

- ¹ Sokal, R., and Sneath, P. H. A., *Principles of Numerical Taxonomy*, 72 and 226 (Freeman, San Francisco and London, 1963).
- ² Anderson, N. O., *Nature*, **227**, 1346 (1970).
- ³ Service, R. C., *Trans. Roy. Soc. South Austral.*, **71**, 212 (1947).
- ⁴ Glaesner, M. F., and Wade, M., *Paleontology*, **9**, 599 (1966).
- ⁵ Glaesner, M. F., *Bull. Geol. Soc. Amer., Notes and Discussions* (in the press, 1971).
- ⁶ Glaesner, M. F., *Biol. Rev.*, **37**, 467 (1962).
- ⁷ Simkiss, K., *Biol. Rev.*, **39**, 487 (1964).

Effect of PCB on Nocturnal Activity in Caged Robins, *Erithacus rubecula* L.

CHLORINATED hydrocarbons are a recognized threat to populations of wild birds, but their precise mode of ecological action is largely unknown. They are, however, known to have a thinning effect on the egg shell^{1,2}, and they react with some hormones^{3,4}, thus affecting the endocrine balance of the body. Such findings suggest that these substances may exert a profound influence on the activity and behaviour of contaminated animals, but little attention has been devoted to this aspect.

The migratory activity of birds is governed chiefly by the interplay of hormonal systems^{5,6}, and the orientation of the migrants is a highly refined instinct pattern. This suggests that the nocturnal activity of affected migratory birds might be a suitable indicator of the possible ecological effects of organochlorines.

The robin, *Erithacus rubecula* L., in Sweden is almost completely migratory, moving exclusively by night. Its main flight direction during the autumn migration is SW-SSW. Robins were trapped at Falsterbo Bird Station (55° 23' N, 12° 50' E) in the last week of September 1970. They were kept singly in opaque plastic containers under a natural light-dark rhythm and were fed mealworms and berries *ad lib*. Beginning on October 2, twenty-eight robins were given one extra mealworm each day, injected with 5 µg of 'Clophen A50', a polychlorinated biphenyl (PCB). These worms were marked with a small dot of red dye to enable us to determine whether the worm had been eaten; in a few cases it was not taken. Eighteen robins were kept in identical conditions but were not given worms containing PCB.

The experiments were performed between 1900 and 2100 on October 21 and 22 (within the normal migratory period of Swedish robins) on birds which had eaten eleven to thirteen PCB-loaded worms. The experimentally contaminated and control birds were placed singly in Erlenmeyer funnels under the open sky at a site 20 km east of Lund, where no artificial light sources interfered. During the first night the sky was overcast, and the experiment was discontinued after 35 min because of rain. During the second night, cloud-cover was approximately 1/8, and the experiment was continued for 75 min as planned. The evaluation of the activity sums and of the mean vectors of the birds followed the procedures described by Råbøl^{7,8}. On the first occasion, twenty PCB-loaded and twelve control birds were tested, and on the second, nineteen and eleven birds, respectively. With a few exceptions, the same individuals were used in both experiments.

The average activity sums were compared separately for each night using a Mann-Whitney U test (two-tailed). The average activity on the first night was much higher in the PCB-loaded birds than in the controls, but the difference was not quite significant. On the second night, when the experiment ran for a longer period, the average activity of the PCB-loaded birds was significantly higher than that of the controls ($P < 0.05$). The dispersion of the mean vectors was greater on the overcast night of October 21 than on the following night which was cloudless. No significant differences between PCB-loaded and control birds with respect to direction or dispersion were detected on either night. The direction was the same as the supposed standard migratory direction of Swedish robins.

The age⁹ and body weight of control and PCB-loaded birds were compared, and no significant differences were found. Both groups had gained weight equally by comparison with birds weighed immediately after trapping at Falsterbo⁹.

Table 1 Organochlorine Residues (ng/g Fresh Weight) in Breast Muscles of Robins

	µg of PCB ingested	p,p'-DDE	p,p'-DDT	PCB
Birds fed with PCB	60	95	7	375
	55	96	25	467
	65	75	25	341
	55	64	24	164
	60	91	22	365
	55	56	2	287
Control birds	—	72	23	120
	—	69	27	70
	—	70	30	90
	—	66	25	51

The breast muscles of six PCB-loaded birds and four control birds were analysed by gas chromatography for organochlorine content (Table 1). The apparatus consisted of a Varian Aerograph 204 gas chromatograph equipped with electron capture detectors, and three different columns using SF 96 (4%), QF 1 (8%) and SF 96/QF 1 (3:1) as the stationary phases on GasChrom P (100/120 mesh) were utilized. The identity of the more important compounds detected was also confirmed by chemical techniques. The PCB level in the experimentally contaminated birds was four times that found in the controls, the difference being statistically highly significant, but it was in unexpectedly low concentration, indicating that much of it had been excreted or stored elsewhere than in the breast muscles. Both groups of birds were also analysed for p,p'-DDE and p,p'-DDT, but no significant differences were detected.

