ical EAE. Furthermore, the antibody response to determinants of the purified basic protein used as the assay antigen (and as encephalitogen in half of the control and T cell–depleted and thymus-reconstituted animals used) was almost, if not completely, thymus-dependent (Table 2, series 1). Injection of thymocytes restored the antibody responses of B rats to normal levels (Table 2, series 2).

In the study of EAE the Lewis B rat should thus be of value in the analysis of the role of different thymus-derived cell populations in restoring the inert recipient to susceptibility to the disease and in a further examination of the role of antibody in the disease process.

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Decline of DDT Residues in Migratory Songbirds

Abstract. *Analyses of ten species of migratory songbirds killed when the birds flew into television towers in Florida showed a progressive decline in the concentration of DDT and its metabolites (DDD and DDE) in their fat depots for the period 1964 to 1973. This decline is apparently correlated with the decreased usage of DDT in the United States during the same time.*

Introduced on a wide-scale basis since World War II, DDT (*1*) quickly became popular for the control of many agricultural pests and disease vectors. Because of its persistence in the environment, solubility in fat, dissemination through air and water, and widespread application, it is now found virtually all over the world in both terrestrial and aquatic ecosystems. By about 1958 there were indications that DDT and its metabolites might be associated with declines in avian populations at the top of food pyramids. Evidence was marshaled by Ratcliffe (*2*), Hickey and Anderson (*3*), and others that DDT accumulates in the fatty tissues of some raptorial and piscivorous birds at the top trophic levels. In birds such as the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), and osprey (*Pandion haliaetus*) decreases in eggshell thickness and population declines from 1947 to 1967 have been correlated by some investigators with DDT usage and subsequent reproductive, metabolic effects on the birds (*2, 3*). A variety of laboratory experiments on other birds (Japanese quail, *Coturnix coturnix*; mallard, *Anas platyrhynchos*; black duck, *Anas rubripes*; American kestrel, *Falco sparverius*; and screech owl, *Otus asio*) subsequently revealed correlations between dietary DDE (*1*) or DDT and eggshell thinning and ensuing poor reproductive success. Hickey and Roelle (*4*) pessimistically reported ". . . the steady numerical decline in the 1950's of the breeding adults [peregrine falcons] in many regions. This decline continues [in 1965], and the end is nowhere in sight." Despite these effects since DDT came into widespread use, the sublethal effects of the chlorinated hydrocarbon pesticides on animals of lower trophic levels, namely, insectivorous and granivorous species, are virtually unknown.

For at least the last two decades hundreds of small birds have been killed as a result of striking tall television towers in northern Florida during nocturnal migratory flights between their breeding grounds in North America and wintering areas in the West Indies and Central and South America (*5*). Such migrants are conspicuously obese, especially in the autumn, when subcutaneous and abdominal fat depots comprise 30 percent or more of the body weight (*6*). These marked fat depots are valuable indicators of the pesticide burdens in the migrants (*7*). The analyses presented here are based upon autumnal samples of chiefly insectivorous birds collected the morning after their deaths at WCTV tower near Tallahassee and WJXT and WJKS towers at Jacksonville. All these south-bound birds (*8*) were classified as "very fat."

From each of five to ten adult males of the same species, fat was dissected from the interfurcular depot and pooled as a species-specific sample for analysis. An attempt was made to remove the same amount of fat from each bird; the pooled fat samples per species had a mean weight of 1.16 g (0.58 to 1.95 g). Subsequent lipids extracted from the fat samples averaged 0.76 g (0.14 to 1.56 g) for all the samples. Samples were then analyzed according to the technique described by Grocki and Johnston (*7*).

In the ten species (*8*) of small migrants totaling 319 individuals analyzed here (Fig. 1), no sample was devoid of DDT or its metabolites. As expected, *p,p'*-DDE was more abundant than either *p,p'*-DDT or *p,p'*-DDD (*1*), the mean ratio of DDE to DDT [in parts per million (ppm), lipid weight] in the 43 samples being 1/0.56. Declines to low concentrations of total DDT (DDT, DDD, and DDE) in 1973 are clearly evident from the regression lines calculated for the bird groups A and B.

One may obtain a further demonstration of the dramatic decline of the DDT burden over a 5-year span by comparing mean annual concentrations—in 1969 the mean for five species was 17.80 ppm, but in 1973 the mean was only 2.06 ppm. Of the 43 samples analyzed, 13 contained no dieldrin (*1*); one species (*Dumetella carolinensis*) was completely devoid of dieldrin. The quantity of dieldrin in the others was small, averaging only 0.27 ppm (range of 0 to 1.50 ppm), and no consistent annual trends were apparent (for 1964 to 1966 the average was 0.51 ppm; for 1969 to 1970, 0.21 ppm; for 1972 to 1973, 1.09 ppm).

