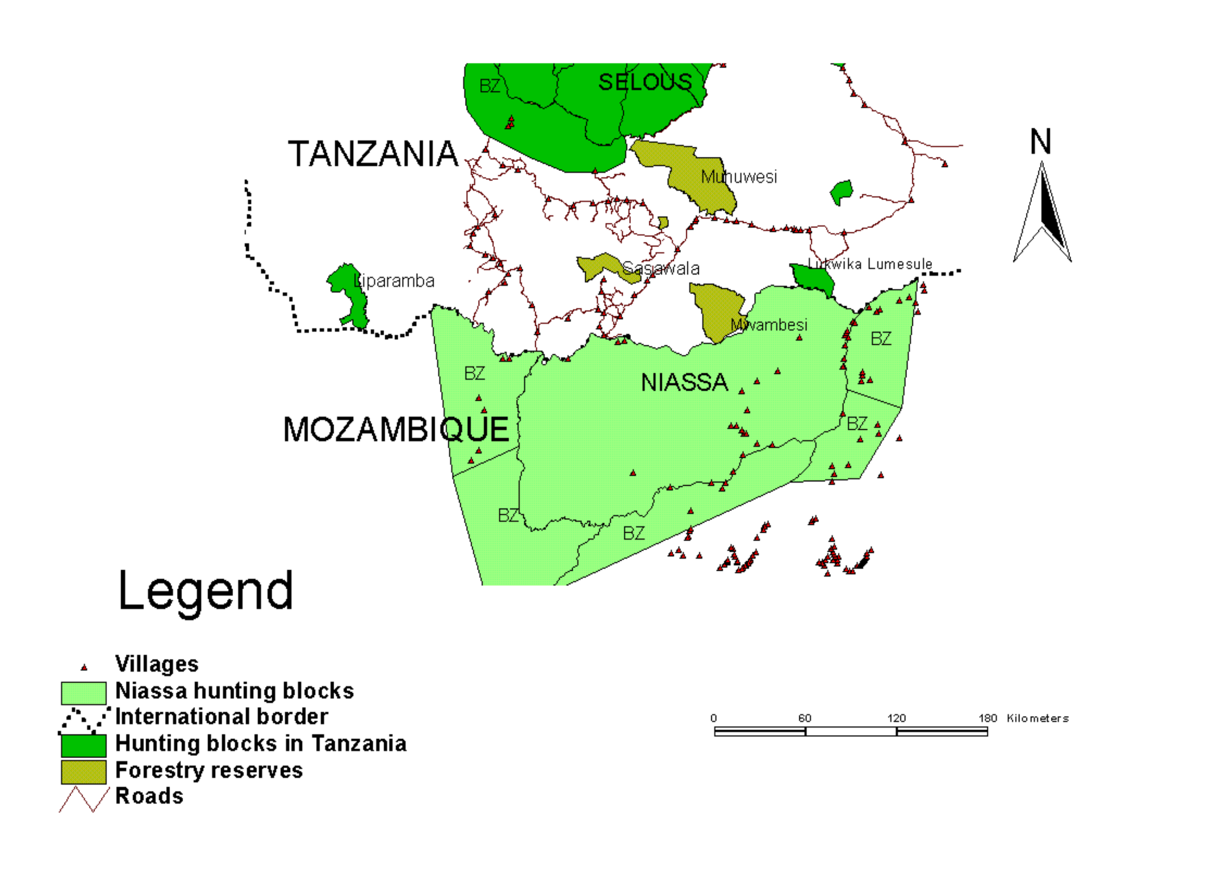

Figure 2: The distribution of villages and roads in relation to the protected areas in and around the Selous-Niassa Wildlife Corridor in Tanzania and Mozambique. BZ: buffer zones around Selous are separate from the Game Reserve, around Niassa are part of the Game Reserve.

Each village owns or has been allocated village land, some of which may cover large areas of dozens of square kilometres. By including the majority of villages from both sections of the SNWC, the study aims to obtain a representative picture of wildlife issues affecting local communities throughout the Corridor.

This study used state-of-the-art techniques such as GPS/ARGOS satellite transmitters for remote tracking of elephants, and advanced methods to assess their health status. In a novel way, it combined such advanced technology with a distinctly low technology approach by involving local personnel based in study villages to gather basic ecological data. Data were also collected by conducting public village meetings, through standardized personal interviews using questionnaires and from field observations during extensive field trips. Other sources of information were reports from district and regional game and livestock offices, and the monthly field patrol reports from village game scouts, including villages from the southern part of the Corridor.