These results demonstrate an effect of organochlorine residues on the activity patterns of the bird. Gwinner¹¹ demonstrated a correlation between the degree of migratory activity (restlessness) and the distance between the breeding and wintering quarters in different warbler species of the genus *Phylloscopus*. A quantitative change in such activity therefore assumes great ecological significance. The rapid mobilization of fat during migration is also an important aspect of this problem^{12,13}.

PCB compounds occur widely in the global ecosystem and, like other chlorinated hydrocarbons, they accumulate in food chains^{14,15}. Their effects, even at the relatively low levels used in these experiments, indicate that they are important environmental contaminants.

S. ULFSTRAND
A. SÖDERGREN

Department of Animal Ecology,
Ecology Building,
University of Lund,
S-223 62 Lund

J. RÅBØL

Zoological Laboratory,
University of Copenhagen,
Universitetsparken 15,
DK-2100 Copenhagen

Received March 29, 1971.

MONS 081717

- ¹ Ratcliffe, D. A., *J. Appl. Ecol.*, **7**, 67 (1970).
² Peakall, D. B., *Science*, **168**, 592 (1970).
³ Peakall, D. B., *Nature*, **216**, 505 (1967).
⁴ Lincer, J. L., and Peakall, D. B., *Nature*, **228**, 783 (1970).
⁵ Farmer, D. S., *Proc. XIV Intern. Orn. Cong. Oxford, 1966*, 107 (Blackwell, Oxford and Edinburgh, 1967).
⁶ Berthold, P., *Zool. Jb. Syst.*, **96**, 491 (1969).
⁷ Rabl, J., *Orn. Scand.*, **1**, 27 (1970).
⁸ Rabl, J., *Dansk Orn. For. Tidsskr.*, **64**, 118 (1970).
⁹ Svensson, L., *Identification Guide to European Passerines* (Naturhist. Riksmuseum, Stockholm, 1970).
¹⁰ Scott, R. E., *Vir. Fidele*, **24**, 156 (1965).
¹¹ Gwinner, E., *J. Orn.*, **109**, 70 (1968).
¹² Helms, C. W., *Amer. Zool.*, **8**, 151 (1968).
¹³ Russell, D. J. T., *Auk*, **86**, 75 (1969).
¹⁴ Riebeling, R. W., Rieche, P., Peakall, D. B., Herman, S. G., and Kirven, M. N., *Nature*, **220**, 1098 (1968).
¹⁵ Jensen, S., Johnsen, A. G., Olsson, M., and Oterlind, G., *Nature*, **224**, 247 (1969).

Skua Numbers and Conservation Problems at Cape Hallett, Antarctica

The flora and fauna of Antarctica are often considered to be secure, principally because of international treaty obligations. Nevertheless, several people have already drawn attention to conservation problems¹⁻³ which are underlined by my own work on the decline of the South Polar skua (*Catharacta macrorhynchos*) at Cape Hallett (lat. 72° 18' S, long. 170° 19' E).

During the two austral summers of 1967-68 and 1968-69, I made an intensive study of the decline of the skua and of skua-penguin feeding relationships, which will be published in full later. Data gathered by Dr T. S. Choate in the 1966-67 season are also incorporated in this report.

Because of the scarcity of suitable coastal building sites, man sometimes competes directly with nesting birds for space. In December 1956, for example, when the joint United States-New Zealand station was established, 3,318 juvenile and at least 4,900 adult Adie penguins (*Pygoscelis adeliae*) were removed from the Hallett rookery⁴, and at that time the breeding population was probably between 36,000 and 62,000 pairs⁵.

