EFFECTS OF A LOW-PERSISTENCE INSECTICIDE ON FOREST BIRD POPULATIONS

JONATHAN D. MOULDING

SEVERAL low-persistence insecticides are currently employed over wide areas in the Northeast to control defoliating forest insect pests. The largest programs are directed toward the gypsy moth (*Porthetria dispar*), which is heavily infesting the southern New England and Middle Atlantic states. The carbamate insecticide Sevin has had the most widespread use in this capacity. During the past 3 years, it has been aerially broadcast over more than one-half million acres of woodland in New Jersey, New York, and recently Rhode Island. An additional 375,000 acres is proposed to be treated with Sevin and the organophosphorous insecticide Dylox in 1974 (U.S. Dept. Agr. 1974).

Despite these measures, the gypsy moth is steadily extending its range and is expected eventually to reach the commercially valuable hardwood forest of the southern Appalachians. This will undoubtedly generate heavy pressures for the use of more insecticides to prevent the tree loss that could result from repeated defoliations. It is thus of increasing importance to get reliable data on the effects of insecticides on non-target components of the forest ecosystem so as to be able to evaluate the benefits of pest insect control in relation to the cost of any alteration in ecosystem function that may result.

Birds, in addition to representing a high aesthetic value, play an important role as insectivores in a forest, feeding on a great variety of insects including all life stages of the gypsy moth (Forbush and Fernald 1896). Forest birds have not been reported as being very successful in controlling outbreaks of certain insect pests, but they undoubtedly play a major role in maintaining many potential pests at low levels and dampening the cyclic abundance of others. Any deleterious effects of insecticides on bird populations would, therefore, be counterproductive to say the least.

Despite the increasing use of insecticides in recent years, there is a remarkable paucity of in-depth field studies of their effects on forest bird populations. The "careful" and "extensive monitoring studies" of birds emphasized by the USDA since 1972 indicate no significant hazard to birds from several insecticides used for gypsy moth control. However, such studies were for the most part designed to detect immediate, presumably toxic, effects only (Anon. 1964; Stitt 1966; Doane and Schaefer 1971; Studholme 1972a, 1972b) or are so lacking in methodology and data as to be of limited use for evaluation (Connor 1960; R. E. Pillmore 1971, pers. comm. to D. E. Ketcham, USDA, Forest Service).

The study reported here dealt with the impact of an aerially applied insecticide on a forest avian community, and was designed to be sensitive to any long-term effects. In order to maximize the relevance of results, it was conducted simultaneously with the gypsy moth suppression program carried out by the State of New Jersey during the spring of 1971.

METHODS AND MATERIALS

Four study plots were chosen on the basis of similar topography and vegetation. Two were within a 5000-acre spray block established by the state in Stokes State Forest, Sussex County, New Jersey. The other two plots were on private land 25 miles east of the spray block, just south of Wawayanda State Park in Sussex County. Replicate plots were within one-half mile of each other. The vegetative community in each plot was a second-growth forest about 100 years old dominated by white oak (*Quercus alba*), red oak (*Q. rubra*), chestnut oak (*Q. prinus*), and red maple (*Acer rubrum*). The understory was characteristically flowering dogwood (*Cornus florida*) and black birch (*Betula lenta*). The shrub cover was almost entirely mountain laurel (*Kalmia latifolia*).

Compared with the spray plots, the canopy was more open in the control plots because of considerable mortality of white and chestnut oaks caused by repeated heavy defoliation by gypsy moths during the previous two or three summers. During the summer of 1971, gypsy moths were present here only in low numbers as a result of a natural collapse in the population the year before. The spray plots in 1971 were initially heavily infested with gypsy moth (10,000 egg masses per acre), but there were relatively few dead trees as extensive defoliation had occurred only during the previous summer.

The insecticide used by New Jersey in 1971 was Sevin (1-naphthyl n-methyl carbamate (carbaryl)). It was applied by a fixed-wing aircraft in a formulation of 80% Sevin wettable powder in water with 4 ounces of 1882 pinolene sticker. The application rate was 1 pound of Sevin (active ingredient) per gallon of water per acre. The uniformity of the spray coverage on the study plots was assessed by observing the density of the deposits on foliage and ground litter. These were readily visible as small white specks.