After lipid utilization in birds some DDT may be excreted (*9*) or become relocated from adipose tissue sites to brain (*10*) or skeletal muscle (*11*), or the bird may die (*12*). The annual declines evident in Fig. 1 could hardly be attributed to excretion or relocation alone because the birds were different individuals killed in different years. Rather, the decline of DDT burdens appears to be more closely correlated with the recent declines of DDT usage in North America, especially the United States, where these birds breed. Through 1968, marked declines in organochlorine pesticide residues were reportedly insignificant or absent in oysters (*13*), piscivorous birds (*14*), human foods (*15*), and other wildlife (*16*), although surface waters in the United States showed a sharp drop in pesticide content from 1964 to 1968 (*17*) and, by 1972, Butler (*18*) noted declines in the DDT content of estuarine mollusks. More recently Coulson *et al.* (*19*) reported decreases in *p,p'*-DDE, aldrin (*1*), and dieldrin in shag's (*Phalacrocorax aristotelis*) eggs of the British Isles, and they associated the decreased burdens with more restricted use of these pesticides. Increased breeding success in Scottish golden eagles (*Aquila chrysaetos*) from 1963 to 1968 was correlated with decreases in the dieldrin and DDE content of the eggs (*20*), and Martin and Nickerson (*21*) reported an "apparent decline" in the DDT content of starlings (*Sturnus vulgaris*) from 1967 to 1970.

According to figures on producer's domestic disappearance of DDT in the United States (*22*), after reaching a peak of 35×10^6 kg in 1959 DDT production steadily decreased to 8.1×10^6 kg in 1971. The virtually total ban on DDT use in the United States by the Environmental Protection Agency effective 31 December 1972 should result in a reduction in the amount of DDT

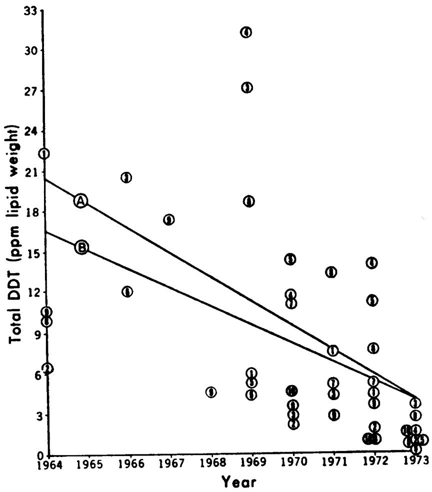

Fig. 1. Total amount of DDT and its metabolites (*p,p'*-DDE, *p,p'*-DDD, and *p,p'*-DDT) in ten species of autumnal migratory birds. Regression line A is calculated for species 1 through 7 (*8*), birds gleaning insects from arboreal surfaces, and line B is calculated for all ten species (*8*), including some that are partly frugivorous or take insects near the ground. Each numbered point represents one analysis of the pooled sample for that species. The slope of line B is significantly different from zero ($P < .01$). For line A, $y = 3398.5 - 1.72x$; for line B, $y = 2810.8 - 1.42x$.

in natural ecosystems. Although DDT may be residual in soils for at least two decades (*23*) without subsequent application at a given site, over a period of time pesticides such as DDT should become less available to arboreal birds; furthermore, there is laboratory evidence that the body burdens of DDT in some vertebrates may rapidly decline when intake is discontinued (*16, 24*). The most plausible explanation for the DDT declines in migratory birds presented here is an apparent correlation with decreased dissemination of DDT in the birds' environment.

Aside from a few scattered reports of the effects of chlorinated hydrocarbon pesticides on feral insectivorous and granivorous birds (*12, 21*), little is known of lethal or sublethal effects on these birds at the population level. Eggshell thinning has not been demonstrated for these small migrants. In one study, however, involving an aerial application of DDT continued over a 4-year period, insectivorous treetop-feeding species (American redstart and red-eyed vireo) decreased in population density by 26 percent, but only the redstart decreased significantly after the first application (*25*). Thus, the pesticide burdens reported here may or may not have had population effects over the past decade, but the significant point is the recent decline in these burdens.

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References and Notes

1. Abbreviations: DDT, 1,1,1-trichloro-2,2-bis-(*p*-chlorophenyl)ethane; DDD, 1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethane; DDE, 1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene, dieldrin, 1,2,3,-4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo-exo-1,4:5,8-dimethanonapthalene; aldrin, 1,2,3,4,10,10-hexachloro-1,4,-4a,5,8,8a-hexahydro-endo-exo-1,4:5,8-dimethanonaphthalene.
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