Although indications of the size of the resident skua breeding population are available⁶⁻⁸, the first census was in subsequent seasons reveal a drastic decline in the numbers of skua pairs breeding: these are 162 pairs in 1963-64 and 147 pairs in 1965-66 (personal communication from F. C. Kinsky); 113 pairs in 1966-67 (personal communication from T. S. Choate); 105 pairs in 1967-68 and 98 pairs in 1968-69 (my own work). Thus there has been a 54% decline during nine seasons. Census records of the Adie penguin breeding population made by Choate (1967-68) and Westerskov (1968-69) indicate a decrease of a similar magnitude during the same period (personal communication from Choate and K. E. Westerskov).

The decrease in the number of skuas during and between the three seasons studied was determined from the recovery records of banded birds. During this period 95-98% of the breeding population and many non-breeding birds were marked with numbered monel-metal bands. There was no significant loss of these bands. The mean annual loss of breeding skuas was 18% compared with 6% for a stable population of skuas at Cape Crozier (personal communication from R. C. Wood). This result for the Hallett skuas probably represents a permanent loss of birds rather than sporadic return or breeding. Of the fifty breeding birds lost between 1966-67 and 1967-68, for example, only one was recovered in the 1968-69 season and as a non-breeder.

During the three seasons, twenty-three skuas, including eight breeding birds, were found dead or dying. The cause of death was established in only six cases, all resulting from human activities (wing breakages or ruptured crops caused by the

ingestion of corn cobs). No breeding birds disappeared without trace. Seasonal losses are therefore only slightly greater than might be expected for a stable population. High sea mortality, however, have been recorded. In 1965-66 K recorded the deaths of thirty-three adult skuas. He analysed three of these, and discovered that they had been poisoning ingesting parts of lead battery plates.

Figures for fledgling production (chicks fledged/few breeding) during the period of the decline are heterogeneous 59/156 in 1959-60 (ref. 6), 116/181 in 1960-61 (ref. 7), 36 in 1966-67 (personal communication from Choate), 41/101 in 1967-68 and 24/98 in 1968-69 ($\chi^2=21.2$, $P<0.001$). In 1966-67, the 1960-61 data are removed from the calculation significant deviation remains (with the value of 0.33 for fledgling production at the stable Cape Crozier colony (personal communication from Wood). The high fledgling production in 1960-61 was probably, therefore, unusual, and this meter does not seem to have changed significantly during the period of the decline. The effect of any alteration in fledgling production on the decline could, however, be recorded after 5-6 yr, the approximate age of first breeding.

I conclude that the decline of the skua population has been the result of adults abandoning the Hallett colony as a breeding area. This decline has coincided with a period of human occupation and with the decline of the Adie penguin population on which skuas prey and scavenge for food. The decline of penguins has itself been established as resulting directly from human disturbance (personal communication from Choate Westerskov). Thus although the skua decline has been the ultimate consequence of human activity, the relative importance of direct disturbance as distinct from the penguin decline proximate cause requires evaluation. This aspect of the decline, which has provided new information about the relationship between skuas and penguins will be published later.

In spite of suggestions by several workers for the elimination of possible sources of poisoning and the reduction of disturbance to both penguins and skuas, this ignominious situation continued virtually for a decade. Holdgate² points out that although the agreed measures for conservation under Antarctic Treaty are comprehensive and therefore should require significant future amendment, three areas for improvement remain, especially with regard to specially protected localities or species. These areas are the perfection of application of the agreed measures, the development of procedures for management and the adoption of educational means to ensure that all personnel visiting Antarctica are aware of the need for conservation. This report should serve to endorse Holdgate's suggestions for the improvement of conservation in the Antarctic, particularly as Cape Hallett is classed as a specially protected area.

I thank Dr T. S. Choate, Mr F. C. Kinsky, Mr R. C. Wood and Dr K. E. Westerskov for valuable information.

BRIAN R. JOHNSTON

Zoology Department,
University of Otago,
Dunedin, New Zealand

MONS 081718

Received March 11; revised April 15, 1971.

- ¹ Stonehouse, B., *NZ Sci. Rev.*, **23**, 1 (1965).
² Shimoizumi, J., *Antarctic Ecology* (ed. by Holdgate, M. W.) 2 (Academic Press, London, 1970).
³ Holdgate, M. W., *Antarctic Ecology* (ed. by Holdgate, M. W.) 2, 974 (Academic Press, London, 1970).
⁴ Eklund, C. R., *Bird-Banding*, **32**, 283 (1961).
⁵ Reid, B. E., *Notornis*, **15**, 191 (1968).
⁶ Reid, B. E., *NZ DSIR Antarctic Div. Rep.* (1961).
⁷ Maher, W. J., *Nat. Hist.*, **75**, 43 (1966).