Bird populations were sampled using a strip transect census method. A 1500-foot transect was walked for 45 min in the morning starting between 0630 and 1030. The pace was regulated so that equal time was spent in each quarter of the transect. "Pishing," whistled bird calls, and other vocal lures were used at times to draw birds closer. All birds located by sound or sight within 100 feet of the transect on either side were identified to species and tallied. Overflying species were not counted unless they normally obtain or search for food on the wing, e.g. hawks and swifts. Two plots were censused each day on a rotating basis to equalize diurnal effects on detectability (Robbins and van Velzen 1969). Rainy or excessively windy days were avoided as these conditions might also affect detectability. Censusing was conducted from mid-May to the end of July 1971, with each plot being covered an average of three times every 2 weeks. A number of censuses were also made in the four study plots during May and June of 1972. All censuses were conducted by the author.

TABLE 1
EXAMPLES OF THE ANALYSIS OF VARIANCE OF THE DATA FOR TOTAL NUMBER OF BIRDS PER CENSUS

Prespray				Postspray			
Source	df	ms	F	Source	df	ms	F
Total	12			Total	49		
Areas	1	97.73	n.s.	Areas	1	4135.5	
Plots(A)	2	25.71	n.s.	Plots(A)	2	321.9	
Residual	9	42.23		Time	3	147.6	
				A × T	3	216.8	4.29[1]
				P(A) × T	6	8.6	n.s.
				Residual	34	50.6	

[1] $P < 0.01$.

RESULTS AND DISCUSSION

Sevin was applied to the Stokes State Forest spray block by the New Jersey Bureau of Forestry during the first week in June 1971. Both study plots were sprayed on 1 June between 0645 and 0730.

A survey of the two study plots was made shortly after the spraying. The impact of the Sevin on the target organism was noticed within 2 h of application as many dead and dying gypsy moth caterpillars were strewn on the ground. A Rufous-sided Towhee was seen feeding on them. The pattern of spray deposits on the foliage throughout the plots showed extensive "skips" in the application in spray plot 2 and skimpy coverage in some parts of spray plot 1. Because of this, the state returned at my request with the airplane and resprayed both study plots on 8 June at 0730. The spray deposits then indicated adequate coverage in both study plots. Additional dead gypsy moth caterpillars were also found, although noticeably fewer than before.

Three to four bird censuses were conducted in each study plot prior to the first application of insecticide. Censuses were continued in all study plots for 8 weeks thereafter. These data were grouped into time blocks of roughly 2 weeks duration, containing an average of 3.5 censuses per plot. For each plot, arithmetic means were calculated for total numbers of individual birds, bird species richness (number of species), and a species diversity index using the Shannon-Wiener formula: $H' = -\Sigma p_i \ln p_i$ (Tramer 1969), where p_i is the fraction of individuals out of the total that belong to the ith species. Pre- and postspray data were analyzed by analysis of variance (ANOVA) techniques (Table 1). Completely randomized ANOVA's of the prespray census data showed no significant differences initially between the bird communities of the four study plots. The postspray data were analyzed by partially hierarchic ANOVA's. The "area × time" interaction term in these analyses showed significant differences between the sprayed and unsprayed areas during the postspray period. This effect was consistent in each of the replicate plots as indicated by the lack of statistical significance of the "plots (A) × time" terms. Therefore the replicate plot data were pooled and the resulting mean for each area plotted (Fig. 1) with a "least significant interval" (LSI) around it calculated at the 0.05 level from the appropriate ANOVA table (Sokal and Rohlf 1969). Nonoverlapping LSI's indicate a statistically significant difference between the sprayed and control areas during the particular time period.

Over the course of the breeding season, all three bird community parameters showed a significant decrease in both sprayed plots compared to the control plots. The decrease was gradual, and continued until censusing ended in late July. No recovery was evidenced in any parameter. The decrease in diversity was due primarily to the decrease in species richness as overall no significant change occurred in the evenness with which individuals were distributed among species (equitability: $J' = H'/\ln$ # species (Sheldon 1969)). The average equitability in the four plots was 0.908.

An analysis of variance of the census data at the species level was performed after a square-root transform was applied to normalize the data. No clear trends emerged. In some cases a decrease in abundance of a species in the sprayed plots was balanced by a similar effect in the control plots. There was also some inconsistency between replicate plots. Among the species that showed consistency between replicate plots, the Scarlet Tanager and Eastern Wood Pewee showed significant declines in abundance in the sprayed area. In general the inconclusive results could have been due to a number of factors. Sampling error was undoubtedly a major one, particularly for species in low abundance. A more intensive study with marked individuals would be needed to clarify the problem.

