Toxic chemicals in sedentary and migratory birds in Fennoscandia and the Baltic area

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The present paper reports some recent results concerning the occurrence of DDT, PCB and mercury in the avifauna of Sweden and the surrounding waters. Special attention is paid to changes in the levels of these substances in birds owing to restrictions in their use in recent years.

Introduction

Most species of the north European bird fauna are migratory. Many bird species breeding in Fennoscandia thus spend the year in different areas with varying contamination and consequently accumulate varying amounts of toxic substances. Owing to the long migration routes of several bird species, known in general terms through bird-ringing, it is incorrect to assign residue levels in bird specimens exclusively to the sampling areas. However, sedentary birds staying or roaming in limited areas and young birds collected when fledged can be used for studying contamination in a particular area. Analytical results obtained from eggs should be regarded with caution as representative for the contamination of the breeding sites. It is often more accurate to refer these figures to levels in the females laying the eggs, which in turn are dependent on their migration routes and residence places before egg-laying. However, birds can be useful as test organisms for different kinds of studies, such as for the determination of environmental contamination, and an indication of the effects of noxious substances.

A considerable amount of information is now available on the occurrence of the most common pollutants (DDT and PCB compounds, toxic trace metals, etc.) in bird species. There are also many indications as to the kind of effects these substances have on birds.

Several bird populations have declined during the last few decades and the continued existence of some species has been threatened by environmental pollution. This applies to the exposed bird species, which are in many cases the predatory birds but which also include species whose food is directly contaminated by toxic and accumulative substances (e.g. seed-eating birds feeding on dressed seed).

However, national and international cooperation between many research institutions and nature conservancy organizations has often been followed by restrictions in the use and release of toxic chemicals in the natural environment, and protection of declining bird populations. Some observations are presented below on the occurrence of toxic chemicals in sedentary and migratory birds, mainly in Fennoscandia and the Baltic area.

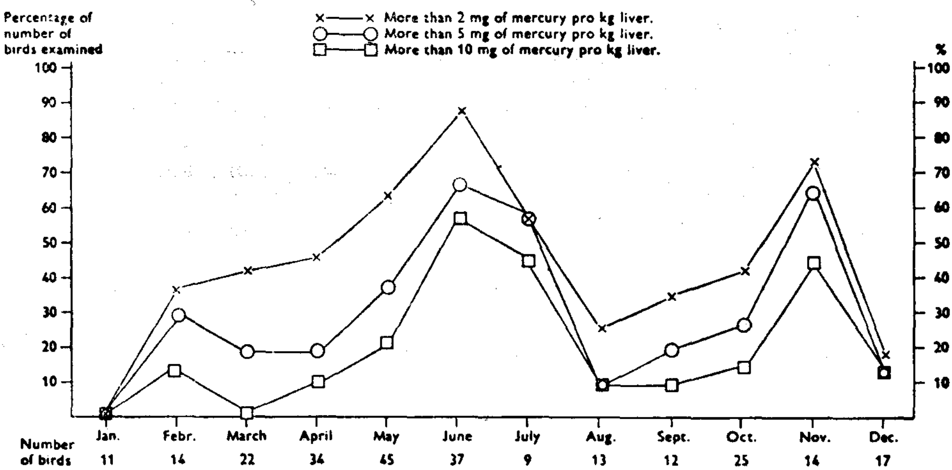


FIG. 1. Seasonal variation of mercury levels inseed-eating birds found dead in 1964 in Sweden. From BORG et al. 1969.

Mercury, DDT and PCB compounds in the terrestrial avifauna

Prior to 1920, inorganic mercury compounds were used in Sweden as seed-dressing agents in agriculture. In the 1920s and 1930s they were replaced by alkoxy-alkyl and phenyl mercury compounds. In 1940, alkyl mercury compounds were introduced, among which methyl mercury was dominant, and by the middle of the 1950s this compound had almost completely replaced the seed-dressing agents previously used. Alkyl mercury was found to accumulate in the central nervous system and other organs at a much higher rate than other mercury compounds (GAGE 1961, ULFVARSON 1962, BERLIN and ULLBERG 1963). BORG (1958) showed high levels of mercury in birds found dead or unhealthy in Sweden. BORG and coworkers (1969) were also later able to demonstrate connections between the seasonal variation of mercury levels in seed-eating birds found dead in Sweden in 1964 and the use of seed dressed with alkyl mercury in spring and autumn (Fig. 1).