3.2 Public village meetings

Village meetings were conducted in order to

- Obtain baseline information on the presence or absence of key wildlife species on village land as perceived by local communities;
- Obtain baseline information on the type of crops grown and livestock kept in the proposed wildlife corridor;
- Get an idea of the extent of the damage inflicted by wild animals on local people and their properties (crops and livestock) and the views of local communities on potential conflicts with wildlife species;
- Record local people's view on wildlife, current local methods of wildlife utilization and their attitude towards wildlife conservation.

Meetings were conducted using a participatory approach with elders and the most influential people in the village. The village officials (the village executive officer or chairperson) selected the interviewees. At least 20 people were involved; in some villages (Amani, Marumba / Morandi and Misiaji), the entire village participated. Prepared questions were read out in Kiswahili and discussed. Responses were summarised and entered into data sheets**.** Table 1 lists details on villages where public village meetings were conducted.

3.3 Individual questionnaire-based interviews

Individual questionnaire-based interviews were conducted to obtain more detailed information on local wildlife issues, particularly

- The presence or absence of key wildlife species on local village land;
- Possible migratory habits of wildlife, seasonality of presence, and traditional migratory routes of elephants and other migratory mammals on local village land;
- Conflicts between local people and wildlife, particularly elephants;

- Plant species that elephants might prefer as food plants and the timing of their fruiting or peak maturity in relation to elephant movement and/or possible crop raiding activity.

In each village, the VEO or the village chairperson selected, organised and arranged the venue for structured individual interviews using questionnaires. Five people were interviewed per village: the VEO or the village chairperson, two elders familiar with the village land and its boundaries, a traditional hunter and a teenager. Data were collected by direct approach. Questions were read out in Kiswahili and the answers given by the respondent filled in the questionnaire data sheet. Table 1 lists details of the villages where structured interviews were conducted.

Additional information on the number and distribution of different wildlife species were obtained from the aerial census report conducted at the same period by the Conservation and Information monitoring Unit of the Tanzania Wildlife Research Institute (CIMU, 2001).

Table 1: Details of villages in the study area where village public meetings, individual questionnaire surveys and field observations were conducted. Villages along the north of the Songea-Tunduru road belong to the northern section of the Selous Niassa Wildlife Corridor (SNWC), villages south of the road to the southern section of SNWC.

#	Village	District	Section of SNWC	Village meeting	Inter-view	Field observations on village land	Village included in wildlife management area scheme?
1	**Ligunga**	Songea	South	✓	✓	✓	No
2	**Msisima1**	Songea	South	-	✓	✓	No
3	**Matepwende1**	Songea	South	-	✓	✓	No
4	**Magazini**	Songea	South	✓	✓	✓	No
5	**Linguseguse**	Songea	South	✓	✓	✓	No
6	**Amani**	Songea	South	✓	✓	✓	No
7	**Milonji**	Songea	South	✓	✓	✓	No
8	**Lusewa**	Songea	South	✓	✓	✓	No
9	**Mteramwahi**	Songea	South	✓	✓	✓	Yes; in SCP/CBC
10	**Songambele2**	Songea	North	-	✓	✓	Yes; in SCP/CBC
11	**Mchomoro2**	Songea	North	-	✓	✓	Yes; in SCP/CBC
12	**Kilimasera2**	Songea	North	-	✓	✓	Yes; in SCP/CBC
13	**Marumba**	Tunduru	South	✓	✓	✓	No
14	**Morandi**	Tunduru	South	✓	✓	✓	No
15	**Misyaje**	Tunduru	South	✓	✓	✓	No
16	**Ndenyende**	Tunduru	South	✓	✓	✓	Yes; in SCP/CBC
17	**Mbatamila**	Tunduru	South	✓	✓	✓	No
18	**Hulia2**	Tunduru	North	-	✓	✓	Yes; in SCP/CBC
19	**Darajambili2**	Tunduru	North	-	✓	✓	Yes; in SCP/CBC
20	**Namwinyu**	Tunduru	North	✓	✓	✓	Yes; in SCP/CBC
21	**Namakungwa**	Tunduru	North	✓	✓	✓	Yes; in SCP/CBC
22	**Nampungu**	Tunduru	South	✓	✓	✓	No

Note: [1]Villagers unwilling to conduct a public meeting, [2]Village meeting not conducted, the villages already run the community based conservation (CBC) programme organised by the Selous Conservation Programme (SCP/GTZ)

3.4 Field observations

Direct field observation was conducted on village land of villages where WMA have not (yet) been put into practise (Table 1). The purpose of these observations was to

- Record encounters with and signs (tracks, faeces, carcasses) of key wildlife species to provide information on relative abundance and distribution of wildlife, particularly in the southern section of the Corridor;
- Locate traditional movement routes of elephants and other large mammals in the Corridor;
- Identify key food plant species for elephants and relate their fruiting or peak maturity with elephant movement and / or crop raiding activities;

- Locate human activities such as logging, bee keeping, poaching, and fishing.

