Chancellor, R.D., B.-U. Meyburg & J.J. Ferrero eds. 1998
Holarctic Birds of Prey
ADENEX-WWGBP

Environmental Contaminants and Movements of Saker Falcons *Falco cherrug* in Central Asia

R.E. Kenward, R.H. Pfeffer, E.A. Bragin,
A. Levin and I. Newton

ABSTRACT

Analyses of eggs, blood samples and feathers from Saker Falcons in Central Asia were used to investigate levels of environmental contamination, in relation to the migratory movements of the falcons revealed by ringing, microtransponders and radio-tags. Ring and microtransponder recoveries showed that Sakers from northern Kazakhstan migrated to the southwest at least as far as the Middle East, with radio-tagged young returning to natal areas after their first winter. There was no good evidence of migration for Sakers in more southern and eastern parts of Kazakhstan, and some radio-tagged young wintered locally. These southern falcons had higher concentrations of DDE than those in the north, but all organochlorine and heavy metal residues were an order of magnitude lower than those typical of some European raptors. Neither the migratory nor the sedentary Saker Falcons in central Asia are currently at risk from these pollutants. Moreover, the very low contamination of feathers with heavy metals may help distinguish Asian from European Sakers, so that trapping in the Middle East could be used to monitor trends in different Saker Falcon populations.

INTRODUCTION

The Saker Falcon *Falco cherrug* is the world's second largest falcon. However, unlike the larger Gyrfalcon *F. rusticolus* and generally smaller Peregrine *F. peregrinus*, the Saker's breeding distribution is confined to continental Eurasia, from Austria to Manchuria and from Iran to Siberia (Cramp & Simmons 1980). Sakers are migratory in the northern part of their range, and those of the nominate race *F.c. cherrug* in more western regions are thought to travel mainly to Africa to winter, although as yet no ring recoveries support this view.

We know of no publications concerning organochlorine or heavy metal residues in Saker Falcons. However, opportunity to collect material from Kazakhstan arose recently, during a study started in 1993 for the National Avian Research Centre in Abu Dhabi. The work, organised by the United Kingdom Institute of Terrestrial Ecology in cooperation with the National Academy of Sciences and Ministry of Ecology and Natural Resources in Kazakhstan, was intended to develop techniques for studying status and possible threats for Sakers throughout their global distribution. Kazakhstan was chosen for the pilot study because this large country embraces more than 50% of the Saker distribution in east-west and north-south directions. Nestlings were to be marked with rings, microtransponders and radio-tags to follow their movements, and tissue samples were taken for analyses of residue levels, molecular genetic traits and presence of pathogens.

There were two reasons for the analyses of organochlorine and heavy metal residues. One was to determine whether environmental contaminants posed any threat to Saker populations. The second was to investigate whether residues might be a useful supplement to genetics (and possibly also veterinary analyses) as "bio-markers" for determining the natal origins of falcons trapped on migration. The large number of Sakers caught annually for falconry (Riddle & Remple 1994) provides an opportunity for monitoring population sizes and trends by mark-recapture methods, provided that the natal areas of trapped birds can be estimated.

METHODS

Data are presented here from the Kustanai region in northern Kazakhstan, the Almati (formerly Alma-Ata) region in the south, the Betpakdala desert in south-central Kazakhstan and the Altai area in the east. The tree-nesting Sakers in the northern area were known to leave the breeding areas in winter, and therefore might be exposed to different environmental contaminants in summer and wintering areas. In the central, southern and eastern areas, where Sakers nest on cliffs, adults had been recorded in winter (Pfeffer 1990) but it was not clear whether young falcons also remained through the year.

Nests of Saker Falcons were visited at least twice during the rearing period. The first visit, typically within 10 days after hatching was anticipated, served to collect any unhatched eggs for analysis and to measure the winglength of young falcons to estimate the date of hatching. The winglength was used to predict when they would leave the nest (Kenward & Pfeffer 1995), so that a second visit could be made less than five days before they would fly. The young were then again weighed and measured. A blood sample of 1-1.5 ml was taken from a brachial vein and divided: one drop for making a thin film slide to investigate blood parasites, 10 drops stored in absolute ethanol for genetic analysis and the remainder stored in the syringe for pollutant residue analyses (organochlorines and mercury). The whole-blood samples for genetic and residue analyses were kept in the field on ice in steel vacuum flasks, and transferred to freezers at -20°C as soon as practical. A length of about 2 cm was cut from a tertiary wing feather of each young Saker for analysis of heavy metal concentrations, in which detection thresholds were 0.5 parts per million (ppm) for mercury and lead, and 5 ppm for cadmium. Full details of analysis procedures for metals and organochlorines are in Newton *et al.* (1993).

