Kapitel 4

Environmental contaminants in organs of free-ranging northern goshawks (*Accipiter gentilis*) from three regions of Germany

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Berliner Habichte bei der wissenschaftlichen Beringung

(Foto: Norbert Kenntner)

Introduction

The northern goshawk (*Accipiter gentilis*) is a common and powerful raptor in the Holarctic forests. Due to its sedentary behavior, the short dispersal distances, the uniform distribution and the well-investigated ecology, the northern goshawk is considered the most suitable bird of prey species for environmental assessment studies within continental Europe (ELLENBERG & DIETRICH 1981; ELLENBERG et al. 1986). This highly sexual dimorphic species is an opportunistic feeder on birds and mammals. In central Europe the smaller but more agile male, weighing up to approximately 800 g, is known to feed mainly on birds commonly up to the size of pheasants (*Phasianus colchicus*), whereas the stronger female, weighing up to 1300 g, is able to kill even larger prey up to the size of European brown hares (*Lepus europaeus*) under favorable circumstances (OPDAM et al. 1977; KENWARD et al. 1981; ZIESEMER 1983; BRÜLL 1984). In recent decades, the German population of northern goshawks has recovered from detrimental human impact like human persecution and, presumably, pesticide use. Actually there is a clear trend of this species to colonize urban areas, especially favored by the high abundance of feral pigeons (*Columba livia*) throughout the year. Feral pigeons play the major role in terms of biomass uptake for "urban goshawks" (WÜRFELS 1999; RUTZ 2001; ALTENKAMP & HEROLD 2001).

Due to their persistence and lipophilicity the organochlorine pesticides and the PCBs accumulate in the food web and therefore birds of prey are known for high exposure to these organochlorines (OC). Especially predatory birds feeding on fish and birds are known for detrimental effects caused by organochlorine pesticides, leading to population declines due to long-time reproduction depression and acute poisoning (PRESTT et al. 1970; COOKE et al. 1982; NEWTON et al. 1992; PORTER 1993). The organochlorine pesticides and organo-mercury compounds, the latter as components for seed-dressings, were widely used in German agriculture and forestry but are banned nowadays, as well as the PCBs for industrial purpose.

The nonessential heavy metals lead (Pb), cadmium (Cd) and mercury (Hg) are emitted and globally distributed mainly through industry, traffic and consumption of fossil fuels. Lead in its alkyl forms was also used as a petrol additive, but this use was successively reduced in Germany from 1970 on followed by a total ban for the reunioned Germany as in most other European countries.

Most studies concerning the impact of environmental contaminants on European northern goshawks deal with heavy metals in feathers or OC in eggs (SPRONK & HARTOG 1971; CONRAD 1977; BEDNAREK et al. 1975; ELLENBERG & DIETRICH 1981; ELLENBERG et al. 1986; HAHN et al. 1993).

We analyzed the concentrations of organochlorine pesticides like p,p´-DDT and its metabolite p,p´-DDE, hexachlorobenzene (HCB) and γ-hexachlorocylohexane (γ-HCH), the concentrations of 7 PCB congeners (PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153, PCB 180) in liver samples as well as the amounts of the potentially toxic heavy metals lead (Pb), mercury (Hg) and cadmium (Cd) in livers and kidneys of 62 free-ranging northern goshawks found dead or injured in Germany from 1995 to 2001. The objectives of the present study were to compare the burden of these environmental contaminants between goshawks in rural and city populations, and among sexes, age classes and different body condition.

Materials and Methods

Sample Collection

All goshawks were found dead or injured in the German counties Baden-Württemberg, Berlin, Brandenburg, Lower Saxony and Saxony between 1995 and 2001. Most birds died by traumatic shocks mainly after collisions or were immediately euthanized because of their severe injuries. Post-mortem investigations were performed in the Institute for Zoo and Wildlife Research (IZW) in Berlin, Germany. Necropsy included determination of sex, body condition and age of all birds. Separated organs were stored in polyethylene bags at –20°C until analysis. The age of the birds was determined by plumage characteristics and month of death. Birds found in their first year between June and September were defined as juveniles, those found between October and March as immatures. Adult birds were at least one year old. The data on origin, sex and age are given in Table 1. The sample sizes differed between the years: 1995 (n = 6), 1996 (n = 10), 1997 (n = 4), 1998 (n = 4), 1999 (n = 17), 2000 (n = 17) and, 2001 (n = 4). Body condition was categorized by body mass, breast muscle shape, and measurements of the subcutaneous, coronary and abdominal cavity fat tissue (Kenntner et al. 2001). Five categories were used ranking from very poor to very good.

