Mercury in feathers of the Peregrine Falcon *Falco peregrinus* in Finland

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Moulted feathers from adult Peregrines and feather samples from nestlings were analysed for mercury by the neutron activation method. The mean level for adult birds in Finland (x = 20.03 µg/g) did not differ from that found for Peregrines breeding in northern Sweden. Both populations feed mainly on migrating aquatic bird species, which have high levels of mercury compared to terrestrial species. The levels in nestlings were lower than in adults, probably due to the shorter time of exposure to mercury.

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Introduction

Mercury compounds used in agriculture and industry have raised the levels of mercury in terrestrial and aquatic food chains. In Finland rivers and lakes have been polluted by mercury used in the paper and pulp industry and in the chloralkaline industry (Särkkä et al. 1978, Häsänen 1973), and high levels of mercury have been noted locally in fish and their predators, such as the Osprey *Pandion haliaetus* (Häkkinen & Häsänen 1980). The poor reproductive success of the White-tailed Eagle *Haliaetus albicilla* in the Baltic was considered to be partly an effect of mercury (Koivusaari et al. 1976).

The Peregrine *Falco peregrinus* population in Finland declined drastically during the 1950s and 60s (Linkola & Suominen 1969), probably due to pesticide contamination, although no clear evidence in the form of pesticide analyses exists from that time. The use of alkyl mercury for seed dressing in Sweden 1940—1966 was probably one of the reasons for the Peregrine decline in Sweden (Berg et al. 1966, Borg et al. 1969, Lindberg, unpubl.). In Finland only small amounts of alkyl mercury were used and no significant lethal poisoning of wildlife was diagnosed up to 1966 (Henriksson et al. 1966). Still, it is possible that Finnish Peregrines were contaminated on their breeding grounds by migratory prey, and also during the time spent on their migration routes and winter areas in western Europe.

Material and methods

Twenty-four moulted feathers (primaries, secondaries and rectrices) from adult falcons were obtained from 10 nests (65°00′ — 68°00′, 24°00′ — 28°00′E) in 1976—77. Most of the feathers were derived from females because they moult earlier (Mebs 1960, Stresemann 1966) and tend to stay closer to the nest than male birds (Enderson et al. 1972). Primaries and rectrices, which are the first in the moulting sequence, predominate in the material. From nestlings (age 21—35 days) we cut the distal part of a secondary and/or a rectrix. From nests with two or more young, we took one feather sample from each bird; from nests with only one chick, we took two feathers.

The mercury levels in feathers are fixed during growth and thus represent the levels in the blood during feather formation. Due to the time lag between the loss of the old feather and the formation of its calamus, the levels do not represent the time of moult. With the aid of the known moulting sequence and the date of which each feather was found, we estimated that the levels recorded for the adult birds reflect intake during July — September, one year earlier.

We were able to determine the exact time of the growth of the nestling feathers, and the mercury levels correspond to the amounts in their food during the period 25 June — 25 July of the same year.

The total mercury concentration in the feathers was determined by the neutron activation method (Sjöstrand 1964, Christell et al. 1965) at the Isotopes Techniques Laboratory in Stockholm, Sweden. From the moulted feathers a small sample of the calamus was taken while the feather samples from the nestlings also contained parts of the vane. The levels are expressed in µg/g dry weight.

Results and discussion

The mean levels found for the adult birds in 1975—76 are given in Table 1. The sample is too small to allow separation of the data for males and females. Furthermore, as no significant differences in the levels were found between the years ($P>0.05$, Mann-Whitney U-test), we used the mean ± S.D. of 20.03±7.40 µg/g obtained for all the feather samples in the following comparisons.

The mercury levels in the young from different nests varied between 3.08 and 12.25 µg/g, averaging 6.95 µg/g (Table 1). The variation within a brood was lower than between broods, because all the young in a nest are fed on mainly the same type of food. Similar observations have been made on young Eagle Owls *Bubo bubo* (Odsjö & Olsson 1975) and Ospreys (Häkkinen & Häsänen 1980). The variation between nests probably reflects differences in contamination levels in the food chains. It was not possible to correlate the levels with certain prey species or to detect a regional trend, with higher levels in nests situated in mercury-polluted areas (Särkkä et al. 1978), because our information on the food choise was sparse.

The mercury levels in the nestlings were significantly lower than in the adults ($P>0.05$, Mann-Whitney U-test), most likely due to the shorter exposure time to mercury. The mean of the adults was 2.8 times as high as that of the nestlings.

Feather analyses from different regions in northwestern Europe show great regional variation in contamination levels. Low levels were noted among falcons in Scotland and southern Sweden (Lindberg & Mearns 1982).