Mercury in birds can be estimated from the levels in their feathers, since these levels are related to the amount of mercury circulating in the bloodstream

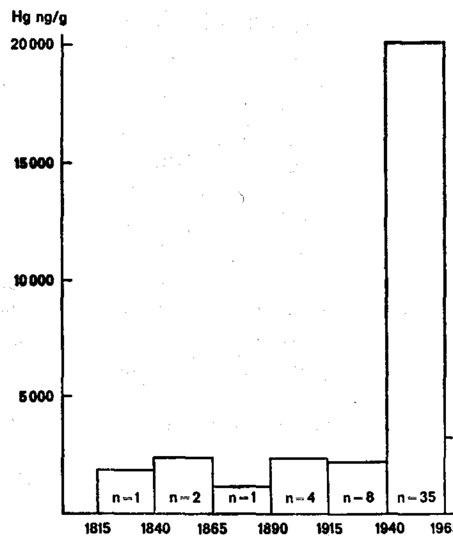


FIG. 2. Mercury levels in feathers from females of Goshawk *Accipiter gentilis* collected at the nest during April-June, from the previous century and up to 1966. The material is combined in periods of 25 years. After 1966 the material is 14 specimens with a mean content of 3 360 ng/g (1 ng = 10^{-9} g). From JENSEN et al. 1972 a.

during the formation of the feathers (BERG et al. 1966). Mercury levels in the feathers of seed-eating and predatory birds increased simultaneously with the change to alkyl mercury in agriculture (Fig. 2). The average increase was 10—20-fold, depending on the investigated species (BERG et al. 1966). At the beginning of 1966, the use of alkyl mercury in seed-dressing agents was banned in Sweden and replaced by the alkoxy-alkyl mercury previously used. Following this ban, the mercury levels in the feathers of many birds e.g. Goshawk *Accipiter gentilis,* Marsh Harrier *Circus aeruginosus,* Yellowhammer *Emberiza citrinella,* dropped to values only slightly higher than those which were prevalent before 1940, i.e. approximately the natural background levels (JENSEN et al. 1972 a, WESTERMARK et al. 1975).

Serious damage, particularly to the populations of predatory bird species had, however, already been inflicted, and remains to some extent even today.

In a series of feathers from adult and juvenile Eagle-Owls *Bubo bubo* from 1964—1974 the mercury content was found to decrease rapidly after 1966. Since 1970 the average levels in the feathers of adults range between 3 and 9 ppm (ODSJÖ and OLSSON 1975). WANNTORP and coworkers (1967) also demonstrated a striking decrease in the mercury content in the liver of the Wood Pigeon *Columba palumbus* between 1964—1966.

In connection with an annual study of pesticides in the Starling *Sturnus vulgaris* carried out since 1967 under the auspices of the OECD, the feasibility of studying the accumulation of contaminants in the winter quarters has been evaluated. Starlings returning to Sweden in the spring were often found to contain dieldrin in the pectoral muscle (JENSEN et al. 1970). The use of dieldrin has been prohibited in Sweden for agriculture since 1964 and for all other purposes since 1970. Consequently, dieldrin was not detected in the native fauna, although it was still in use at later dates on the Starlings' wintering grounds in western Europe and was thus accumulated.

The investigations were extended to other migrants, chosen for the purpose of studying conditions in widely scattered wintering regions. The bird species primarily studied were the Robin *Erithacus rubecula* (winter quarters for birds breeding in Sweden: southern Europe), the Pied Flycatcher *Ficedula hypoleuca* (Iberian peninsula and northwestern Africa), the Garden Warbler *Sylvia borin* (tropical Africa) and the Barn Swallow *Hirundo rustica* (southern Africa). Old birds were collected on spring passage and young birds on autumn passage at Falsterbo and Ottenby in southern Sweden. The levels in young birds showed the quantities of various chlorinated hydrocarbons, which were accumulated in the north European area, while the levels in old birds indicated for the most part the accumulation in the winter quarters and along the migration route to the north. The levels are certainly to some extent a function of the age of the bird (i.e. o fthe period of exposure to the substances in question). DDE levels are especially high in adult Robins and Pied Flycatchers, which spend the winter in the Mediterranean countries and on the Iberian peninsula, where pesticides are used on a large scale in orchards and vineyards in particular. The Barn Swallow and the Garden Warbler, which winter in south Africa and tropical Africa respectively, seem to be less exposed to contamination because of the small use of DDT within the wintering areas (although in these cases one must take into account their long migration routes).