Table 1: Origin, age and sex of 62 goshawks (*Accipiter gentilis*) from Germany.

		age			
sex	origin	juvenile	immature	adult	n
male	Berlin	10	6	6	22
	Brandenburg	2	1	1	4
	Lower Saxony	3	1	3	7
	Saxony	1	0	0	1
female	Berlin	0	2	5	7
	Brandenburg	2	3	6	11
	Lower Saxony	0	5	3	8
	Baden-Württemberg	0	0	2	2
	n	18	18	26	62

Chemical Analysis

Sample preparation and residue analyses were performed in the Research Institute of Wildlife Ecology (FIWI) at the University of Veterinary Medicine Vienna, Austria.

Identification and quantification of the OC compounds were performed using capillary gas chromatography with an electron capture detector after extraction by hexane, and a clean-up using deactivated aluminum oxide. The heavy metals in livers and kidneys were analyzed with atomic absorption spectrometer equipped with a graphite-furnace unit for lead and cadmium, and using cold-vapor technique for mercury. A detailed account of the methods is given previously (KENNTNER et al. 2001; KENNTNER et al. submitted). All results were calculated as mg*kg^{-1} (ppm) on a wet-weight (wet wt) basis.

Statistical Treatment

For statistical analysis all residue data were log-transformed to obtain nearly Gaussian distributions (Kolmogorov-Smirnov test for goodness of fit). Homogeneity of variances were tested with Levene´s-test before data analyses were performed with simple linear regression, General Linear Model (GLM) and Analysis of Variance

(ANOVA) using Tukey Post hoc to adjust for multiple comparisons. Variables failing the Levene`s-test were excluded from analysis. Significance was determined at the $p \leq 0.05$ level. Statistical analyses were computed using SPSS 9.0 for PC.

Results

Highest median, mean and standard deviation were found for the sum of DDT and DDE (ΣDDT) in hepatic tissue which was dominated by the concentrations of the main metabolite DDE. The general PCB pattern was PCB 153 > PCB 138 > PCB180 > PCB 118 > PCB 101 > PCB 28 > PCB 52. The PCB congeners are identified by their IUPAC numbers (BALLSCHMITTER & ZELL 1980). Concentrations for γ-HCH (lindane®) and PCB 52 were frequently below detection limit and failed the test for goodness of fit, therefore these data were excluded from further statistical analysis, however, PCB 52 was linked to the sum of the seven PCB congeners (ΣPCB). The concentrations of contaminants are given in Table 2 and Table 3.

Table 2: Residues of chlorinated hydrocarbons in liver tissues of northern goshawks (*Accipiter gentilis*) from Germany. All values are given in ppm on a wet-weight basis.

	n	Range		Median	Mean	SD[a]	n≤dl[b]
HCB	62	0.001-	1.087	0.012	0.063	0.178	0
γ-HCH	62	nd[c]-	0.090	0.001	0.003	0.012	21
DDT	62	nd-	0.583	0.013	0.055	0.112	5
DDE	62	0.027-	97.965	1.992	7.862	17.985	0
ΣDDT	62	0.029-	98.049	2.007	7.917	18.049	0
PCB 28	62	nd-	0.261	0.004	0.015	0.039	9
PCB 52	62	nd-	0.160	0.006	0.017	0.031	16
PCB 101	62	nd-	0.522	0.020	0.056	0.106	2
PCB 118	62	nd-	5.798	0.059	0.314	0.901	2
PCB 138	62	0.015-	16.922	0.363	1.603	3.093	0
PCB 153	62	0.019-	28.299	0.530	2.535	5.298	0
PCB 180	62	0.006-	27.628	0.330	2.067	4.954	0
ΣPCB	62	0.058-	73.383	1.264	6.607	13.939	0

[a]SD = Standard deviation; [b]n<dl = number of samples below detection limit; [c]nd = not detectable

Table 3: Residues of heavy metals in liver and kidney tissue of northern goshawks (*Accipiter gentilis*) from Germany. All values are given in ppm on a wet-weight basis.

