DDE RESIDUES IN THE ENDANGERED HAWAIIAN DARK-RUMPED PETREL (*PTERODROMA PHAEOPYGIA SANDWICHENSIS*)

WARREN B. KING
International Council for Bird Preservation
Smithsonian Institution
Washington, D.C. 20560

AND

JEFFREY L. LINCER[1]
Section of Ecology and Systematics
Cornell University
Ithaca, New York 14850

INTRODUCTION

The Hawaiian Dark-rumped Petrel (*Pterodroma phaeopygia sandwichensis*), an endangered subspecies (Vincent 1966), maintains relict breeding populations on the islands of Maui and Hawaii. The latter population is very small, widely scattered, and still decreasing (Winston Banko, pers. comm.). The former is more substantial. It numbers about 350 breeding pairs and a total population of ca. 1500 birds (King 1971). The entire breeding range of the Maui population lies within Haleakala National Park, primarily on the rim and inner walls of the western side of Haleakala Crater between 7000 and 9700 ft elevation.

A substantial reduction in the range of the subspecies has taken place in historical times and can be attributed primarily to the introduction of terrestrial mammalian predators. Bryan (1908), for example, found evidence of mongoose (*Herpestes auropunctatus*) predation in a colony on Molokai, and even found a mongoose and its young utilizing a former Dark-rumped Petrel burrow. On Maui the lower limit of the petrel's breeding range now coincides with the upper limit of permanent mongoose infestation. Although the Maui petrel population is no longer depredated by the mongoose, feral cats (*Felis catus*) and especially black rats (*Rattus rattus*) are predators in some years (Larson 1967).

Another possible cause of population decline is eggshell-thinning and consequent reproductive failure induced by concentrations of residues of persistent pesticides (e.g., Hickey 1969; Ratcliffe 1970). The purpose of this note is to document the present residue levels in the Maui population of the Dark-rumped Petrel and to present mensural data on the second, third, and fourth eggs of this subspecies to be collected.

METHODS

Four eggs, abandoned in the mouths of burrows or ejected entirely from burrows, were collected for analysis in the summer of 1970. The analytical procedure was a modification of an earlier one (U.S. Food and Drug Administration 1970) and was reported in detail previously (Cade et al. 1971).

Two Dark-rumped Petrel chicks were found dead by Park Rangers of Haleakala National Park in July 1971. These were sent to Patuxent Wildlife Research Station for autopsy, and brain tissue from the one chick that was sufficiently fresh was analyzed for pesticide residues. The analytical procedure has been described previously (Mulhern 1968). There were no eggs taken prior to 1947 (pre-DDT era) with which to compare shell measurements.

[1] Present address: Mote Marine Laboratory, 9501 Blind Pass Road, Sarasota, Florida 33581.

TABLE 1. Egg measurements of Dark-rumped Petrels from Maui.

	Length (mm)	Breadth (mm)	Total weight (gm)	Shell weight (gm)	Shell[c] Index
Egg 2[a]	64.4	48.8	69.97	4.8407	1.524
Egg 3[b]	61.0	45.8	55.20	4.0749	1.459
Egg 4	60.2	49.7	50.95	3.5600	1.322

[a] Egg 1 was smashed in transit, contents saved.
[b] Infertile.
[c] Weight of dried shell in milligrams divided by the length times the breadth in millimeters (Ratcliffe 1970).

RESULTS

Table 1 lists the measurements of the three intact eggs. Two are broader and two are shorter than the other eggs that have been measured (62 × 44 mm in Richardson and Woodside 1954; 64 × 45, 66 × 46, 67 × 46 mm in Larson 1967).

The autopsy of chicks revealed no internal or external lesions, but Dr. L. Locke, Pathologist, U.S. Bureau of Sport Fisheries and Wildlife, noted enlarged livers in both specimens. The eggs and chick were analyzed for residues of DDE, the primary metabolic derivative of p, p′-DDT (table 2).