Concerning the Robin, two specimens

with extremely high levels of DDE can be noted; 1 800 ppm and 810 ppm respectively in the fat of the pectoral muscle. Such high amounts may lead to acute poisoning during periods of starvation, when the chlorinated hydrocarbons in the body fat are rapidly transferred to the nervous system (BERNARD 1963, LUDWIG and LUDWIG 1969). The fact that dieldrin is accumulated abroad has already been mentioned; this also applies to lindane. PERSSON (1972) obtained similar results for total DDT and lindane in Whitethroats *Sylvia communis*. Regarding the results from the analysis of PCB in these bird migrants, there were significant differences between adults and juveniles in Robins. For mercury, significant differences exist between adults and juveniles of both Robins and Garden Warblers. The highest mean levels were found in adult specimens.

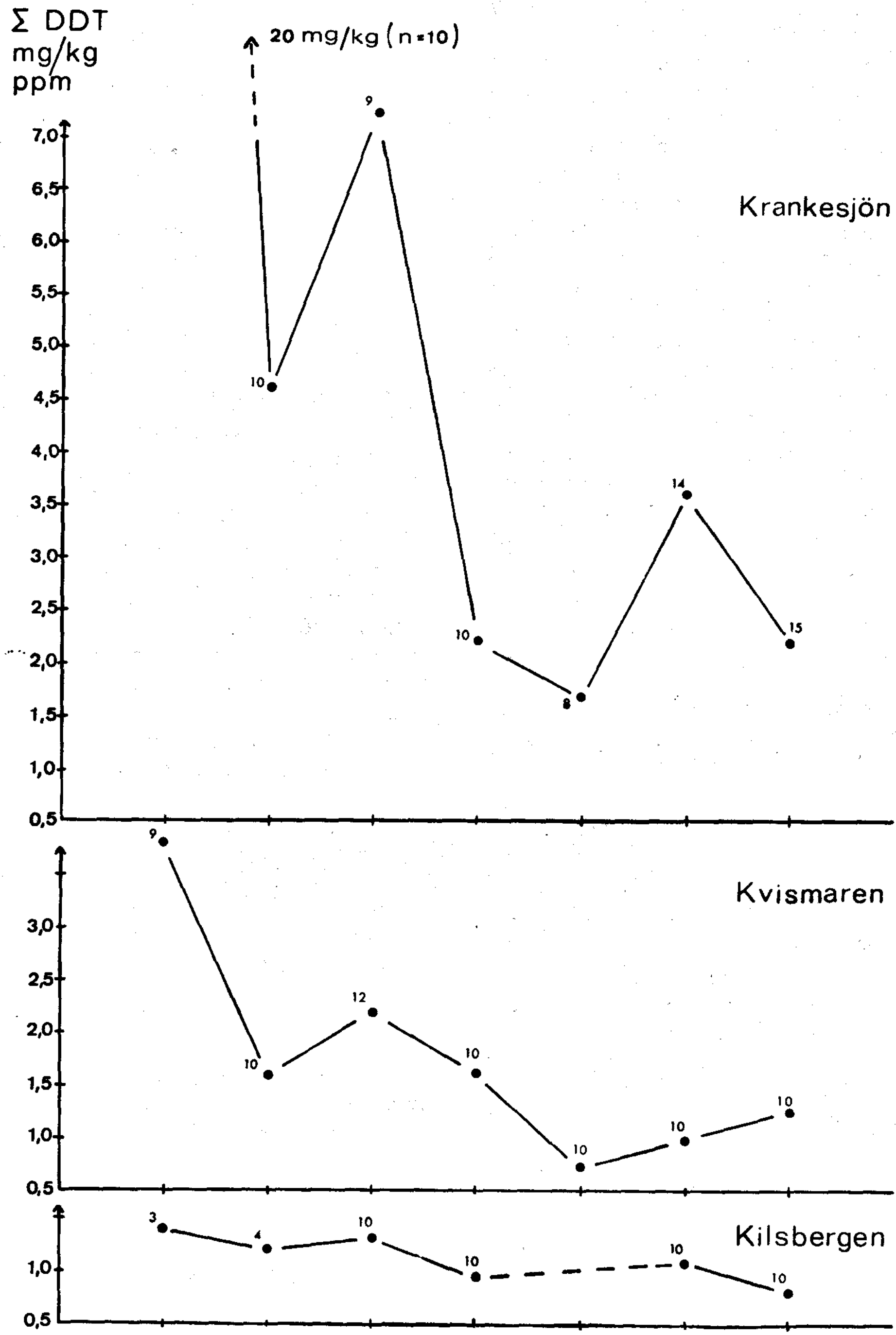
A ban on the use of DDT in Swedish agriculture has been in effect since 1970, although it is still used to some extent in forestry (about 6 metric tons per year) for the treatment of pine and spruce saplings prior to planting. The results of this restriction has apparently been a considerable decrease in the levels of DDT in the Swedish fauna. The contamination of migratory birds with DDT in recent years has definitely been due more to foreign than Swedish use. The levels of total DDT in the pectoral muscle of juvenile Starlings has been studied since 1967. Specimens from 4 different localities were analysed and the levels of DDT substances were found to decrease after 1970 in the typical agricultural areas (Krankesjön, Kvismaren) while they remained unchanged in the forest areas (Kilsbergen, Enånger. Fig. 3.)