Organ	Element	n	Range		Median	Mean	SD[a]	n≤dl[b]
Livers	Pb	61	0.028-	50.951	0.133	1.190	6.539	0
	Hg	61	0.006-	1.444	0.069	0.138	0.213	0
	Cd	61	0.001-	0.791	0.030	0.060	0.106	0
Kidneys	Pb	61	0.017-	14.609	0.126	0.450	1.875	0
	Hg	61	nd[c]-	1.170	0.066	0.138	0.189	1
	Cd	61	0.014-	1.097	0.118	0.221	0.255	0

[a]SD = Standard deviation; [b]n<dl = number of samples below detection limit; [c]nd = not detectable

One-way ANOVA indicates differences of contaminant burden between sampling years during the period from 1995 to 2001 only for ∑DDT and mercury residues. However, there was no trend over time and ∑DDT ($p = 0.040$) values from 2001 were higher than in the sample year of 1995, whereas mercury residues in liver ($p = 0.026$) were higher in the year 1996 than 1999 and renal mercury concentrations were higher in birds found in 1996 than in those from 1995. In addition, simple linear regression throughout the sampling period did not prove any significant temporal trend.

For further statistical analyses we excluded the northern goshawks from Baden-Württemberg (n = 2) and Saxony (n = 1) because of the small sample sizes as well as lead values of two birds, which showed very high and probably toxic lead concentrations in their organs.

General Linear Model (GLM) including all levels of log-transformed residue data as dependent variables and origin, age, and body condition as factors indicate highly significant effects for the origin ($F = 2.101$; $df = 34$; $p = 0.048$), body condition ($F = 2.125$; $df = 68$; $p = 0.004$), and for the interaction between age and body condition ($F = 1.773$; $df = 119$; $p = 0.002$).

Organochlorine Pesticides and PCBs

There were significant differences for ∑DDT between Lower Saxony and Berlin ($p = 0.025$), and also between Lower Saxony and Brandenburg ($p = 0.001$), with higher DDT concentrations in Berlin and Brandenburg. Comparing the three age classes, adult birds had significantly higher PCB 28 concentrations than juveniles ($p = 0.006$), as well as immature birds had higher PCB 101 concentrations than juveniles ($p = 0.019$). The highest significant differences ($p \leq 0.001$) were found for all higher chlorinated PCBs (IUPAC No. 118, 138, 153, 180) and ∑PCBs between juvenile and immature birds and also between juvenile and adult birds, with lower concentrations in juveniles. However, there were no significant differences comparing immature and adults for any of the analyzed PCB congeners, as well as for DDE residues between any of the three age classes.

To figure out these contaminant differences for the age classes we computed one-way ANOVA for each age class, further we investigated the sample for differences between the sexes.

There were no significant regional differences between the juvenile and immature goshawks from different areas. However, adult birds from Berlin had significantly higher concentrations for PCB 153 ($p = 0.050$) and ∑DDT ($p = 0.002$) than birds from Lower Saxony. In addition goshawks from Berlin had higher PCB 180 concentrations than birds from Brandenburg. Figure 1 shows the original OC residue data for adult northern goshawks separated for sampling areas, the seven analyzed PCB congeners were summarized to ∑PCBs.