To investigate migratory movements and proportions harvested for falconry, the young falcons were marked with rings (under permission from the British Trust for Ornithology) and microtransponders (Avid Inc, Norco, California 91760, U.S.A.) implanted subcutaneously. Even if rings have been removed, the larger veterinary hospitals in the Middle East routinely scan falcons' transponders because these are used for marking birds examined clinically, and transponders could also be used to log breeding adults at nests without the need to trap them. To help determine whether birds remained for the winter in southern Kazakhstan, as well as recording the return of migrants in the north, 35-40 nestlings each year were also marked with VHF radio tags (Biotrack Ltd, Wareham BH20 5AJ, U.K.) and checked at intervals.

RESULTS

Organochlorine and Heavy Metal Concentrations

Preliminary analyses reported here were on five clutches of abandoned eggs from central and eastern Kazakhstan, with samples of whole blood from five different broods in northern Kazakhstan and five from the south (Table 1). The insecticide Dichloro-Diphenyl-Trichloroethane (DDT) is represented in the table by its usual metabolite, pp′-DDE. HEOD represents residues from the cyclodiene insecticides dieldrin and aldrin, and the chemically similar PCBs (Polychlorinated Bi-Phenyls) enter the environment as industrial lubricants, coolants and a number of other products. In some of the samples analysed, residues (if present) were below the threshold for detection. Residue levels in these samples were set at the detection threshold, which deliberately overestimated the contaminant concentrations, and average levels are shown

Table 1. Organochlorine and mercury concentrations in whole blood from nestling Saker Falcons, and abandoned eggs, which were collected in Kazakhstan during 1993 and 1994.

	Whole blood		*Eggs*	
	Northern area	*Southern area*	*Central area*	*Eastern area*
N	5 broods	5 broods	2 clutches	1 clutch
HEOD (ppm wet wt)*	<0.004	<0.005	0,032	0,014
pp'-DDE (ppm wet wt)*	0,005	<0.024	0,07	0,851
PCBs (ppm wet wt)*	0,018	0,012	0,37	0,994
Mercury (ppm dry wt.)	<0.30	<0.40	0,23	<0.10

as <X.

Organochlorine levels in blood are less easy to interpret than in bird eggs or livers, the most usual tissues analysed, because there is much less fat in blood, organochlorines being highly fat-soluble. However, fat concentrations in blood averaged 0.4% in wet weight, about a tenth of the 4% fat in wet weight of eggs. Multiplication of organochlorine levels in blood by 10 therefore puts them at a broadly equivalent level to those in eggs. At this "equivalent fat" level, the mean HEOD level in blood was less than 0.05 ppm in both areas, broadly similar to the 0.01-0.03 ppm in eggs. The DDE levels in nestlings were significantly higher in the south than in the north ($P < 0.01$), at "equivalent fat" levels of 0.24 ppm and <0.05 ppm, compared with 0.07-0.85 ppm in eggs. The PCB levels in eggs tended to be above the "equivalent" fat levels in blood, but differences were not significant. Exact equivalence was not to be expected, because levels in eggs reflect levels in adult females, accumulated over many months, while levels in the blood of nestlings largely reflect accumulation during the first few weeks after hatching.

Concentrations of mercury, estimated as ppm dry weight in all cases, were broadly similar in the different samples. Levels of mercury. lead and cadmium in feathers were all below the detection level of the spectrometry system, and thus less than 0.5 ppm for mercury and lead, and less than 5 ppm for cadmium.

