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PCB in Swedish wildlife
A preliminary report

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In 1966 Jensen identified polychlorinated biphenyls (PCB) in samples of fish and birds and also found indications that these compounds might appear as contaminations in the ecosystems. Since then it has been demonstrated that the PCBs are widely dispersed in the global ecosystem (Risebrough et al. 1968). Studies have shown that they are also distributed in Britain (Prestt et al. 1970), in the coastal areas of the Netherlands (Koeman et al. 1969), and in the marine waters along the Swedish coast (Jensen et al. 1969).

The treatment of the material and the analytical method has been described previously (Jensen et al. 1969). The material has been collected at localities, the positions of which are indicated in fig 1. The values based on extractable fat are of particular interest from an ecological point of view (Jensen et al. 1969). Fat is important in the transport of energy and as a carrier of residues between the species in the food web. Furthermore, there is a seasonal variation in fat content within the populations. The difference between the greatest and the smallest residue level in the extractable fat of individuals of one species, at a given time in a given place, is less than in fresh tissue. The figures therefore are based largely on resudue levels in extractable fat.

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Terrestrial

Adult specimens of starling (Sturnus vulgaris) have been sampled on their arrival at breeding areas where later also juveniles have been collected. The sampling has been performed in three years, 1967-69. Pectoral muscle has been removed and each specimen has been analysed individually. The results are presented in fig. 2. Locality 1, Kranklesjön, is situated

in typical farmland in the southernmost part of Sweden. Locality 2, Kvismaren, also is dominated by cultivated areas. As in the case of locality 1 the bedrocks here is of cambro-silurian origin. Locality 3, Kilsbergen, is situated only 20 kilometres to the west of number 2 but the area is dominated by coniferous forests and the bedrock is granite. Locality 4, Enånger, is within the area of coniferous forest typical of North Scandinavia. Although there is a variation in the levels between the years, it can be seen from the diagram (fig 2) that they are, as a rule, lower in the juveniles than in the adults. Although the localities are widely distributed and differ markedly concerning natural conditions as well as influence of human activities the levels are roughly the same within the groups of juveniles and adults. The adults have spent the winter in western Europe (Great Britain, the Netherlands, Belgium and France). It is known that on return from these areas they contain some dieldrine which has been acquired within their winter quarters. If the same process takes place in the case of PCB is not certain. The lower content of PCB in the juveniles than in the adults may be the result of a slow accumulation process.

The levels of total DDT (DDT and metabolites of this compound) and of PCB in pectoral muscle and eggs of some Swedish birds are listed in table 1. With the exception of a few adult fieldfares with an exceptionally high level of DDT the predatory birds are, as is well known, generally on a higher level than other birds in the case of both types of compounds. The levels are higher in the adults and as a rule also the ratio between DDT and PCB is higher in the adults than in the juveniles.

Fresh water

Samples of pike have been collected in the years 1967, 1968 and 1969 in lake Bolmen (fig. 1, nr 5) in the southern part of Sweden and for some of the years in lake Storvindeln (fig 1, nr 8) in the northern part of Swedon. Some specimens are

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available also from the lakes Roxen and Ymsen (fig 1, nrs 6 and 7) in the south central part of Sweden. The results from lake Bolmen indicate that considerable changes may occur between the years. It seems, however, that the ratio between DDT and PCB is fairly constant. Bolmen is an ologotrophic lake and so is Storvindeln. This lake is very remote from industrial influence, at least within the borders of Sweden, but nevertheless the levels of PCB seem to be roughly comparable between these two lakes. The lakes Ymsen and Roxen are both highly eutrophic. However, Ymsen is located in a farmland area while Roxen also has a strong influence from densely populated and industrialized areas. This may serve to explain the great difference in PCB-content, Roxen being very high.

Marine

In table 3 material of the following species is included: herring (Clupea harengus), Dog fish (Squalus acanthias), Salmon (Salmo salar), Grey seal (Halichoerus grypus), Common seal (Phoca vitulina) and ringed seal (Pusa hispida), guillemot (Uria aalge), white-tailed eagle (Haliaetus albicilla). A few samples of separated fish oil were also analysed. Two of the samples from the west coast were from the Norway pout (Borcogadus esmarki) and one from herring. The single oil sample from the Baltic is herring oil which was unseparated.

In fish axial muscle tissue was analysed. Most of the samples from the seals were taken from the blubber in the tail. In the white-tailed eagle samples were taken from both the pectoral muscle and the brain. All the eagles were found dead and in some cases in a state of decay.

DDE is the principal metabolite of DDT found. In the case of seals from the Archipelago of Stockholm and in salmon from the Baltic proper relatively large amounts of DDD were found (about 40 % DDD of total DDT).