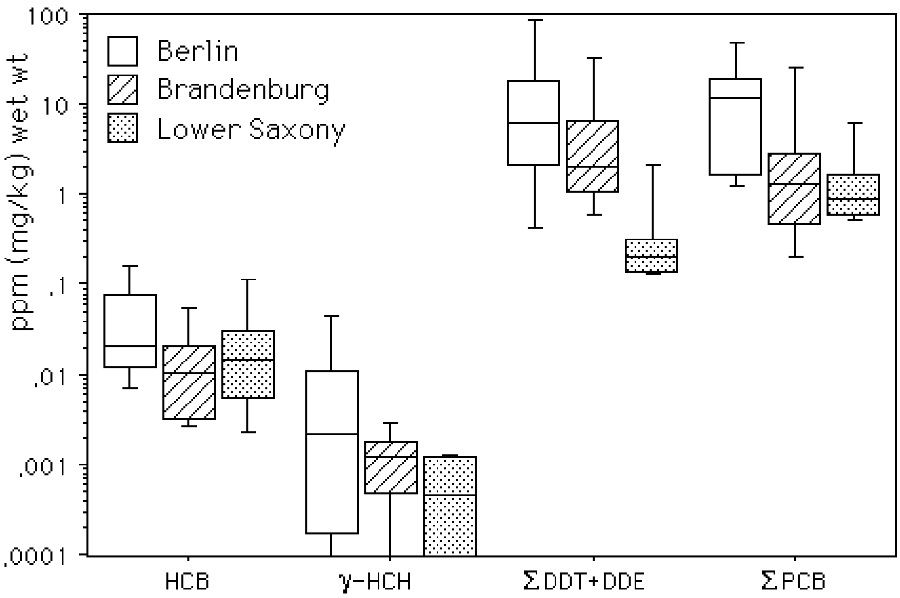

Fig. 1: Concentrations of HCB, γ-HCH, ΣDDT, and ΣPCBs in livers of adult goshawks from Berlin (n = 11), Brandenburg (n = 7) and Lower Saxony (n = 6). Box-plots illustrate the 10, 25, 50 (median), 75 and 90 percent percentiles.

No differences were found between the sexes in juvenile and immature birds. However, the 10 adult males from the three main regions had significantly higher lindane concentrations than 14 adult females ($p = 0.042$). Analyses of adult goshawks from the city of Berlin revealed differences between 6 male and 5 female goshawks for PCB 101 ($p = 0.025$), PCB 118 ($p = 0.012$), PCB 153 ($p = 0.043$), PCB 180, ($p = 0.030$) and ∑PCB ($p = 0.039$), respectively, with higher means in females.

The comparisons between each category of body condition is shown in Tab. 4. Hepatic residues of HCB, ∑DDT, and ∑PCBs were significantly higher ($p \leq 0.001$) in emaciated birds in very poor condition compared to birds categorized as moderate, good or very good. Among the categories very poor and poor the only significant difference was found for HCB concentrations ($p = 0.020$), with higher concentrations in the very poor category. Northern goshawks in poor body condition had also higher hepatic residues for ∑DDT compared to birds in moderate ($p = 0.029$), good ($p < 0.001$) and very good ($p = 0.022$) body condition, respectively. The latter also applies for ∑PCBs residues in poor conditioned birds compared to goshawks in moderate ($p = 0.011$), good ($p = 0.002$) and very good ($p = 0.005$) body condition, respectively (Figure 2).

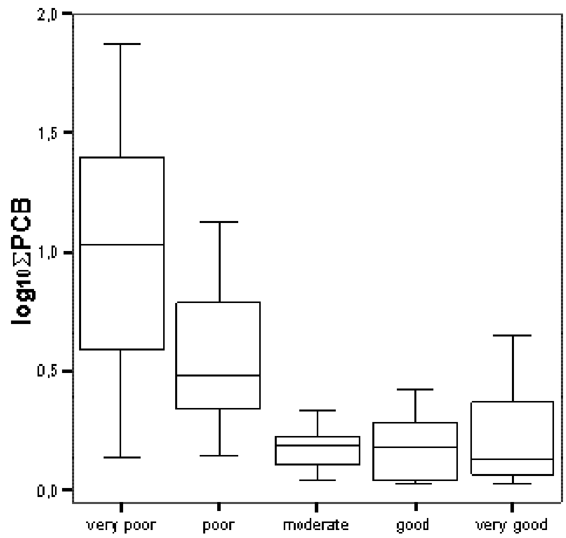

Fig. 2: Box-Plots show data for $\log_{10}$ transformed hepatic ∑PCBs concentrations for each category of body condition (n = 59).