Additional censusing was conducted during part of the following summer in the same study plots. No additional spraying was conducted that year. Bird populations were significantly lower in the formerly sprayed plots during early summer 1972 than during the corresponding time in 1971 (Fig. 2). In fact, they approached the depressed levels observed at the end of censusing in 1971. Species richness and diversity were also lower.

The Eastern Wood Pewee and Ovenbird were significantly less abundant in 1972 than in 1971. The pewee shows a trend consistent with that occurring during 1971, but caution should be used in interpreting data for any individual species from either year. Generally, the number of birds per species was too low to instill confidence in analysis at this level.

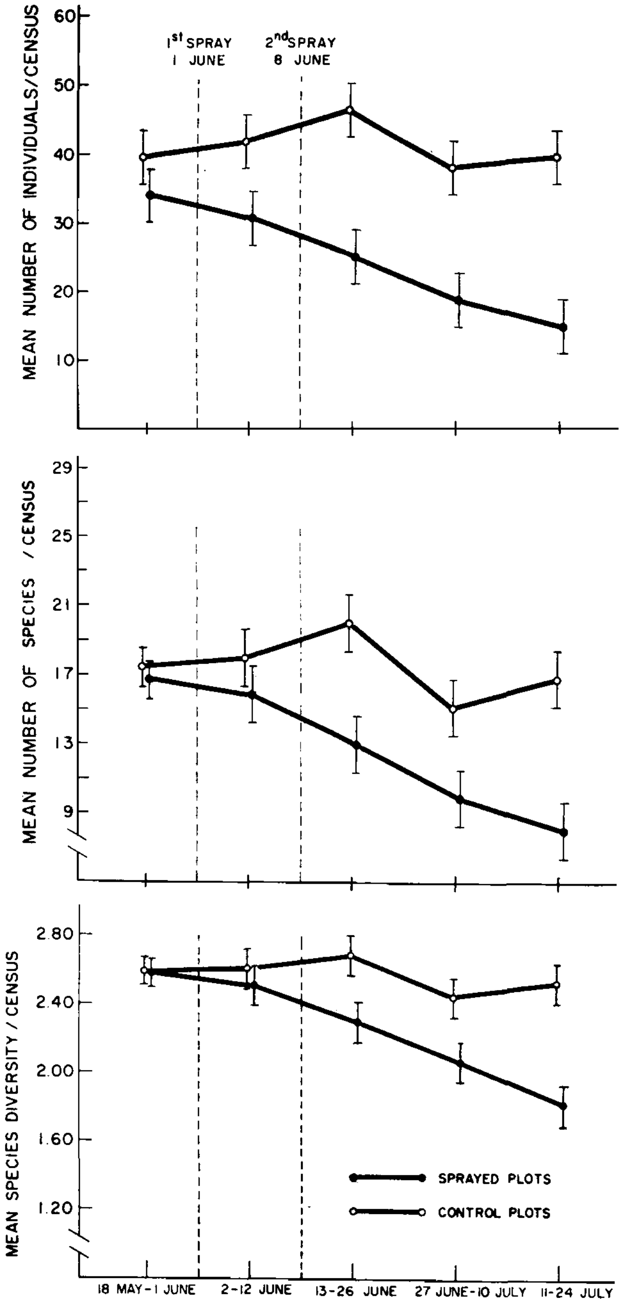

Fig. 1. Effects of application of Sevin on bird abundance, species richness, and species diversity (Shannon-Wiener index).

