# Redistribution of DDE in Sparrowhawks During Starvation

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## Introduction

Organochlorine compounds are lipophilic and are therefore found in the greatest concentration in fatty tissues. As birds starve, organochlorines may be released from metabolised adipose tissue and relocated in other tissues. Since organochlorines act principally on the central nervous system, it is important to know the effects of starvation on the concentrations of organochlorines in brain.

This paper examines the distribution of DDE in 18 Sparrowhawks (Accipiter nisus) found dead in various states from healthy to starved. To judge from their weights, these Sparrowhawks represented the full range of nutritional state. Only carcases in good condition and estimated to have been found soon after death were used for analysis.

Most analysts have measured organochlorine concentrations in liver or muscle (because of the convenience in obtaining the sample) rather than in brain as a measure of the hazard presented to the bird. Since organochlorines act principally on the central nervous system (HRDINA et. al 1975) and it is the concentration in brain which is critical, we have examined the relationship between liver and brain and between muscle and brain concentrations in terms of both wet wt and lipid wt in order to assess which measure from liver or muscle best reflects the concentration in brain.



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## Materials and Methods

The brain, liver and a piece of omental fat, if present, were taken from each bird. Breast muscle was removed as completely as possible. Each tissue and the remainder of the carcase were minced separately, ground with sand and anhydrous sodium sulfate and extracted in a soxhlet with hexane: acetone 2:1. The solvent was evaporated to give a measure of lipid in each tissue and the residue was taken up again in hexane. An aliquot of the reconstituted residue was used for a duplicate measure of lipid concentration. The hexane solution was cleaned up using Florisil, and the organochlorines measured using electron capture-gas chromatography. Of the organochlorines, only DDE (the terminal metabolite of DDT) was measured in all tissues of all birds. However in four birds (two with high lipid content and two with low), dieldrin and PCB were also measured; the kinetics of these compounds appeared to be similar to those of DDE. One of the birds was obtained one day after completing a clutch of six eggs, two of which were also analysed.

## Results and Discussion

Although all birds were obtained in Great Britain, the total amount of DDE in the birds varied widely (Table 1).

Table 1
Distribution of DDE in Sparrowhawks

| Bird No. | % lipid in Bird | Total DDE in Bird (μg) | % total in Brain | Liver | Breast Muscle | Carcase Remainder |
|---|---|---|---|---|---|---|
| 1 | 8.88 | 5377 | 0.06 | 0.08 | 2.89 | 96.97 |
| 2 | 5.87 | 1578 | 0.20 | 1.16 | 7.58 | 91.06 |
| 3 | 4.79 | 659 | 0.09 | 0.63 | 3.80 | 95.48 |
| 4 | 4.72 | 461 | 0.35 | 1.11 | 11.06 | 87.48 |
| 5 | 4.08 | 1193 | 0.21 | 0.98 | 8.31 | 90.70 |
| 6 | 3.69 | 390 | 0.31 | 1.21 | 8.47 | 90.01 |
| 7 | 3.29 | 1804 | 0.21 | 1.31 | 5.91 | 92.53 |
| 8 | 3.22 | 1359 | 0.51 | 1.34 | 6.78 | 91.37 |
| 9 | 2.64 | 312 | 0.27 | 1.16 | 6.41 | 92.15 |
| 10 | 2.36 | 69 | 0.55 | 1.60 | 6.08 | 91.76 |
| 11 | 2.14 | 849 | 0.64 | 1.08 | 12.25 | 86.03 |
| 12 | 1.74 | 110 | 0.63 | 3.22 | 8.63 | 87.51 |
| 13 | 1.45 | 1087 | 1.84 | 4.05 | 9.94 | 84.17 |
| 14 | 1.29 | 1359 | 2.73 | 5.92 | 6.99 | 84.36 |
| 15 | 1.04 | 151 | 2.33 | 3.31 | 11.55 | 82.81 |
| 16 | 0.97 | 1575 | 1.72 | 5.09 | 17.16 | 76.03 |
| 17 | 0.96 | 169 | 3.31 | 5.71 | 10.52 | 80.46 |
| 18 | 0.64 | 3578 | 2.97 | 5.02 | 6.56 | 85.45 |

The percentage of DDE located in brain increased slowly in birds with progressively less fat but was markedly higher in birds which contained less than 1.5% fat (Figure 1).

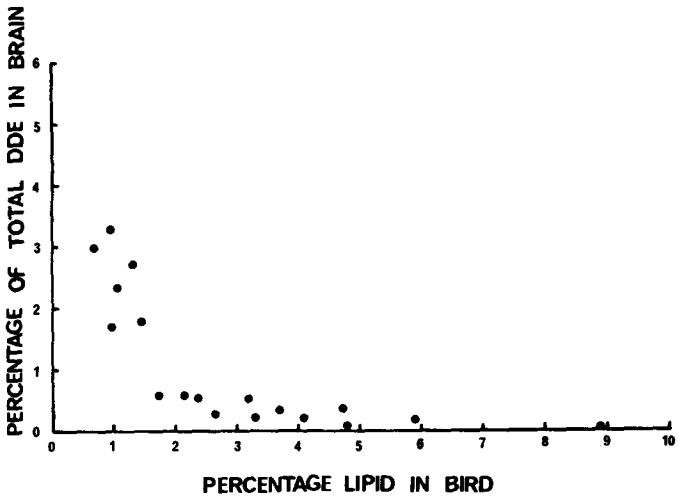


Figure 1. The percentage of the total DDE in the bird located in the brain of Sparrowhawks with differing amounts of body lipid.