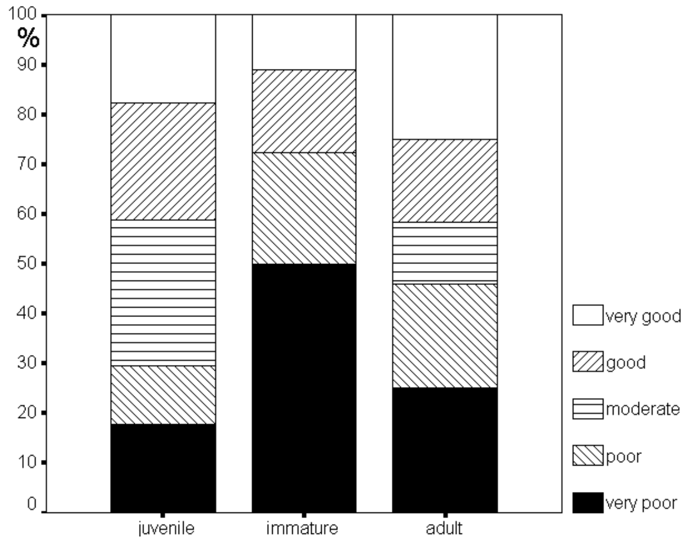

Fig. 3: Percentages of body condition status separated for each age class (n = 59).

Table 4: Comparison between five categories given for body condition and organochlorines and heavy metals. Same characters indicate no significance ($p > 0.05$).

		body condition				
		very poor	poor	moderate	good	very good
n		18	11	8	11	11
HCB		a	b	b	b	b
∑DDT		a	a	b	b	b
PCB 28		a	ab	b	ab	ab
PCB 101		a	ab	b	b	b
PCB 118		a	a	b	b	b
PCB 138		a	a	b	b	b
PCB 153		a	a	b	b	b
PCB 180		a	a	b	b	b
∑PCB		a	a	b	b	b
Liver	Pb	a	a	a	a	a
	Hg	a	ab	b	b	b
	Cd	a	ab	b	b	ab
Kidney	Pb	a	ab	ab	b	ab
	Hg	a	ab	b	ab	ab
	Cd	a	ab	b	b	ab

Heavy Metals

The cadmium concentrations in liver tissue from northern goshawks collected in Lower Saxony were higher than in the samples from Berlin ($p = 0.042$). Lead and cadmium residues in liver tissue and cadmium residues in kidney tissue were significantly higher in adults than in juveniles ($p < 0.001$). However, differences of lead residues between juvenile and immature birds were significant for hepatic tissue ($p = 0.003$) and marginal for renal tissue ($p = 0.051$). These latter lead concentrations as well as cadmium concentrations in liver tissue ($p = 0.005$) and in renal tissue ($p < 0.001$) were significantly higher in immature birds than in juveniles. For immature and adult birds only a significant difference was found for cadmium residues in renal tissue ($p = 0.003$), which were higher in adults.

However, comparing the sexes we computed significantly higher hepatic cadmium concentrations for the 14 adult females ($p = 0.019$) compared with the 10 adult males. Investigating only the 6 adult males and 5 adult females from Berlin, we found higher cadmium residues in livers of females ($p = 0.016$), but higher lead residues in kidneys of males ($p = 0.046$).

For body condition (Table 4), significant differences were computed for cadmium concentrations in liver tissue between birds in very poor condition and moderate condition ($p < 0.001$) and between those in very poor and good condition ($p = 0.023$), respectively, with higher residue levels in more emaciated birds. The latter was also found for hepatic mercury, for comparisons among birds of the category very poor and those birds determined as moderate or good ($p = 0.003$), respectively, and between birds in very poor and very good condition ($p = 0.005$). For mercury residues in kidney tissue we found differences only between goshawks in very poor and moderate body condition. Contrarily, lead residues in renal tissue were significantly higher in birds in good than in those in very poor body condition ($p = 0.020$). In addition renal cadmium residues were higher in specimens in very poor compared to moderate ($p < 0.001$) as well as good condition ($p = 0.037$). Higher renal cadmium concentrations were also found in birds in poor condition compared with those in moderate condition ($p = 0.002$). However, there were no significant differences between birds in moderate, good and very good body conditions for any of the analyzed heavy metals.

Discussion

The goshawk is a protected species in Germany, therefore our sample consists of birds, which had suffered from trauma, illegal persecution and infectious diseases, and thus does not represent randomly collected specimens. Nevertheless, for the northern goshawk from Europe only few other residue data of most of the analyzed contaminants through the last decades are available.