Mercury, DDT and PCB compounds in the aquatic avifauna

Until 1967, extensive quantities of mercury were discharged into Swedish lakes and waterways by chlorine-alkali factories, and paper industries and pulp mills. The latter used organic mercury compounds as fungicides. The amounts of mercury in fish were so high at some places that a clear health hazard to man was involved and this led to a ban on the sale of fish from a number of lakes, streams and coastal areas — a ban which is still in effect.

The mercury was accumulated in the food-webs and reached the birds. Certain fish-eating species were found to contain high levels. Through analysis of feathers from museum specimens of the Great Crested Grebe *Podiceps cristatus* and the Osprey *Pandion haliaëtus*, the historical development of mercury contamination in these species was successfully elucidated (JOHNELS, OLSSON and WESTERMARK 1968; JOHNELS and WESTERMARK 1969). In contrast to the terrestrial bird species, which were exposed to methyl mercury in seed-dressing agents in the 1940s (see above), the fish-eating species exhibit a progressive increase in mercury accumulation from the close of the 19th century (Fig. 4). This fits in with the fact that the aquatic environment has been subjected to an increase in the discharge of mercury accompanying industrial development since the turn of the century, mainly from the wood and paper industries and from chlorine-alkali factories, and aquatic organisms have been affected as a result (JOHNELS et al. 1967).

With the knowledge gained through ringing concerning the residence quarters of the Osprey during the various seasons (ÖSTERLÖF 1951 and personal communication), together with the study of its moulting pattern (EDELSTAM 1969), it has been possible to compare the levels of mercury pollution in Sweden and tropical Africa (Fig. 5). A nestling contained mercury at approximately 20


Σ DDT
mg/kg
ppm
20 mg/kg (n=10)
Krankesjön
Kvismaren
Kilsbergen
7,0
6,5
6,0
5,5
5,0
4,5
4,0
3,5
3,0
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2,0
1,5
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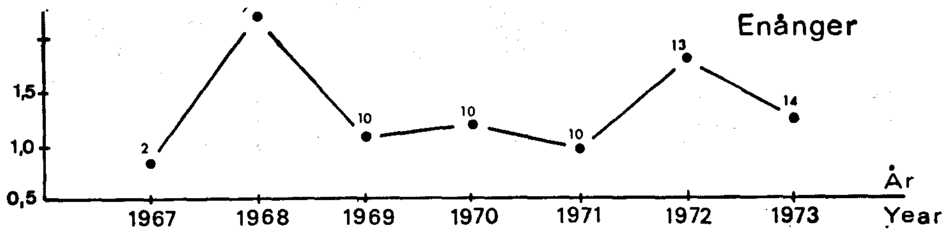

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FIG. 3. Average levels of DDT-compounds in extractable fat of pectoral muscle of young Starlings in 1967—73. The Starlings were sampled in Krankesjön and Kvismaren (agricultural areas) and in Kilsbergen and Enånger (woodland areas). Number of specimens indicated in the graph (JENSEN, S., JOHNELS, A. G. and ODSJÖ, T., unpublished).

ppm in its wing remiges, reflecting the contamination of the Swedish lake where it was raised (JOHNELS et al. 1968). The wing remiges of an old Osprey, which returned from its winter quarters in Africa, on the other hand, contained widely scattered levels, reflecting the mercury levels in the waters where it had been fishing at the various periods when the remiges were grown. The feathers with the highest levels were grown in the summer in Sweden, feathers with medium levels at the beginning of the winter and feathers with the lowest levels at the end of the winter in tropical Africa, reflecting the relatively low levels of mercury in fish in this region (JOHNELS and WESTERMARK 1969).