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The mean figures in table 3 are calculated from the average value of each locality within the regions "Swedish West Coast", "Baltic Sea" including the sound between Sweden and Denmark, "the Archipelago of Stockholm" and the "Gulf of Bothnia". The residue values are based on hexane extractable fat. Most of the material including figures on fresh tissue basis have been published earlier (Jensen et al. 1969).

The samples of herring from the Baltic proper, the Archipelago of Stockholm and the Gulf of Bothnia had all larger residues of DDT-compounds and PCB than the herring samples from the West Coast. Juvenile herring from coastal waters of the Netherlands contained DDE-residues in fresh tissue with an upper level of the same magnitude as in herring from the Baltic Sea area (Koeman et al. 1967). Residues of PCB and DDT-compounds in one sample of fish oil from the south part of the Baltic were about 5-10 times greater than the three samples from the West Coast of Sweden. One herring from the sound between Sweden and Denmark had a much larger content of PCB (23 ppm on fat basis) than the herring from the rest of the Baltic area. This level increases the average value of this area from 4.6 to 6.8 ppm. This may suggest that there is a local contamination of PCB in the sound. There is an increase in content of DDT-compounds as well as PCB from the Gulf of Bothnia via the Stockholm Archipelago to the south of Baltic proper, indicating increasing sources of both these substances towards the south of the Baltic Sea.

The vagrant Baltic salmon has about ten times more chlorinated hydrocarbon residues than a sample reported from Great Britain (Holden and Marsden 1967).

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The seals from the Baltic area generally contain large amounts of residues of both DDT and PCB, about ten times greater than the amounts found in Great Britain, Canada (Holden and Marsden 1967) and the Netherlands (Koeman and van Genderen 1966). Seal pups one week old from the Gulf of Finland also contained high levels of DDT-compounds and PCB and seal milk from the stomach from one of these pups had residues of the same magnitude.

The population of white-tailed eagle in Sweden seems to be on the decline. The number of probably fledged young per checked pair in Sweden has decreased from 0.80 in 1964 to 0.28 in 1969 and the number of successful breeding has decreased from more than 50 % in 1964 to about 20 % in the last few years (Helander 1970). All specimens of white-tailed eagle studied up to the present contain at least 3 accumulating substances known to be toxic. These are the DDT-compounds, PCB and mercury compounds (Berg et al. 1966). Figures for 4 birds are reported in table 3. Two specimens from northern Sweden, one of which had died by accident, contained of DDT-compounds 1.8 and 3.4 ppm respectively and of PCB 1.8 and 3.9 ppm in muscle tissue. The figures for specimens from the Archipelago of Stockholm are between 290-400 and 150-240 ppm for DDT and PCB respectively.

In fig 3 data are shown graphically for three substances (mercury based on fresh tissue and total DDT and PCB based on extractable fat) in three bird species from the Baltic, the black guillemot (Cepphus grylle), guillemot (Uria aalge) and cormorant (Phalacrocorax carbo sinensis). The means and range are indicated.

Guillemots from St Karlsö (site 9 in fig 3) almost invariably stay throughout their lives in the Baltic (unpublished data for ringed guillemots, Sten Österlöf). After breeding they move to the south part of the Baltic where they remain for the winter. In March and April they return to their breeding localities at St Karlsö.

In the guillemot eggs examined there is no difference in the content of mercury or in chlorinated hydrocarbon content between the years 1968 and 1969. Approximately the same levels of chlorinated hydrocarbons are found in fat from eggs and fat from the breast muscle of breeding guillemot. In three weeks old chicks the concentrations are somewhat lower. This may be due to a less contaminated food source in the breeding area and/or a slow accumulation process which gives young birds low concentrations in comparison with older ones.

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Black guillemots breed in the Archipelago of Stockholm (position indicated in figure 1) and spend the winter close to the edge of the ice. This is seldom situated south of Gotland. Although only four birds of this species were examined (two adults and two juveniles) it would appear that the figures for DDT-compounds and PCB in extractable fat are much lower in the juveniles than in juvenile guillemots. This difference is maintained in the adults for DDT-compounds but not for PCB where adults of both species have much the same values. This may indicate a lower contamination with DDT-compounds in the middle part of the Baltic as compared with the southernmost part. Conversely, the mercury figures suggest that adult black guillemots may have higher mercury content than guillemots. It is known that mercury contamination exists in the breeding locality of the black guillemot (Johnels et al. 1967).

Cormorants breed in a single locality close to the mainland west of Öland (site 10 in figure 1). They spend the winter in the Balcan area (Österlöf 1964, 1965, 1969). Although the juveniles examined had levels of chlorinated hydrocarbons in extractable fat only a little higher than those found in the black guillemot adult cormorants gave values rather similar to the high concentrations found in guillemots. The values for mercury are highly elevated in the old birds.