Excursions were made to remote areas of village land to confirm information previously recorded in the public meetings and individual questionnaire-based interviews. Animal signs such as footprints, faeces, feeding sites, or den holes were observed and entered in a field observation book. Plant species reported to be selected by elephants as food were identified, collected and stored for future identification. The exact locations in fractions of degrees latitude and longitude of tracks and movement routes for large mammals such as elephants were noted and recorded using hand-held Global positioning system (GPS) devices (Garmin Olathe, Kansas USA). If a group of elephants or other key wildlife species was encountered, the GPS position was noted and total group size, mother/calf ratio and adult sex ratio were recorded. Signs of human activities such as logging, bee keeping, poaching, and fishing was documented wherever they occurred and their GPS location and extent noted. The "density" of elephant signs per kilometre transect traversed by foot was calculated as described by Sundaram et al. (2003). Direct observations of elephants and other wild animals were recorded as and when they occurred. For each participating village, excursions took a minimum of two days and were accompanied by one or two traditional hunters or any other guide familiar with the village borders, porters and a game scout from the respective district.

3.5 Field patrols by village game scouts

To understand more about the population and distribution of key wildlife species, particularly elephants, village game scouts and game officers where WMA has been in practise were furnished with field patrol data sheets to record location, group size, group composition and group structure of key mammalian species encountered during field patrols. By involving scouts from several villages, a larger area was covered than could have been a single person, thus sample sizes were increased and data became more representative. This also provided an opportunity to test whether such data might be a reliable basis for a low cost effective population monitoring system.

3.6 Crop damage, human and livestock injuries or death

Data on crop damage and other conflicts inflicted by wild animals on local people and their property were retrieved from village monthly crop damage reports, district and regional annual reports, including reports from periods before and after the establishment of WMA in some villages. Information on the type and number of domestic livestock injured or killed by wild animals was collected from district and regional game offices. This will provide a longer-term view of the trends in conflicts between people and wildlife.

3.7 Elephant immobilization and radio-collaring

3.7.1 Capture procedures

The overall capture operation was organised in two operational teams. The capture or darting team was composed of a veterinarian responsible for darting, trekkers (traditional hunters and game scouts familiar with the study area), and three safety personnel equipped with .500, .458 and .375 rifle and VHF radio. The second team or back up team was composed of additional veterinarian/s, biologist/s, game officer, and additional guards armed with .375 rifles, and porters. This group was responsible for carrying the radio-collars, first aid kits (for members of the team and the elephants), VHF radios to maintain contact with the capture team, instruments for monitoring anaesthesia and all necessary equipment for procurement of biomedical samples.

The capture operations was organised in three different periods, the first two periods which took place from late August to early September 2000 and November 2001 were aimed at radio-collaring and assessment of elephant health and reproductive status. The third period, which took place in October 2002, was aimed at removing the radio-collars. During the first capture period, scouting and trekking of elephants was performed by foot. When trekkers found fresh signs (spur, dung or recently destroyed food plants) the teams followed the ensuing elephant trail. Once spotted, elephants were approached under cover from downwind and darted at a distance of about 20-30 meters. However, the second and third capture periods were performed with the assistance of the helicopter. During these periods, the organisations and roles of the capture teams remained unchanged, although the number of trekkers and security personnel was reduced and no porters were required. All the scouting process and ferrying of heavy equipments was performed by helicopter. During the second capture period, more attention was paid to the southern section of the corridor in order to expand the distribution of radio-collared individuals. The shape of the lumbar region was subjectively used to assess the physical conditions of the elephants as described by Albl (1971)