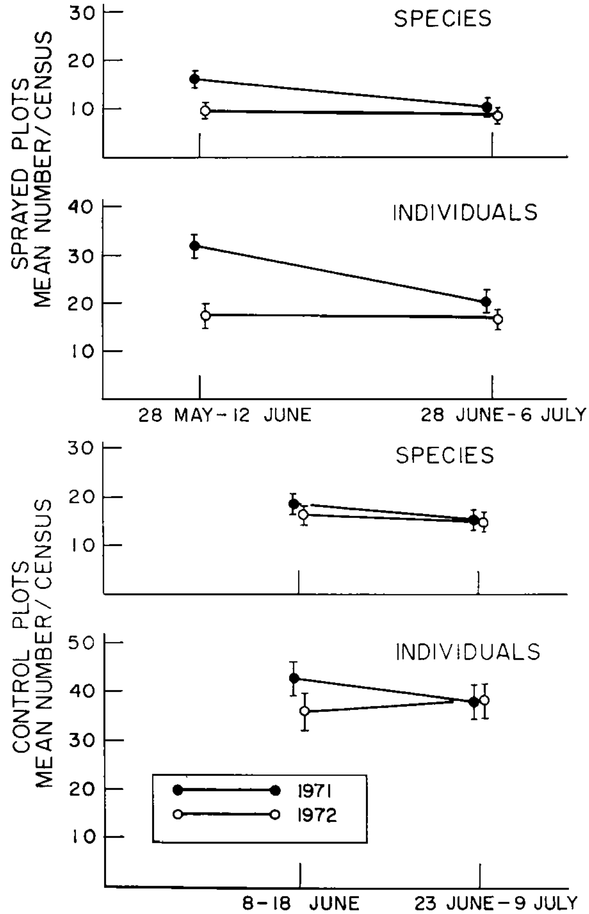

Fig. 2. Comparison of bird abundance and species richness during early summer of the year of spraying and the year following.

Censuses made during midsummer showed no further decline and no significant difference between the two years. The control plots showed no significant differences between years at any time.

In this study it was assumed that the unsprayed plots could be considered a norm or "control" against which the sprayed plots could be compared. All the study plots were chosen carefully to be as similar as possible. The absence of any suitable habitat near Stokes State Forest that would not be sprayed or had not been sprayed the previous year necessitated locating the control area at some distance from the sprayed area. Despite this, the study plots were very similar in the species

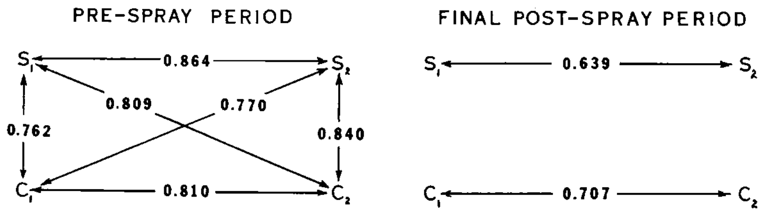

Fig. 3. Comparison of the similarity of the bird species composition of the four study plots using a coefficient of community.

composition of their avian communities. As a means of quantifying this, a coefficient of community was calculated for each pair of plots. The coefficient was based on the importance values of the species in each plot. The importance value is defined as the decimal sum of the frequency of detection and relative abundance (i.e. relative to the total number of birds of all species in the plot). The importance value can reach a maximum of 2.0. The coefficient of community is calculated by the expression $C = 2W/(A + B)$ (Bray and Curtis 1957), where A and B are the sum of the importance values for all species in plots A and B respectively, W is the sum of the importance values for the shared species in plots A and B (whichever is smaller), and C is the coefficient. This parameter expresses the degree to which the two plots shared species, with each species weighted according to its prevalence. A coefficient equal to 1.0 indicates that the two plots have all their species in common. Fig. 3 shows a comparison of the coefficients of community for all pairs of the four study plots during the prespray period and between replicate plots during the final postspray census period. There is no objective criterion for assessing similarity with this parameter, but the consistently high values indicate that all the plots can be considered replicates of one another during the prespray period.

There were no breeding bird species in the sprayed plots that did not breed in one or both of the control plots. The only numerically important species that bred exclusively in both control plots was the Hooded Warbler. The American Redstart was a major breeding species in one control plot, but was absent in all other plots. A few other breeding species such as Canada Warbler, Chestnut-sided Warbler, and House Wren were of minor importance in one or the other of the control plots. Migrating transients were never encountered in significant numbers on any census day in either year. It might be asked if these slight differences could nonetheless have masked a noninsecticide-related (i.e. seasonal) population decrease in the control plots among the species shared with the sprayed plots. To examine this possibility, the original data were reworked to include only the breeding species common to all four study plots. An analysis of variance of these data still showed a consistent pattern of declines in the three bird community parameters. Therefore it is reasonable to consider the trends evidenced in both sprayed plots to be abnormal and caused by the insecticide application.

The lack of an immediate sharp drop in bird numbers suggests that indirect rather than direct factors were involved in the avian community response. This is buttressed by the absence of any evidence of bird mortality or disability in the sprayed plots following the applications. It is also consistent with toxicological studies that indicate Sevin has relatively low toxicity to birds (Pimentel 1971). Some behavioral change might be suspected, although no immediate effect on behavior was detected. Birds watched in one of the study plots while the aircraft was spraying overhead showed no signs of alarm. A Rose-breasted Grosbeak and Wood Thrush sang continuously throughout. Contrary to the findings of Doane and Schaefer (1971) and Giles (1970), I noted no decreased vocal activity in the several days following spraying.