The pollution of the Baltic Sea with DDT and PCB substances has been thoroughly investigated during the last decade (JENSEN et al. 1969, 1972 a, b). The levels were 5—10 times higher in organisms from the Baltic proper compared to those from the Swedish west coast. Furthermore, the DDT levels increased from the Bothnian Bay towards the southern part of the Baltic proper. The PCB levels were more or less constant throughout the Baltic area.

The Guillemot *Uria aalge* breeds on Stora Karlsö just off the island of Gotland, and is vagrant during the winter in the southern Baltic proper. JENSEN and coworkers (1972 a) found that the average mercury level in the secondaries of the Guillemot during the period 1906—1925 was 2.7 ppm, while the average level in 1969 was 5.4 ppm, a statistically significant increase suggesting pollution of the Baltic with mercury.

SOMER and APPELQUIST (1974) analysed the mercury contents in the feathers of about 160 Guillemots and Black Guillemots *Cepphus grylle* from the Baltic, the Kattegat, the Faroe Islands and Greenland. Significantly higher mercury levels were found in bird feathers from the Kattegat and the Baltic than in those from the north Atlantic. This was found to be valid for the last few years as well as before the turn of the century. From the beginning of this century up to the 1960s, the mercury content in both species from the Swedish Baltic area has increased. However, SOMER and APPELQUIST found a mean level of 3.4 ppm in the feathers of Guillemots from 1973, which was significantly lower than the mean level of 5.4 ppm in 1969 given by JENSEN and coworkers (1972 a). The levels from 1973 are approximately the same as the levels found for 1906—1925 — 2.7 ppm (JENSEN et al. 1972 a). The mercury content in the eggs of Guillemots from Stora Karlsö has decreased signifi-

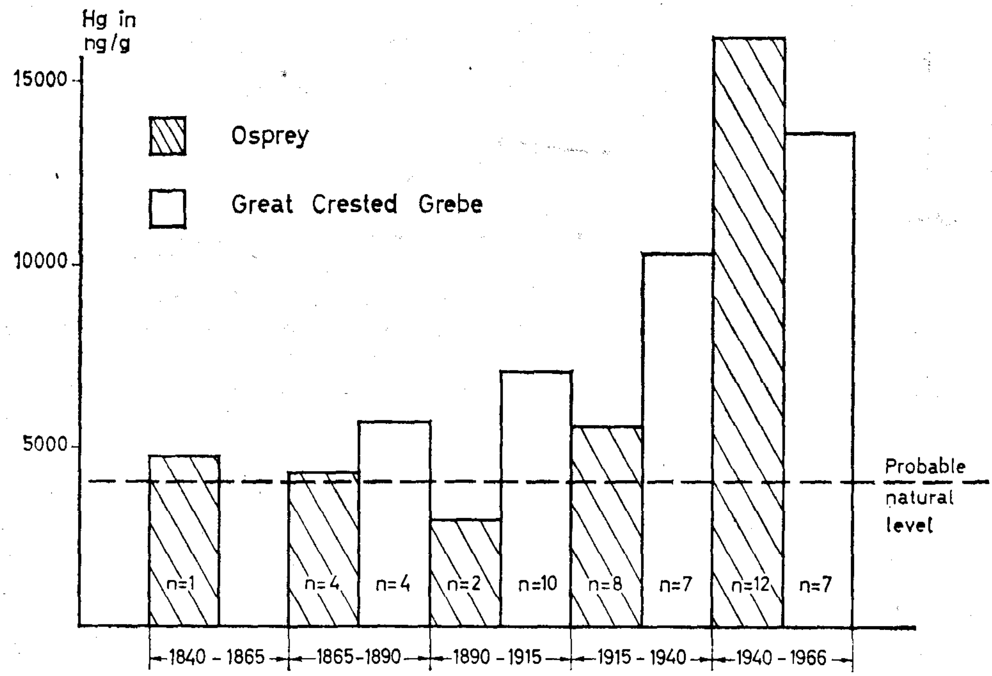

FIG. 4. Average mercury levels in feathers of Osprey *Pandion haliaëtus* and Great Crested Grebe *Podiceps cristatus* grouped mainly in 25 year periods from 1840—1966. From JOHNELS et al. 1968.

cantly from 1970 to 1973, from 0.54 ppm to 0.36 ppm (JENSEN, JOHNELS and OLSSON, unpublished data). The levels tend to approach the magnitude prevalent at the beginning of this century. This may be due to the decreased discharge of mercury from the paper and pulp industries and the chlorine-alkali industries around the Baltic.