Organochlorine pesticides and PCBs

In spite of some extraordinary high hepatic concentrations for ∑DDT and ∑PCBs (Table 2), levels of OCs do not indicate any health risk of acute poisoning for the birds. They are far below suspected lethal values found in other raptor species (PROUTY et al. 1982; GARCELON & THOMAS 1997; STONE & OKONIEWSKI 2000). Few birds proving concentrations in the range of 10 ppm to 100 ppm for ∑DDT or ∑PCBs may have suffered from subtle sub-lethal effects (COOKE et al. 1982).

The northern goshawks from Lower Saxony were obviously less exposed to ∑DDT than birds from Berlin or from Brandenburg. These results reflect clearly the differences in the legislation for DDT between the Federal Republic of Germany (FRG) and the former German Democratic Republic (GDR) before the German reunion in 1990. The FRG banned the use of DDT in agriculture in the year 1972 (STREIT 1994) and it was totally phased out by the year 1974 (BAUM & CONRAD 1978). Whereas in the former GDR the use of DDT was stepwise reduced in the 1970s, this insecticide was once more applicated in high amounts by airplanes for the control of the moth *Lymantria monacha* in forests in 1983 and 1984, followed by a decreasing use until the year 1988 (BEITZ et al. 1991; HEINISCH 1992; SCHMIDT 1994).

The significantly higher hepatic ∑DDT concentrations in organs of adult goshawks from Berlin, compared to adults birds from Lower Saxony are surprising, due to the fact that DDT was expected to have been never applicated extensively in the metropolitan Berlin. However, DDT was synthesized in large quantities in a chemical plant in eastern Berlin (former GDR) until 1954 and production of different DDT-formulations continued until 1988 with high DDT contaminations of adjacent ground and river sites (HEINISCH 1992). We assume this contamination by the former manufacturing in Berlin, accompanied with its applications by airplanes in the surrounding county of Brandenburg, as sources for the extraordinary high hepatic ∑DDT concentrations in some "urban goshawks", due to bioaccumulation through the food web.

In the present study we could not prove differences between the three age classes for ∑DDT of the total sample, whereas the burden of higher chlorinated PCBs seems to increase rapidly with age in northern goshawks and was therefore significantly lower in juveniles compared to immature as well as adult birds. These results seem to be highly influenced by individual body condition. Especially immature birds (from October to March) are more susceptible for starvation periods (Figure 3) probably due to low hunting abilities and the lack of fledglings as easily accessible prey. During starvation lipophilic organochlorines are mobilized from fatty tissue catabolism to the blood stream and are therefore redistributed to highly metabolic organs as the liver (BOGAN & NEWTON 1977; ELLIOTT et a. 1996).

As our findings for PCBs, a rapid increase with age in organochlorine burden was also proved for the northern goshawk´s related species; e.g. the Eurasian sparrowhawk (*Accipiter nisus*) from Great Britain (NEWTON et al.1981; COOKE et al. 1982).

NEWTON et al. (1981) reported that female sparrowhawks lost organochlorine body burden through egg laying and therefore female birds laid eggs with highest organochlorine concentrations in their first clutch and had intermediate OC concentrations in eggs of successive breeding seasons. In our study the higher liver concentrations for most OCs from adult female goshawks from Berlin in comparison with adult males of the same region did not indicate significant reduction of contaminant body burden through annual egg laying. This absence or low loss of OC through egg laying could be caused by the smaller clutch size and proportionally smaller eggs of goshawks compared to the much smaller sparrowhawk. However, caution must be taken by interpreting these results because contamination with most OCs was strongly correlated with individual body condition and the sample is small; further analyses should prove these findings.