It might be argued that, rather than reduced abundance, the observed effect could have been due to reduced detectability as a result of birds eventually becoming quieter and more secretive. This question cannot be answered objectively with the available data, but considering the magnitude of the decrease it is very unlikely that so many birds could remain undetected if they were indeed present, particularly as the leisurely pace and the relatively long duration of each census enabled a thorough scrutiny of the vegetation along the transect.

While it is not possible to delineate with any certainty the exact mechanisms of the effects on birds, much circumstantial evidence suggests that applying Sevin affected some birds by reducing their food resources. One possible explanation of the decline observed during the 8 weeks of postspray censusing is that it was caused by opportunistic feeding outside the sprayed study plots. Long forays for food would decrease the probability of detecting individual birds in the study plots. The steady rather than abrupt decline could have been due to increasing demands for food by growing nestlings. This would have been reflected in more frequent food gathering by parent birds and correspondingly more frequent absences from the census area. Several other authors have also suggested out-of-area feeding as an avian response to insecticide-induced food shortages (McEwen et al. 1964, Giles 1970, Doane and Schaefer 1971). The sprayed tracts in the first two studies were small enough to permit easy access to the adjacent unsprayed study areas. In the present study, it was initially thought that the large size of the Stokes State Forest spray block would preclude such edge effects. But a mid-July survey along the roads in the spray block revealed a pattern of gypsy moth defoliation undoubtedly caused by skips in the spray application. An aerial survey revealed that these were extensive strips paralleling the direction of flight of the spray plane. These "food islands" would have facilitated opportunistic feeding.

In a companion study I found no significant changes in insect abundance in light-trap and sweep-net samples that could be attributed to the insecticide (Moulding 1972). But this sampling, which was conducted in the lower vegetative strata of the forest, may not have been indicative of overall effects. It is reasonable to expect that the greatest impact on arthropods would occur in the canopy because it receives the spray most directly and in greatest quantity. The maximum penetration of Sevin to ground level was only 25% of the calculated rate applied by the aircraft (Moulding 1972). The effect in the canopy might be similar to that found by Barrett (1968) from an application of Sevin (2 pounds/acre) on a unistratum crop. This resulted in a 70% reduction in total numbers and biomass of arthropods, with biomass but not numbers recovering in 7 weeks. Davis et al. (1963) reported that application of Sevin was followed immediately by a reduction in the number of Rufous-sided Towhees that foraged in trees and a shortening of the period of arboreal foraging. No other effects on towhees were reported. They attributed this to a reduction in the number of insects available to the birds. As almost all birds are primarily insectivorous in early summer (Martin et al. 1951), any such differential effect on insects might be reflected similarly among birds depending upon the vertical stratification in their feeding behavior. To examine this possibility, a separation of birds by feeding habits in the forest was made from the original census data, and trends in the mean number of individual birds were compared. Species were grouped according to whether they typically forage high in the trees or close to the ground. These data were then plotted against the time blocks previously used, with replicate plot means pooled (Fig. 4). The results indicate that canopy-feeding birds in the sprayed plots decreased in abundance relative to the controls but ground-feeding birds showed no difference. A linear regression analysis supported the line of evidence for canopy-feeding birds, but failed to show significance among ground-feeding birds because of the high scatter of the data in late summer. Nevertheless the trend is evident and consistent with observations by Pearce (1967) in which he found that warblers with medium or high foraging ranges were particularly hard hit by an application of the organophosphorous insecticide Sumithion (fenitrothion) used for spruce budworm control.