Adult Cormorants *Phalacrocorax carbo sinensis* had statistically significantly higher mercury levels compared with juveniles in 1969, indicating heavy pollutions in their wintering quarters in south-eastern Europe (JENSEN et al. 1972 a). Analysis of the pectoral muscle of adults and juveniles showed an average mercury level on a fresh tissue basis of Whether we are primarily dealing with 3.3 ppm and 0.48 ppm respectively. agricultural or industrial mercury in this case is as yet unclear. The DDT levels in the extractable fat of the pectoral muscle of adults and juveniles were 580 ppm and 20 ppm respectively and for PCB's 240 ppm and 14 ppm.

The White-tailed Eagle *Haliaeetus albicilla* from the Stockholm Archipelago contains very high levels of both mercury and chlorinated hydrocarbons. In one specimen the DDT and PCB compounds comprised 3.6 % and 1.6 % respectively of the body fat. The average levels of DDT and PCB compounds in the extractable fat of the pectoral muscle in four White-tailed Eagles from the Stockholm Archipelago were 25 000 ppm and 13 000 ppm respectively, and the average mercury level in the fresh tissue of the pectoral muscle was 13.2

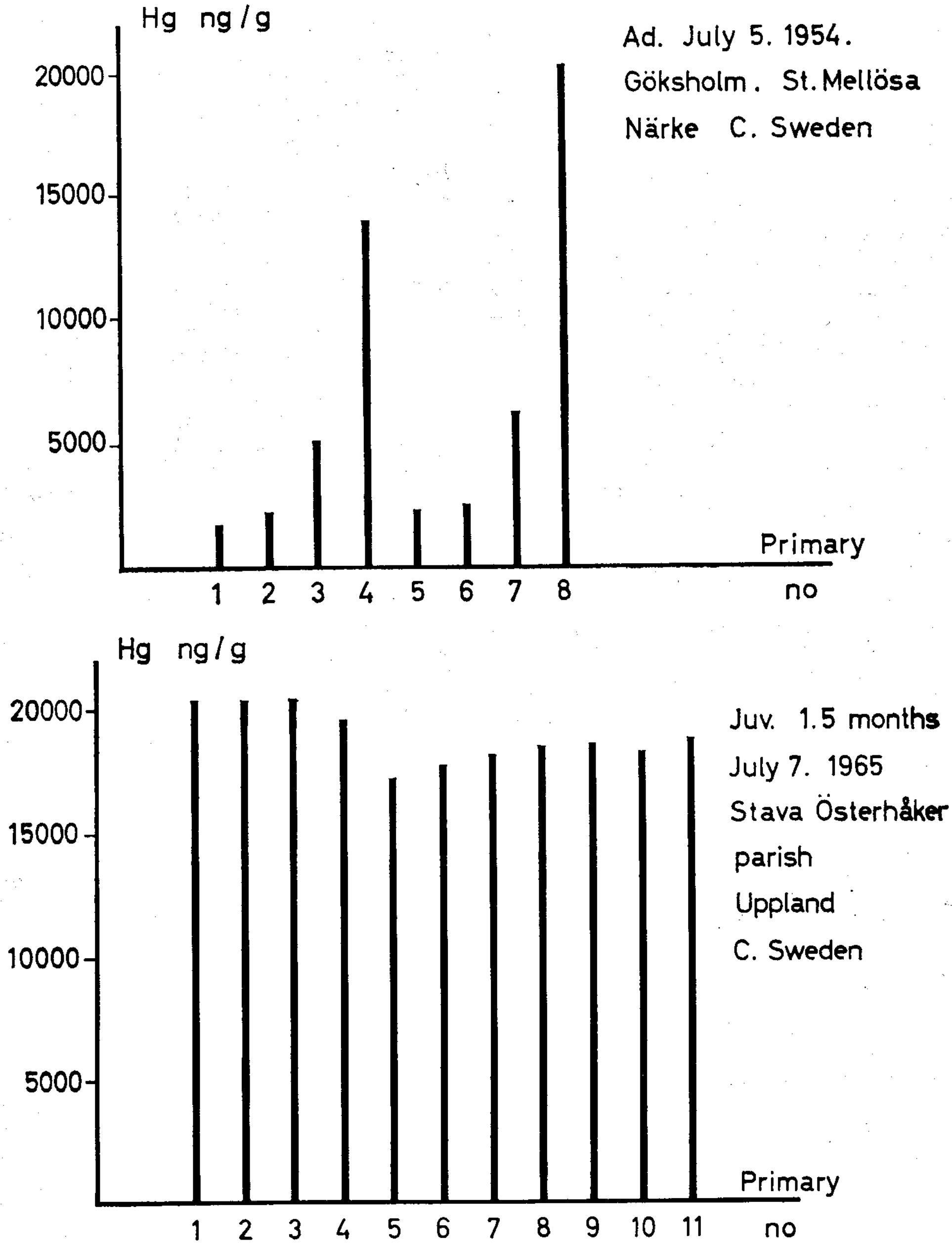

FIG. 5. Mercury levels in the primary feathers of Osprey *Pandion haliaëtus*. Upper and lower figures show levels in an adult and a juvenile respectively. From JOHNELS et al. 1968.

ppm (JENSEN et al. 1972 a). The high levels of mercury, DDT and PCB are due partly to the fact that the White-tailed Eagle feeds to a considerable extent on large fish and waterfowl, which in turn accumulate contaminants from the water. The catastrophic nature of this situation is evident from the almost total reproductive failure of this bird species in recent years (Helander 1972, 1973). Helminen and coworkers (1969) reported mercury levels in the kidney and muscle tissue of four White-tailed Eagles from the Archipelago of Åland. The levels were 48.6—123.1 ppm and 1.9—8.5 ppm respectively.

References

Berg, W., Johnels, A. G., Sjöstrand, B. and Westermark, T. 1966. Mercury content in feathers of Swedish birds from the past 100 years. Oikos 17:71—83.