The raptors in the low-level areas prey mainly on terrestrial bird species, while aquatic species form the bulk of the food of the northern Peregrines. We compared the Finnish Peregrines with the birds breeding at the same latitude (65°00′ — 68°00′N, 16°00′ — 24°00′E) in northern Sweden. The breeding period, food choice and wintering areas were similar, but the nest sites differed. Migrant waders formed 52 % (N = 404) of the food items in Finland (Huhtala & Sulkava 1977) and 57 % (N = 765) in Sweden (Lindberg 1977). In a study of pesticide levels in certain prey species in 1976—77, high mercury levels were recorded in waders, such as the Snipe *Gallinago gallinago* and the Greenshank *Tringa nebularia,* while low levels were found in terrestrial bird species, such as the Willow Grouse *Lagopus lagopus* and the Pigeons *Columba palumbus, C. livia* (Lindberg et al., unpubl.). We thus presume that the Peregrines in northern Fennoscandia mainly take up mercury from certain waders.

The mercury levels in the adult Finnish Peregrines did not differ markedly ($P>0.05$ Mann-Whitney U-test) from those of Swedish birds from the same period, 1975—76, $\bar{x}$ = 18.17 ± 6.86 µg/g (N = 18). The same holds for the mean levels in the nestlings ($\bar{x}$ = 6.93 ± 1.97 µg/g, N = 8, 5 nests).

Table 1. Mercury concentrations as µg/g dry-weight (mean, S.D. and range) in feathers of adult and nestling Peregrines in 1975—77.

Year of feather formation	Number of individuals	Sample size	Hg $\bar{x}$ µg/g ± S.D.
Adults			
1975	8	11	21.96± 9.25
1976	10	13	18.40± 5.24
Total	18	24	20.03± 7.40 (4.76—37.30)
Nestlings			
1976	12	15	7.52± 3.51
1977	8	10	6.08± 1.45
Total	20	25	6.95± 1.45 (2.02—13.3)

At present we have no information on the natural background levels for Finnish Peregrines. However, up to 1940 the concentrations in Peregrines in Finland were probably of the same magnitude as in Sweden. The means recorded here for the nestlings and adults are both significantly higher than that for Swedish Peregrines in 1834—1940 ($\bar{x}$ = 2.58 ± 1.65 µg/g, N =11; Berg et al. 1966). Still lower levels were found in a captive Finnish Peregrine fed on a controlled diet of chickens and laboratory rats. The initial level, $\bar{x}$ = 5.37 ± 1.06 µg/g, reflecting the intake on the breeding ground, decreased to a mean of 0.57 ± 0.27 µg/g in the second plumage grown in captivity.

Häkkinen & Häsänen (1980) showed great regional variation in mercury levels in Osprey nestlings. In 1972, the mean levels in contaminated areas varied between 18.3 and 24.7 µg/g, being five to sevenfold those in unpolluted areas. No difference in reproductive success was observed between the areas. Certain nests in the contaminated area were re-sampled in 1978. Although the mercury levels had decreased significantly, in most nests they still exceeded 10.0 µg/g. The decrease in levels was not followed by increased productivity and the authors conclude that the observed decrease in the Finnish Osprey population must be due to other factors than mercury.

The levels recorded in the Peregrine nestlings are lower than in Osprey nestlings in contaminated areas. It is thus probable that the mercury contamination during the investigation period had

only minor effects on the condition of the population. This conclusion is supported by the stabilization and slight increase in reproductive success of the Peregrine population during the period 1975—1980.

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Selostus: **Muuttohaukan sulkien elohopeapitoisuuksista Suomessa**

Vuosina 1975—77 kerättyjen 18 aikuislinnun ja 20 poikasen sulkien elohopeapitoisuudet analysoitiin neutroniaktivointi-menetelmällä Ruotsissa. Sulkien elohopeamäärät kuvastavat lintujen veren elohopeapitoisuuksia kesäkuukausina. Vuosien välisiä eroja ei havaittu. Aikuislintujen sulkien elohopeapitoisuus oli keskimäärin 20.03 Hg µg/g (taulukko 1). Poikassulkien pitoisuudet vaihtelivat rajoissa 2.02—13.30 µg/g (keskimäärin 6.95 µg/g). Pesyeiden välinen vaihtelu oli suurempi kuin pesyeen sisäinen vaihtelu. Tämä kuvastanee eroja ravintoketjun kuormituksessa. Poikasten elohopeapitoisuus oli merkitsevästi alhaisempi kuin aikuisten (suhde 1:2.8), mikä todennäköisesti johtuu poikasten lyhyemmästä alttiinaoloajasta.

Aikuislintujen sulkien elohopeapitoisuudet olivat samalla tasolla kuin Pohjois-Ruotsin muuttohaukkojen. Etelä-Ruotsin muuttohaukoilla on mitattu pienempiä elohopeamääriä. Pohjoisen muuttohaukat käyttävät ravinnokseen etupäässä kahlaajia kun taas etelässä tärkeimmät ravintokohteet ovat maalintuja; kahlaajilla on mitattu korkeampia elohopeamääriä kuin maalinnuilla. Muuttohaukan elohopeakuormitus oli kuitenkin niin alhainen, että elohopealla lienee hyvin pieni vaikutus kannan kehitykseen.

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