This confirms the findings of Sodergren and Ulfstrand(1972)based on starving individual robins. Possibly the failure of Findlay and de Freitas(1971) to demonstrate this effect in the pigeon was due to their terminating the experiment too early when the birds had lost only 50-75% body fat; in Sparrowhawks and Robins the marked increase occurred only beyond this stage.

Further, the increase in the total amount of DDE in the brain with starvation was apparently greater than the increase in liver or breast muscle content. Comparing the five birds with the highest lipid content ($>4\%$) with the five with the lowest ($<1.5\%$), brain content differed by a factor of 13, liver content by 6 and muscle content by 2. Brain lipid content was almost the same in both groups (mean 8.36 in the high group; 8.32 in the low group), while muscle lipid content differed markedly (2.62 compared with 0.86). Thus as a bird loses weight, lipid content is better maintained in brain than that in other organs. It is presumably this which results in brain accumulating a disproportionate amount of redistributed organochlorine. In other words a starving bird is more at risk from not only the increased circulating organochlorines released from adipose tissue but also from the brain accumulating more than its 'share' of this relocated organochlorine.

No measure of liver or muscle levels reflects well the brain concentration at all states of body condition. However the muscle or liver concentration on a lipid wt basis gave a slightly more accurate reflection of brain concentration at all states of nutrition than did muscle or liver concentration on a wet wt basis (Figure 2).

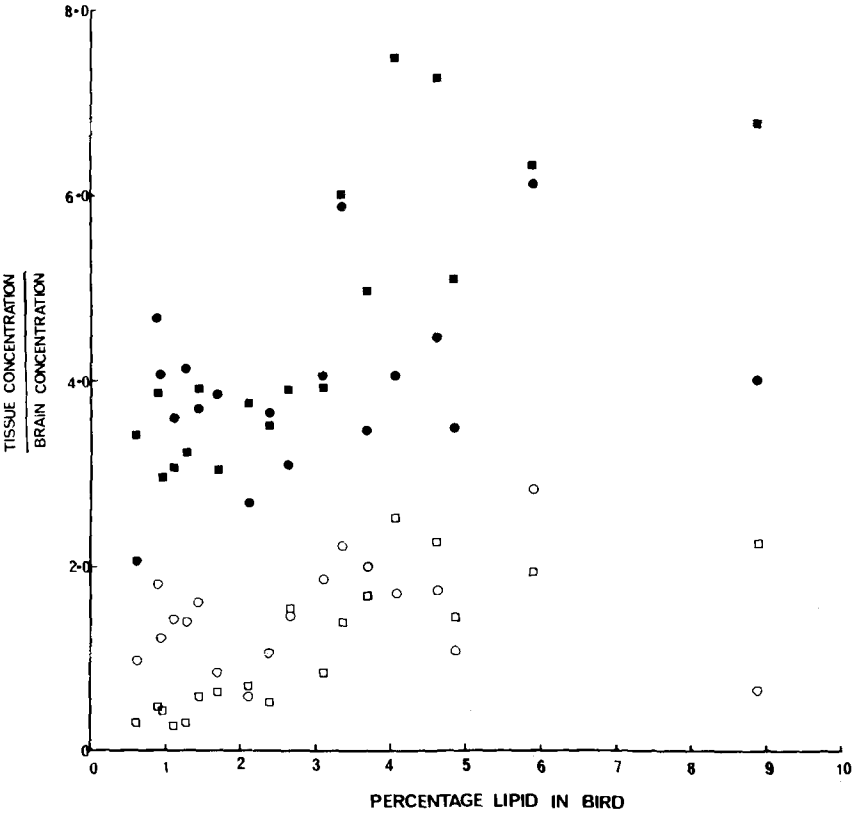


Figure 2. Ratios of the concentrations of DDE found in liver and muscle to that in brain in Sparrowhawks with differing amounts of body lipid.

| | | |
|---|---|---|
| $\frac{\text{Muscle concentration}}{\text{Brain concentration}}$ | □ wet wt basis | ■ lipid wt basis |
| $\frac{\text{Liver concentration}}{\text{Brain concentration}}$ | ○ wet wt basis | ● lipid wt basis |

Thus to assess whether organochlorines may have caused death, the best tissue for analysis is brain and, if liver or muscle are used, there will be wide variations in lethal concentrations, especially since the percentage lipid in the whole bird is not usually known.

The concentration of DDE on a lipid wt basis in brain was consistently lower than in liver or muscle. This could mean either that the lipids in brain differ markedly in composition from those in the other tissues or that the turnover of brain lipid is too rapid for equilibrium of DDE between plasma and brain lipid to be reached. Whatever the reason, it is obviously not correct to regard organochlorines as distributed between body compartments in proportion to the amount of lipid in each.

Sparrowhawk No. 3 laid 6 eggs. At death one day later it contained 659 ug DDE. The mean concentration of DDE in each egg was 5.5 μg/g wet wt. The loss of DDE in egg-laying was therefore substantial being 726 μg (132 g wet wt in 6 eggs) or 52% of the presumed total content at laying. This bird contained 16.6g lipid at death and had deposited 10.6g lipid in the eggs. The concentration of DDE in lipid in the whole bird (39.7 μg/g) corresponded well to that in lipid in the eggs (mean 38.0 μg/g). This would justify the use of egg residues as a reflection of those in the parent bird.

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