Berlin, M. and Ullberg, S. 1963. Accumulation and Retention of Mercury in the Mouse. Archives of Environmental Health 6:589—616.

Bernard, R. F. 1963. Studies on the effects of DDT on birds. Publications of the Museum. Michigan State University. 2(3).

Borg, K. 1958. Inverkan av betat utsäde på viltfaunan. Proc. VIII Nord. Veterinärmötet, Helsingfors, pp 394—400.

Borg, K., Wanntorp, H., Erne, K. and Hanko, E. 1969. Alkyl mercury poisoning in terrestrial Swedish wildlife. Viltrevy 6:302—379.

Edelstam, C. 1969. Ruggologi eller fåglarnas fjäderbyte. Forskning och Framsteg 3:25—29.

Gage, J. C. 1961. The Trace Determination of Phenyl- and Methyl-mercury Salts in Biological Material. The Analyst 86:457—459.

Helander, B. 1972. Örndata. Projekt havsörn under 1971 och 1972. Sveriges Natur 6:287—290.

— 1973. Projekt havsörn 1973. Sveriges Natur 6:299—301.

Helminen, M., Henriksson, K. och Karppanen, E. 1969. Kvicksilverhalter hos våra vattenfåglar. Jakt och Vilt. Årsbok för Finlands jägare och fiskare, pp 102—106.

Jensen, S., Johnels, A. G., Olsson, M. and Otterlind, G. 1969. DDT and PCB in Marine Animals from Swedish Waters. Nature 224:247—250.

Jensen, S., Johnels, A. G., Odsjö, T., Olsson, M. and Otterlind,G. 1970. PCB-occurrence in Swedish wildlife. PCB-Conference. Ed. by National Swedish Environment Protection Board, Stockholm pp 29—42.

Jensen, S., Johnels, A. G., Olsson, M. and Westermark, T. 1972 a. The avifauna of Sweden as indicators of environmental contamination with mercury and chlorinated hydrocarbons. Proc. of the XVth Intern. Ornith. Congr. 1972. E. J. Brill. Leiden, pp 455—465.

Jensen, S., Johnels, A. G., Olsson, M. and Otterlind, G. 1972 b. DDT and PCB in herring and cod from the Baltic, the Kattegat and the Skagerrak. Ambio Special Report, No. 1:71—85.

Johnels, A. G., Westermark, T., Berg, W., Persson, P. I. and Sjöstrand, B. 1967. Pike (Esox lucius L.) and some other aquatic organisms in Sweden as indicators of mercury contamination in the environment. Oikos 18:323—333.