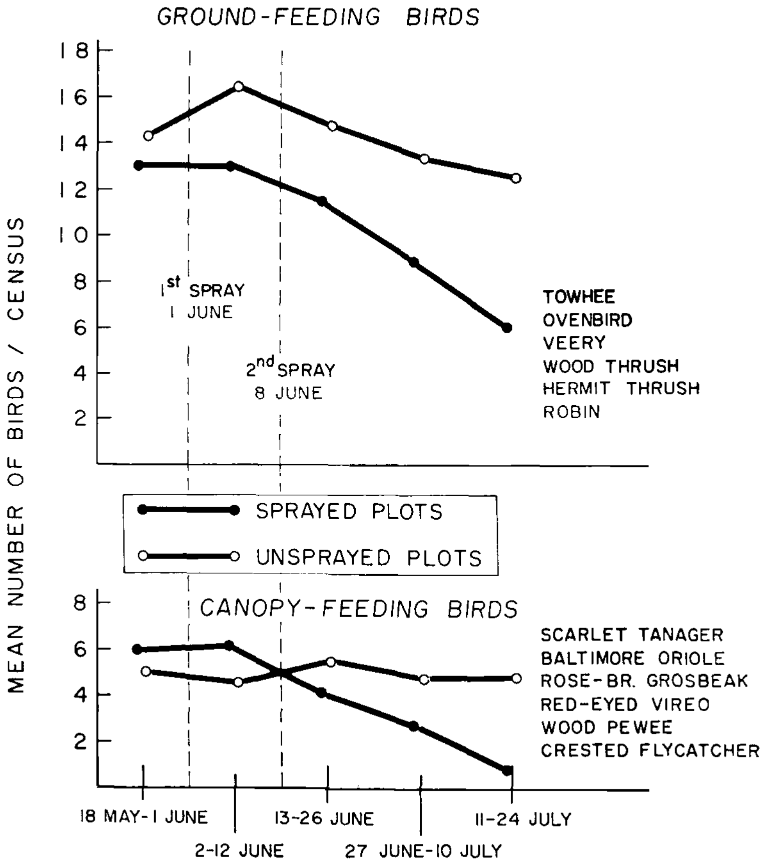

Fig. 4. Effects of application of Sevin on grouped species of canopy-feeding and ground-feeding birds.

Canopy-dwelling arthropods were not sampled directly, but obviously the mortality in gypsy moth caterpillars and presumably other phytophagous insects that feed primarily in the oak canopy was very high. Doane and Schaefer (1971) implied that the effects they noted on bird populations in areas treated with insecticides (including Sevin) were mostly due to the 99% reduction in the high density gypsy moth population on which birds had been feeding. Evidence from preliminary work for the present study suggests that dramatic decreases in gypsy moth larval density do not substantially affect the stability of breeding bird populations. During the summer of 1970 when the gypsy moth population peaked in the control plots, the number of bird species and individuals

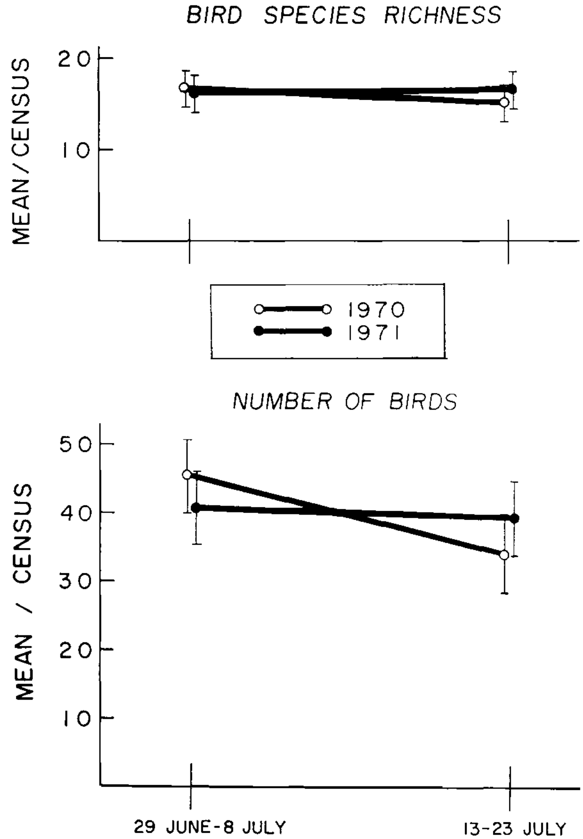

Fig. 5. Comparison of bird abundance and species richness in the control area before and after a natural crash in the gypsy moth population.

was not significantly higher than during the same period in 1971 after the population had crashed (Fig. 5). Many species of birds feed on gypsy moth caterpillars, but high larval density apparently does not necessarily induce inflated and, thereby, dependent bird populations.