3.7.2 Delivery systems and immobilizing drugs

Throughout the capture operation, a knock-down dose of the immobilizing drug was administered according to the main age group, as suggested by Kock MD et al. (1993), Kock RA et al. (1993) and Hoare (1999a) to induce rapid recumbency and limit the animal’s post-darting movements. In addition, 3 to 4 drops of thermo-stable, tissue-accelerant compound (an experimental substance supplied by Prof. Henning Wiesner, Munich, Germany) was added to the dart to increase the rate of drug absorption and hence the speed at which immobilization and neuroleptoanalgesia would take effect. Stresnil was included during the first period to prevent pink-foam syndrome as a certain degree of excitement and stress was expected during approaches on foot. The ducts of all needles were covered by a silicone cap to prevent leakage during scouting and subsequent trekking. Either a capture gun (Parker Hale) or a dart gun (Dan-Inject) was used to administer the immobilizing drug mixture remotely. Etorphine hydrochloride (M99, C-Vet Ltd.) was the principal immobilizing drug and a dosage of 10 to 12 mg of M99 was used for females and 12 to 15 mg for bulls (Table 2).

Table 2: Estimates of dosage for immobilization of elephants. (Etorphine was available at a concentration of 9.8mg/ml, and Azaperone at a concentration of 40 mg/ml).

Size class	Etorphine (mg)	Azaperone (mg)
Large adult bull	15	40
Moderate adult bull	12	40
Adult female	10-12	40
Calves	5	40

M99 was combined with 40 mg of Azaperone (Stresnil^R, Janseen-Cilag, Neuss, Germany) irrespective of the elephant's size. Anaesthesia was terminated by intravenous injection of a reversing agent (Naltrexone-HCL, Trexonil™, Wildlife Laboratories Inc., USA) or Diprenorphine (M5050) to accelerate the animals' recovery.

3.7.3 Monitoring of anaesthesia

Once the animal was successfully darted, it was followed cautiously until it went into recumbency. The various body measurements were taken as described by Whyte, 1996 and the age category estimated as described by Du Toit (2001). The following definitions were adopted when referring to time events at different stages of immobilization and neuroleptoanalgesia. The time to first effect was the interval between the administering of an immobilizing agent and the first observed immobilization effects such as slowing of pace, tail flaccidity, and separation from the herd. It is a common phenomenon for the darted elephant to stand still soon after it has lost control of its trunk (Raath 2003). Induction time was the interval between administering an immobilizing agent to the point at which the depth of immobilization was sufficient to cause recumbency. Recovery time was the interval from administering the antidote until the animal stood again. Total down time was measured from the moment when the animal went into lateral recumbency until the time when it stood up. Neuroleptoanalgesia was judged to be ineffective when frequency and strength of trunk and ear movements increased.

3.7.4 Haematology and blood chemistry

Blood for haematology and clinical chemistry was collected from the ear vein within 10 minutes of lateral recumbency, in vacutainer tubes (plain, EDTA, heparin and NAF tubes). These were kept at 4°C in a portable cool box. Plasma and serum separations, haemoglobin (Hb) and haematocrit (PCV) measurements were performed at the camp not later than six hours after the samples were collected from the field. Blood stabilized in EDTA was used to assess PCV and Hb concentration and to determine the number of red and white blood cells using standard methods as described by Coles (1986). PCV was measured by the micro-haematocrit method using a portable battery-operated micro-haematocrit centrifuge (Microspin,® Bayer, Germany) in which the PCV was read without removing the micro-capillary tubes. The acid haematin method was used to measure Hb concentration (Coles 1986). This method depends upon converting haemoglobin to acid haematin by using dilute hydrochloric acid. The resulting brownish yellow mixture is matched with a standard in a comparator. To determine the total white blood cell count, 50 µl of EDTA blood was mixed with 950 µl of Tuerk solution, while blood for the total red blood cell count was prepared by mixing 4 ml of sterile isotonic (0.85 N) solution with 20 µl of EDTA blood as described by Benjamin (1986). Both preparations were stored at 4°C until final analysis was done within 14 days at the SUA Faculty of Veterinary Medicine, Tanzania. Blood stabilized in heparin, NaF and in plain tubes was used to extract plasma and serum. After extraction, serum and plasma was deep frozen in liquid nitrogen for transportation to Germany. Blood samples stabilized in NaF were used to extract plasma in which glucose concentration was determined. Serum and plasma from blood collected in plain and heparin tubes was used to measure various clinical chemical parameters and sero-prevalence to various pathogens of veterinary and public health importance. With the exception of PCV and Hb (measured in the field) and red blood count and white blood count values (measured at SUA), all clinico-chemical parameters were determined using an automated analyser-Hitachi 747-400 or Hitachi 917-Japan (Roche-Germany). An accredited laboratory, the Labor für Medizinische Chemie und Serologie GmbH, Berlin, Germany, analysed the clinico-chemical parameters.