Johnels, A. G., Olsson, M. and Westermark, T. 1968. *Esox lucius* and Some Other Organisms as Indicators of Mercury Contamination in Swedish Lakes and Rivers. Bull. Off. int. Epiz. 69:1439—1452.

Johnels, A. G. and Westermark, T. 1969. Mercury contamination of the environment in Sweden. In: Chemical Fallout. Editor: M. W. Miller and G. G. Berg. Springfield, Illinois, pp 221—239.

Ludwig, J. P. and Ludwig, C. E. 1969. The effect of starvation on insecticide contaminated herring gulls removed from a Lake Michigan colony. Proc. 12th Great Lakes Res.:53—60. Internat. Assoc. Great Lakes Res.

Odsjö, T. and Olsson, V. 1975. Kvicksilverhalter i en population av berguv *Bubo bubo* i sydöstra Sverige efter 1966 års alkylkvicksilverförbud. Vår Fågelvärld 34 (in press).

Persson, B. 1972. DDT Content of Whitethroats Lower After Summer Stay in Sweden. Ambio 1:34—35.

Somer, E. and Appelquist, H. 1974. Changes and differences in mercury level in the Baltic and Kattegat compared to the north Atlantic using *Uria sp.* (Guillemot sp.) and *Cepphus grylle* (Black Guillemot) as indicators. Conference of the Baltic Oceanographers, Kiel. 17—20 April 1974.

Ulfvarson, U. 1962. Distribution and excretion of some mercury compounds after long term exposure. Int. Arch. für Gewerbepath. u. Gewerbehyg. 19:412—422.

Wanntorp, H., Borg, K., Hanko, E. and Erne, K. 1967. Kvicksilvernivåer hos ringduvor 1964 och 1966. Svensk Jakt 105:364—365.

Westermark, T., Odsjö, T. and Johnels, A. G. 1975. Mercury content of bird feathers before and after Swedish ban of alkyl mercury in Agriculture. Ambio 4:87—92.

Österlöf, S. 1951. Fiskgjusens, *Pandion haliaëtus* (L.), flyttning. Vår Fågelvärld 10:1—15.

Japans fåglar — Japanin linnut.

Japans Ornitologiska Förening gav 1974 ut en Check-List of Japanese Birds (fifth and revised edition, Tokyo, Gakken förlag). Arbetet omfattar två band, det första, 364 sidor, helt på engelska och det andra på japanska. Det behandlade området skiljer sig från det område, som upptogs i fjärde upplagan (A Hand-List of the Japanese Birds, 1958). Det innefattar utom det egentliga Japan och dess övärld också Kurile, Ryukyu, Ogasaware (Bonin) och Iwo (Volcano). Faunans artantal har därigenom ökats från 424 till 490. Den nya upplagan börjar med lommarna och slutar med tättingarna, d.v.s. följer Wetmores system, som numera är antaget nästan överallt i världen. För varje art ges världsutbredningen och den japanska utbredningen, med noggranna lokalitetsuppgifter och kortfattade biotopbeskrivningar. Underarterna behandlas noga och i fotnoter dryftas ofta deras systematiska ställning. Dessa kritiska anmärkningar och vissa uppgifter om förekomsten har inte publicerats tidigare. Ehuru Japans fauna kan tyckas stå mycket fjärran från Finlands om man utgår från det geografiska avståndet mellan länderna, hör båda till den palearktiska djurregionen och har således mycket gemensamt. T.ex. över en tredjedel av tättingarterna är gemensamma med Europa, ytterligare hälften av arterna hör till samma släkte, och bara ungefär 15 % av släktena är främmande för en europé. Därför kan denna klart och noggrannt skrivna artlista hälsas välkommen. Författarna, i synnerhet Nagahisa Kuroda, Hiroyuki Morioka och Keysuke Kobayashi, som stått för lejonparten av redigeringen och systematiken, kan lyckönskas.

MIKLOS VON UDVARDY

Tämä kaksiosainen lintuluettelo ja -fauna on painotuotteena harvinaisen puhdas ja miellyttävä. Ennen kaikkea tämä koskee lyhyempää, japaninkielistä osaa siroine kirjaimineen. Kiinassa ja Japanissa kalligrafiasta on kehittynyt taiteen muoto, jota aikoinaan verrattiin maalaustaiteeseen ja runoiluun. Tämä vanha kulttuuriperinne vaikuttaa vielä meidänkin päivinämme huolimatta siitä, että Japanista on kehittynyt länsimaisen teollistuneen sivistyksen supervalta.

L.v.H.