A large material of mainly various fish species is at the present time under study for elucidating the contamination with chlorinated hydrocarbons in the Swedish marine areas.

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Fig 1. Position of localities and areas mentioned in the text.

Fig 2. Levels of PCB on extractable fat basis in pectoral muscle of starling (Sturnus vulgaris). Samples of adults and juveniles from 1967, 1968 and 1969. Dates of samples indicated. Positions of localities in fig 1.

Fig 3. Concentrations (means and ranges) of mercury and chlorinated hydrocarbons in birds from the Baltic.

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Table 1

Total DDT and PCB levels in pectoral muscle and eggs of some Swedish birds in ppm on extractable fat basis. Means and range when possible.

Species	number	total DDT	PCB	ratio
Gyr Falcon (Falco rusticolus)	1	280	220	1,27
Osprey (Pandion haliaetus)	3	43 (24-87)	32 (13-58)	1,34
Tawny Owl	ad. 1	390	360	1,08
(Strix aluco)	juv.3	10 (7,3-13)	16 (10-26)	0,62
White Wagtail	ad. 1	7,1	1,3	8,40
(Motacilla alba)	juv.1	28	11	2,55
Yellow Wagtail (Motacilla flava)	3	0,44 (0,36-0,50)	0,74 (0,64-0,92)	0,59
Fieldfare (Turdus pilaris)	ad. 6	110 (7,5-400)	5,4 (2,1-12)	20,37
	juv.9	2,6 (0,87-5,8)	1,2 (0,66-1,8)	2,10
Eggs				
Marsh Harrier 1968 (Circus aeruginosus)	6	757 (180-3000)	358 (110-870)	2,11
1969	6	398 (230-670)	448 (300-630)	0,89
Osprey 1968 (Pandion haliaetus)	6	224 (24-610)	137 (75-250)	1,64
1969	9	61 (4,5-130)	73 (2,7-290)	0,84

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Table 1

Total DDT and PCB levels in pectoral muscle and eggs of some Swedish birds in ppm on extractable fat basis. Means and range when possible.

Species	number	total DDT	PCB	ratio
Gyr Falcon (Falco rusticolus)	1	280	220	1,27
Osprey (Pandion haliaetus)	3	43 (24-87)	32 (13-58)	1,34
Tawny Owl	ad. 1	390	360	1,08
(Strix aluco)	juv.3	10 (7,3-13)	16 (10-26)	0,62
White Wagtail	ad. 1	7,1	1,3	8,40
(Motacilla alba)	juv.1	28	11	2,55
Yellow Wagtail (Motacilla flava)	3	0,44 (0,36-0,50)	0,74 (0,64-0,92)	0,59
Fieldfare (Turdus pilaris)	ad. 6	110 (7,5-400)	5,4 (2,1-12)	20,37
	juv.9	2,6 (0,87-5,8)	1,2 (0,66-1,8)	2,10
Eggs				
Marsh Harrier 1968 (Circus aeruginosus)	6	757 (180-3000)	358 (110-870)	2,11
1969	6	398 (230-670)	448 (300-630)	0,89
Osprey 1968 (Pandion haliaetus)	6	224 (24-610)	137 (75-250)	1,64
1969	9	61 (4,5-130)	73 (2,7-290)	0,84

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Table 1

Total DDT and PCB levels in pectoral muscle and eggs of some Swedish birds in ppm on extractable fat basis. Means and range when possible.

Species	number	total DDT	PCB	ratio
Gyr Falcon (Falco rusticolus)	1	280	220	1,27
Osprey (Pandion haliaetus)	3	43 (24-87)	32 (13-58)	1,34
Tawny Owl	ad. 1	390	360	1,08
(Strix aluco)	juv.3	10 (7,3-13)	16 (10-26)	0,62
White Wagtail	ad. 1	7,1	1,3	8,40
(Motacilla alba)	juv.1	28	11	2,55
Yellow Wagtail (Motacilla flava)	3	0,44 (0,36-0,50)	0,74 (0,64-0,92)	0,59
Fieldfare (Turdus pilaris)	ad. 6	110 (7,5-400)	5,4 (2,1-12)	20,37
	juv.9	2,6 (0,87-5,8)	1,2 (0,66-1,8)	2,10
Eggs				
Marsh Harrier 1968 (Circus aeruginosus)	6	757 (180-3000)	358 (110-870)	2,11
1969	6	398 (230-670)	448 (300-630)	0,89
Osprey 1968 (Pandion haliaetus)	6	224 (24-610)	137 (75-250)	1,64
1969	9	61 (4,5-130)	73 (2,7-290)	0,84

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