3.8 Satellite-based radio-tracking of elephants

In addition to observations of elephant signs and groups encountered incidentally in the field as described above, elephants were also located using a GPS device and a hand held Yagi antenna and telemetry receiver (Telonics, Arizona, USA) that received the VHF signal of the GPS/ARGOS transmitter system (See below). The GPS locations recorded in the field were later downloaded to a laptop computer using Fugawi software (Northport System, Canada) and then exported to a Geographical Information System (GIS) computer program (Arc View 3.2a). The bulk of elephant location data came from satellite-based remote tracking of elephants using the fitted electronic devices (Telonics, Arizona, USA) that included

- A GPS receiver for highly accurate records of the latitude and longitude of the elephant's location at pre-set intervals to an accuracy of better than 100m;
- An ARGOS satellite communication unit that broadcasted the GPS records to the low-orbit ARGOS satellite at regular, pre-set intervals, and thus enabled the remote downloading of location data;
- A VHF component that permitted elephants to be located using conventional radio-tracking techniques (over distances of 3-4 km on the ground or up to 40km using aircraft).

The ARGOS satellite received information broadcasted by the elephant collar and passed all information to the ARGOS ground station in France. In contrast to previous, conventional satellite tracking technology, the ARGOS satellite system was used as a system to relay information in addition to providing an estimate of the current location of the transmitter. ARGOS ground station then transferred the information by electronic transfer to the Institute for Zoo and Wildlife Research (IZW) in Berlin where the data were processed. The extracted locations were used for analysis of animal movements, home ranges and habitat use and preferences. Home range sizes were calculated using a special module available for Arc View (Hooge and Eichenlaub, 2000), applying the well-known and most commonly used home range models reviewed by Harris et al. (1990). Home range interaction was calculated using the Geo-processing extension programme in Arc View (ESRI, 1996). The home range interaction was expressed as a percentage overlap of an elephant's home range with the home range of each of the other studied individuals. The Arc GIS 8x programme was used to digitise the habitat TIFF map of the corridor and to calculate the area of each habitat polygon using the Structured Quelling Language (SQL) programme. Habitat classification was based on dominant canopy as described by Holmes (1995) where the habitat types woodland, bushed grassland, cultivated land, seasonal swamps, permanent river and dry evergreen forest were identified and included in analyses.

3.9 Data analysis

Analysis of data was performed using the SYSTAT computer programme. Descriptive statistics was performed to all data from the village public meeting, questionnaire, field observation and monthly patrol reports by the VGS and elephant immobilisation. One way ANOVA was used to test whether the monthly MCP home range size differed between the data accrued from the GPS and ARGOS satellites and the seasonal (wet and dry season) variation in the MCP home ranges (Dytham, 2003).

Seasonal (wet and dry season) habitat use and habitat preferences and seasonal changes in habitat preferences were analysed by using state-of-the-art techniques developed by Manly et al. (1993) and implemented by Höner et al. (2002). The selection ratio $(\hat{w}_i)$ for habitat $_i$ was calculated as the proportion of habitat used (O_i) to its proportion (π_i) in the total area considered (Manly, McDonald and Thomas, 1993). To describe habitat preference, the standardized selection ratio α_i (Chesson 1978, 1983) as $\alpha_i = (O_i/\pi_i)/(\Sigma\, O_j/\pi_j)$, or in terms of selection ratio $\hat{w}_i$, $\alpha_i = (\hat{w}_j)/\Sigma\hat{w}_j)$ (Manly et al., 1993) was used. The standardized selection ration α_i gives the estimated probability that a randomly selected habitat type will be in category i if all categories are equally frequent in the original population of the available resource units (Manly et al., 1993). To assess changes in habitat preference, habitat selection ratios of the wet and dry season were compared using estimates of standard errors, confidence limits and chi-squared statistics as described by Manly et al. (1993) and denoted by χ^2_M.

To define the home range characteristics, the monthly cumulative MCP home range per individual animal was calculated and plotted against time as described by Bowen (1982) and Viljoen (1989). The boundary of the home range was assumed when the observation area curves attained an asymptote or when the increase in the index was $\leq 2.5\%$ for a period of one month. Unless otherwise stated, the P values less than 0.05 was considered significant.