Movements of Saker Falcons

Radio-tracking showed that young falcons in each area dispersed about five weeks after leaving the nest, with a survival of 90% through the pre-dispersal period. Young from the northern area were not then recorded again until the following spring, when 20-25% made visits of 1-3 weeks to their natal areas. This gives a minimum estimate of their overwinter survival. In the southern area, however, two young falcons were detected again in autumn and winter. One, which had been heard passing through the area near its nest in autumn, was found dead under power-lines in the same area during winter, apparently in good condition. The other was found in a relatively rich river valley 250 km from the area in which it was marked, and which a radio-tagged adult was also known to visit in the winter. So at least some young from this region remained in winter.

A total of 136 young falcons were marked with rings and microtransponders in 1993 and 1994. During their first autumn and winter, seven rings were recovered and 4 microtransponders detected outside Kazakhstan, all on captured falcons. One ring recovery referred to a falcon whose microtransponder was also detected. The 11 reports therefore represent the capture of 10 falcons. Five ring recoveries for falcons from northern Kazakhstan came from Iraq (October), Syria (October), Turkey (October), Saudi-Arabia (October) and Yemen (December), whereas four transponder records from central and southern areas were reported either as captured or sold in Pakistan, and one marked in eastern Kazakhstan had apparently been trapped in China.

DISCUSSION

Wintering areas

The tree-nesting Saker Falcons in northern Kazakhstan are relatively isolated geographically, by semi-desert areas lacking trees or cliffs for nesting, from falcons in the south-central, southern and eastern regions. The previous visual records of adult Sakers at breeding sites during winter in southern and eastern Kazakhstan (Pfeffer 1990) indicated that some adults at least are sedentary. Adults and juveniles seen wintering in Almati (Pfeffer & Pfander 1986, Pfeffer 1990) could have come from other areas, including the north, but the new radio-tracking data indicate that some juveniles may be sedentary too. Nevertheless, radio-tagged juveniles were highly mobile, and some may have dispersed to be captured in Pakistan. It is also possible, however, that the young falcons sold at markets in Pakistan had actually been trapped much nearer to their natal areas in southern Kazakhstan. The falcon from eastern Kazakhstan that was trapped in China had been marked within 50 km of the Kazakh-Chinese border.

The northern falcons apparently migrate to the southwest. Recovery data from Turkey, Saudi Arabia and Yemen are considered reliable, and those from Iraq may be reliable, but the report from Syria could represent a falcon trapped by Syrians in Kazakhstan. Records from the Red Sea coast (Saudi Arabia, Yemen) suggest that, like the eagles from Siberia tracked by satellite (Meyburg *et al* 1995) these northern Sakers may winter in Africa.

Organochlorines

The most toxic organochlorines for raptors are the cyclodienes, such as dieldrin and aldrin. These compounds start to become lethal when HEOD is present in liver tissues at 6-10 parts per million in wet weight (Newton *et al.* 1992). DDE is less toxic than the cyclodienes, and only becomes lethal to adults or eggs at concentrations in liver above 60-150 ppm. However, DDE at levels above 20 ppm in wet weight can cause failure of eggs, primarily through thinning the shell (Ratcliffe 1970; Newton 1979, 1986). Many PCB congeners are found in living tissue, which makes it difficult to give general values for toxic effects, but no obvious toxic effects have been found in wild raptors, even at levels above 20 ppm wet weight in liver (Newton 1979).

Levels of 5-20 ppm DDE and 0.5-2 ppm HEOD were usual in tissues and eggs from raptor populations that were recovering from effects of these pesticides (Newton *et al.* 1993), with 1-3 ppm DDE more common at present. Levels in the Saker Falcons eggs were even lower. Similarly, concentrations of PCBs were well below levels now typical in European raptors.

The low organochlorine levels in young falcons from northern Kazakhstan show that they are not being fed a contaminated diet. Although residues from their eggs would have been much diluted by growth, the concentrations in blood are so low that there cannot have been high concentrations in the eggs from which they hatched. These migratory falcons seem to have little contact with organochlorine contamination either in breeding or wintering areas. The higher DDE levels in blood from southern areas than from northern Kazakhstan presumably reflected differences in contamination of prey fed to the young, because concentrations in southern eggs were no higher than "fat equivalent" levels in blood even before dilution through growth.. Mammals were the main food for the young falcons, and even adults feeding in winter on birds took mainly sedentary species (Solomatin 1974; Bragin 1986; Pfeffer 1986,1990). Perhaps in southern areas the falcons occasionally killed birds from cotton-growing areas with some history of DDT-use. Nevertheless, their nestlings still contained far less DDE than might be expected in Europe. At least in the centre of their geographic range, Saker Falcons are remarkably uncontaminated with organochlorines. Within other falcon species that have been studied, species differences in response to organochlorines were minor (Newton 1979), so there is no reason to think that Sakers might be unusually vulnerable.