Similar to our results, no clear long-time trends for residues of persistent OCs were found for egg contents in sparrowhawk. However, sparrowhawk eggs from clutches in the vicinity of the city of Chemnitz (Saxony, former GDR) had significantly higher residues of PCB 138 than eggs from rural areas collected between 1989 and 1994 (WEBER et al. 1997). Higher ∑DDT and PCB residues were also found in eggs from peregrine falcons (*Falco peregrinus*) collected in German urban areas compared to eggs from peregrine falcon inhabiting more rural areas (BAUM & HÄDRICH 1995). In addition, eggs of sparrowhawks collected in Brandenburg (former GDR) from 1993 to 1998 had significantly higher burdens of DDT and its metabolites than eggs from the same species from North-Rhine Westphalia (FRG) collected in the single year 1998. Whereas the PCB concentrations were higher in the latter one, the pattern of the 93 analyzed PCB congeners did not differ between those two distinct regions (DENKER et al. 2001). An earlier investigation in the years 1981 to 1987 in the same study area from North-Rhine Westphalia had analyzed 315 egg contents from 231 different clutches of sparrowhawks. Despite the great sample there was no proved decline for any OCs and mercury, moreover the burden of PCBs seemed to have been increased throughout the sample period (BEYERBACH et al. 2000). Other German studies on OC on egg contents of northern goshawks and peregrine falcons indicated a strong decline for HCB and a moderate decline for DDT residues shortly after the ban in 1977 and 1972, respectively. Residues for ∑DDT and PCBs in egg contents of peregrine falcons from 1988 to 1993 oscillate without a clear long-term trend, however, only the ∑DDT residues were on a lower contaminant level compared with the results from the 1970s (BAUM & CONRAD 1978; BAUM & HÄDRICH 1995).

Environmental contaminant concentrations in body tissue of northern goshawks from Europe and elsewhere are rare in literature, but analyses of OC in egg contents of northern goshawks from Germany indicated that this species belongs to the moderately exposed predatory birds (BEDNAREK et al. 1975; CONRAD 1977; BAUM & HÄDRICH 1995). LÜTHGEN et al. (1982) reported OC data of 13 northern goshawks from the German state Hesse, however, they analyzed OC concentrations partly in adipose tissue or cerebral tissue and there is evidence that some of these goshawks were held for falconry purpose. Data of OC concentrations from body tissue of free-ranging northern goshawks from Europe were reported from Norway (HOLT et al. 1979; FRØSLIE et al. 1986). The latter investigation seems also to contain the data of the first survey and thus we compare our data only with the greater sample. FRØSLIE et al. (1986) detected higher medians and maximal concentrations in livers from northern goshawks for DDE, ∑PCBs, HCB, and lindane in liver samples of 35 to 141 northern goshawks from 1965 to 1983, including the period when most of the organochlorine pesticides were still in use and the post-ban period in Norway, as in most other European countries. Considering the different analytical techniques in the 1960s and the long period between this Norwegian study and our study we avoid detailed comparisons.

OC concentrations in body tissue of free-ranging northern goshawks from North America were reported for seven specimen found in the winter 1972/73 in Illinois. According to these results the northern gohawk shows the lowest OC exposure compared with other raptor species (HAVERA & DUZAN 1986). Contrarily to these data of the North American subspecies, the liver concentrations for OCs of one juvenile northern goshawk from Japan were among the highest concentrations compared to the other investigated species (SENTHILKUMAR et al. 2002).

Heavy metals

Whereas the liver concentrations of OCs in some specimens were extremely high, the residues of mercury and cadmium do not indicate high exposure. Average lead levels in livers were low, except for two goshawks from Lower Saxony and from the city of Berlin, each. In the case of one immature female northern goshawk from Lower Saxony lethal lead poisoning was clearly indicated by lead concentrations of 50.951 ppm in liver tissue and 14.609 ppm in renal tissue. One adult male goshawk found moribund in Berlin had 6.454 ppm and 1.596 ppm in hepatic and renal tissue, respectively, and was therefore obviously exposed to metallic lead ingestion. These latter tissue concentrations are difficult to interpret, however, they are in a range known for severe physiological effects and presumably lethal effects (FRANSON 1996). A further adult female found in a Lower Saxony forest with paralyzed legs was euthanized after 8 days in captivity because of a poor prognosis. This bird had lead concentrations of 2.782 ppm and 1.386 ppm in liver and kidney tissue, respectively, and could be also assumed to suffer strong physiological effects due to metallic lead exposure (FRANSON 1996). Lead poisoning in northern goshawks is suggested to result mainly from ingestion of lead ammunition embedded in shot-crippled prey, and in a lesser extent from feeding on carcasses or gut piles with embedded lead shot or lead ammunition. For goshawks scavenging is rarely reported as an important food supply (KENWARD et al. 1981; ZIESEMER 1983). Until now, lead poisoning in free-ranging northern goshawks was only reported in one case from France (PAIN & AMIARD-TRIQUET 1993). Considering the 28% of suspected lead poisoned white-tailed eagles from Germany and Austria (KENNTNER et al. 2001), we do not judge the goshawk as a species of high risk for this metal toxicosis.