DISCUSSION

The residue levels found in these petrels are lower than levels in some other pelagic species. In the Bermuda Petrel (*Pterodroma cahow*), the geographic representative of the same superspecies in the subtropical North Atlantic, eggs and chicks averaged 6.44 ppm wet weight total residues, 62% or 3.99 ppm of which was DDE (Wurster and Wingate 1968). These authors consider "contamination by insecticides as a probable major cause of the decline" of this species. Risebrough et al. (1967) found average concentrations of 7.4 ppm DDE wet weight in three Sooty Shearwaters (*Puffinus griseus*) and 29.4 ppm DDE in a Slender-billed Shearwater (*Puffinus tenuirostris*), both pelagic migrants to the North Pacific and the North American coast from Southern Hemisphere breeding grounds. These accumulations were at least as high as those in a sample of North Pacific residents or migrants from farther north. For example, eggs of 14 Cassin's Auklets (*Ptychoramphus aleuticus*) averaged 10.4 ppm DDE wet weight and eggs of 9 Western Gulls (*Larus occidentalis*) averaged 5.3

TABLE 2. DDE residues in eggs and brain tissue of Dark-rumped Petrels.

	PPM DDE based on:		
	Wet weight	Oven dry weight	Extractable fat weight
Egg 1	—	0.38	1.19
Egg 2	1.14	4.64	11.50
Egg 3	0.14	0.49	1.31
Egg 4	0.07	0.23	0.63
Chick brain	0.35	—	—

ppm DDE wet weight. Five Common Murre (*Uria aalge*) eggs from the Farallon Islands, California, averaged 21.7 ppm DDE, 12.3 ppm PCB, and 0.002 ppm Dieldrin wet weight (Gress et al. 1971). Associated with these high pesticide levels in Murre eggs was a decrease in thickness of 12.8%, which may be sufficient to cause increased egg loss. Minimum residue levels that can be associated with reduced productivity are not yet established in fish-eating birds. Different species can be expected to have widely differing tolerances to pesticide loads.

There is little doubt that the Dark-rumped Petrel feeds well out at sea (King 1970), far enough away from islands to permit us to assume that pesticide levels reported in this study were passed on through a pelagic food chain, of which this subspecies is a terminal link. Thus, there are measurable amounts of DDT metabolites in the open ocean ecosystem of the Central Pacific Ocean, which can and should be monitored by periodic samples from the seabird populations of the Central Pacific.

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EXPERIMENTAL STUDY OF FEEDING RATES OF NESTING COOPER'S HAWKS

NOEL F. R. SNYDER

AND

HELEN A. SNYDER

Box 21
Palmer, Puerto Rico 00721

The adaptive significance of brood size in birds has been investigated by a number of methods (see reviews of von Haartman, p. 391 *in* D. S. Farner and F. R. King [eds.], Avian biology, vol. 1, Academic Press, New York, 1971; Cody, p. 461, ibid.). In some studies the success rates of broods of various natural sizes have been followed; in other studies brood size has been changed experimentally to explore the capacities of adults to handle unusual numbers of young. The results of such studies have generally, but not always, indicated that the predominant brood size found in nature produces the maximal number of surviving young. A number of species varies brood size depending on food supplies present during the egg-laying period, and optimal brood size may vary with quality of the breeding season and quality of the particular habitat of the breeding pair.

In table 1 we present data on feeding rates of nestlings at several nests of Cooper's Hawks (*Accipiter cooperii*) observed from blinds in Arizona and New Mexico during 1969 and 1970. Feeding rates were generally highest at nests containing the most young, a result that could be interpreted either as an adaptive adjustment in feeding rates of adults to numbers of young or as an adaptive adjustment of brood size to feeding capacities of adults. Since the nests studied were in diverse habitats, the smaller broods may have been associated with relatively poor habitat and the larger broods with relatively good habitat. The data of table 1 do not necessarily indicate that adults vary their feeding (foraging) efforts to accommodate different numbers of young. In an attempt to distinguish between the effects of habitat quality and possible flexibility in adult feeding rates, we performed an experiment in the summer of 1971 in which numbers of young were systematically varied in two Arizona Cooper's Hawk nests, and rates of feeding were