Heavy Metals

Heavy metals, including lead, cadmium and mercury, can reach relatively high concentrations in the biosphere as a result of industry, and alkyl mercury has also been used to dress seeds as a protection against fungal attack. Alkyl mercury seed-dressings were implicated in the deaths of raptors in Scandinavia during the 1960s (Borg *et al.* 1969; Johnels *et al.* 1979). However, following reduced usage, mercury has not recently been identified as a problem, nor has contamination with cadmium been shown to kill raptors, and lead is only known to have killed raptors when ingested as gunshot.

Zinc occurs naturally in feathers, but other metals seem to become incorporated in two main ways. Metals such as mercury tend to get built into the feather structure, possibly instead of zinc, through presence in the diet (Johnels *et al.* 1979). Other heavy metals, such as lead and cadmium, appear to be be deposited on the feather surface from airborne sources (Hahn *et al.* 1993). They seem to reflect the level of contamination where the feathers were grown and thus, for a young bird, that of the natal area (Dietrich & Ellenberg 1986). The spectrum of metal contamination of feathers should thus provide a better "chemical fingerprint" than organochlorines, which are liable to vary according to what the bird has recently eaten, to indicate the origin of a young Saker trapped on migration.

The maximum concentration of mercury in blood, egg and feather samples averaged less than 0.5 ppm. Feathers also contained less than 0.5 ppm of lead, and less than 5 ppm of cadmium. In comparison, levels of metals in the feathers of diurnal European raptors would be about 1-40 ppm for mercury, 2-100 ppm for lead and 35-2000 ppm for cadmium (Dietrich & Ellenberg 1986; Hahn *et al.* 1993). Concentrations of these industrial contaminants in the feathers of Saker Falcons from Kazakhstan were therefore less than half those of the least contaminated European diurnal raptors. This confirms the relative lack of environmental contamination in the central Asian part of the Saker distribution. Moreover, it suggests that, when more material has been collected, it may be practical at the least to distinguish Sakers from the European part of their range from those in Kazakhstan on the basis of metals in small samples of feather.

ACKNOWLEDGEMENTS

Many thanks are due to M. al Bowardi, N.J. Fox, R.J. Hornby and K.E. Riddle for helping to keep this project running. In Kazakhstan we were extremely grateful to O. Belyalov, T. Bragin, V. Bulekbayev, A. Kovshar and O. Kurilova for advice and practical help, to the Ministry of Ecology and Bioresources for licences and to the National Academy of Sciences Institute of Zoology for facilities. In Britain we thank K.H. Hodder for logistic support, M. French for chemical analyses, A.J. Gray for commenting on a draft manuscript and the British Trust for Ornithology for use of their ringing scheme.

We also thank N. Barton and K.E. Riddle in the U.A.E. for reporting microtransponders, P. Paillat for information from Saudi Arabia, and C.J. Henny for the opportunity to publish this material. The project depended on generous support from Board Members of the National Avian Research Center, particularly His Highness Sheikh Khalifa bin Zayed Al Nahyan, Crown Prince and Deputy Ruler of Abu Dhabi, and Lt. General His Highness Sheikh Mohammed bin Zayed Al Nahyan, Chief of Staff of the UAE Armed Forces.

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Robert E. Kenward
Institute of Terrestrial Ecology,
Furzebrook Research Station,
Wareham BH20 5AS,
United Kingdom.

Anatoli Levin
Institute of Zoology,
Kazakhstan Academy of Sciences,
Alma-Ata
480032 Kazakhstan

Ralf H. Pfeffer,
Kolbenzeil 12,
69126 Heidelberg,
Germany

Evgeny A. Bragin,
Altinsarina Street 45.I,
Kystanayskaja Oblast,
Naursymskii Rajon,
459730 Kazakhstan

Ian Newton,
Institute of Terrestrial Ecology,
Monks Wood Experimental Station,
Abbots Ripton,
Huntingdon PE17 3PS,
United Kingdom.