The mercury residues in the present study are lower than reported by FRØSLIE et al. (1986) and comparable to mercury concentrations in body tissue of Finnish northern goshawks after the ban of organic mercury compounds as seed dressing (HENRIKSSON & KARPANNEN 1975).

The cadmium residues in kidney tissue increased with age and cadmium concentrations are in general higher in renal than in hepatic tissue, with only two exceptions, due to the long half-life of cadmium in kidneys (SCHEUHAMMER 1987). The higher female cadmium burden in hepatic tissue compared to males could result from the generally higher female resorption rate for cadmium (SCHEUHAMMER 1987). In contrast to the OCs and mercury there is only little correlation between body condition and concentrations of lead and cadmium in soft tissues. The significantly higher hepatic cadmium concentrations of northern goshawks collected in Lower Saxony compared to birds from Berlin are most likely due to different sex ratio or the different age structures of the samples (Table 1).

Besides the three lead exposed goshawks all concentrations of heavy metals in body tissue of northern goshawks found in this study were far below any thresholds suspected for inducing detrimental physiological effects or intoxications (BORG et al. 1970; FURNESS 1996; THOMPSON 1996) and are within the range of background contaminations as reported previously from several other European surveys (NORHEIM & FRØSLIE 1978; HOLT et al. 1979; DELBEKE et al. 1984; FRØSLIE et al. 1986; TERNES et al. 1986; PAIN et al. 1995).

Conclusions

This study clearly indicates significant differences of contaminant burdens between local populations and between age classes. The differences between the OC residues of sexes of northern goshawks from Berlin should be investigated by detailed analyses of prey preferences using telemetry (KENWARD et al. 1981; ZIESEMER 1983) and contaminant analyses of the preferred prey items of both sexes. However, the wide range of contaminant concentrations in this study seems to depend strongly on body condition of individual specimen. Therefore we recommend strongly to report individual nutrition state of analyzed specimen in addition to toxicological data on body tissue of raptorial birds. The northern goshawk as a suitable species for monitoring environmental contaminants at the top of the terrestrial food web should be continuously monitored for further comparable investigations.

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Abstract

The northern goshawk (*Accipiter gentilis*) is a top predator in the terrestrial food web of large parts of the Holarctic. Due to its sedentariness and well investigated feeding ecology it represents the most suitable species of birds of prey in continental Europe for monitoring environmental pollutants. We analyzed the contaminations with organochlorine pesticides, polychlorinated biphenyls (PCB) and nonessential heavy metals in organ samples of 62 free-ranging northern goshawks found dead or injured in Germany from 1995 to 2001. Our results indicate significant differences between the contaminant burden of northern goshawks from three regions in Germany. Presumably, these differences were caused by different application periods and legislative restrictions before the German reunion, especially for the use of DDT in agriculture and forestry. Extraordinarily high residues for PCBs and DDE, the main metabolite of DDT, were found mainly in livers of northern goshawks inhabiting the city of Berlin. This study points out that body condition is highly correlated with the contamination level of the individual, especially for concentrations of the persistent and lipophilic organochlorines and for mercury. PCB concentrations in hepatic tissue increase rapidly with age, therefore birds in their first summer were significantly lower contaminated than birds in first winter or older. Adult female northern goshawks from Berlin had significantly higher hepatic concentrations for most of the higher chlorinated polychlorinated biphenyls and for cadmium than males from the same region. Cadmium residues were in general higher in renal tissue than in hepatic tissue and cadmium levels in kidneys increased with age. Lead concentrations proving acute lead poisoning were detected in one bird, whereas lead levels in liver and kidney of two further birds suggest acute lead exposure. All other heavy metal concentrations were low and represent background levels for birds of prey in Germany.

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