The residual effect on bird populations noted in 1972 suggests that more was involved than just transient changes in behavior. Most of the birds that enter an area to breed in the spring are not a random collection of individuals of each species, but rather those individuals that bred or resided there in the past. Kendeigh (1934) concluded that "variations in the abundance of a [bird] species in the same locality during consecutive years is dependent upon the number of birds breeding during the previous year, the amount of reproduction and the survival over winter." The residual effect, therefore, would be due to the absence of some of those individuals that through site loyalty would have normally made up the bulk of the next year's breeding population. This absence could have been mediated by mortality of fledglings or very young nestlings. Several attempts have been made to assess the effects of field applications of Sevin on avian reproductive success. A study by Bednarek and Davidson (1967) indicated that Sevin could be toxic to newly hatched passerine nestlings. The only possible effect reported in 10 nests studied by Willcox (1972) was that nestling American Robins showed erratic weight gains and delayed fledging in comparison with controls. In the present study data on two closely synchronized House Wren nests showed that several days prior to fledging of the young the parent birds made 50% more trips per half hour to the sprayed nest. The food items brought were almost exclusively small arthropods as compared to mostly caterpillars in the control area, which indicates a higher energy cost for adult birds to raise young, and presumably for fledglings to feed themselves in sprayed tracts.

Although too few nests have been studied to permit generalizations, these studies nonetheless indicate that reproductive success of birds may be lowered to some degree by insecticide application. How this would affect adult birds is not clear. Nesting failure with concurrent food stress might lead to a breakdown in further nesting behavior or a shift towards unsprayed habitats for renesting later in the season, with a resulting site loyalty shift expressed the following year. This could be part of the explanation for the decline in the avian community found in the present study.

This study and most of the discussion of other workers' results have been concerned with the use of Sevin, but evidence is accumulating that similar effects may follow the use of several other insecticides. Chambers (1972) found a disproportionate reduction in bird abundance relative to control 2 weeks following application of the organophosphorous insecticide Dylox to an oak forest. In a follow-up study with the same insecticide, Caslick and Cutright (1973) reported a 13% reduction in bird populations compared with prespray levels. Pearce (1970), in earlier studies of Dylox and the carbamate insecticide Matacil used for spruce budworm control, reported no mortality in birds, and concluded that no spray effect was revealed, but his data for Dylox show an average depression of 12% in a bird population index relative to control levels, and a 10 to 16% decline for Matacil during the 2 or 3 weeks following field applications (values approximated from his graphs). These declines are equal in magnitude to that reported in the present study at the corresponding time postspray. Bart (1973) suggested that territorial abandonment may have occurred among birds that fed on foliage insects in an oak-maple forest sprayed with the organophosphorous insecticide Orthene. The effect was more pronounced in the center of the study plot than on the edges, suggesting that opportunistic feeding may have occurred.

The study described here was conducted within a functional gypsy moth control program. The only modification for the purpose of the study was the respraying of the study plots to obtain a more even insecticide application. The double application probably had no effect of itself on the ecosystem that would not also have occurred from a single even application. Double coverage would not have been atypical in some parts of the spray block in any case. To fly an aircraft over essentially unmarked forest and lay down exactly contiguous swaths of spray is almost impossible, but the amount of insecticide applied is carefully metered to ensure that the volume calculated for the total acreage involved is actually used. Thus for every skip a corresponding area receives a double dose. The effects of the 1-week delay between applications is harder to evaluate. The residual toxicity of Sevin from the first application was probably still effective during this time. In that case, the only effect of spray overlap would be on those susceptible organisms that somehow were protected from the initially highly toxic residues after the first spray. That the number of such organisms is probably small can be seen from a study by Hoffmann and Merkel (1948). They collected insects in drop-trays after two equal doses of DDT were applied 1 week apart to a lodgepole pine forest in midsummer. Only about one-tenth as many insects were found in the same trays after the second application.

The ramifications for bird populations of continued use of chemicals for gypsy moth control revolve around the accuracy of the hypotheses here put forth. If the population declines were only due to reduced detectability caused by opportunistic feeding, and such recourse is available to birds close by, the effects would be minimal, but if reproduction was disrupted by direct or indirect mortality of young or by failure to renest, the consequences would be more severe. It could be particularly serious if large-scale spraying is done to control outbreaks such as are expected eventually in the southern Appalachians. With this magnitude of operation, it is economically practical to employ electronic ground guidance systems for the spray aircraft. This ensures a more even application, but would also deny opportunities for birds to obtain additional food from the typical skips of unguided spraying.

Considering the serious implications of this study for bird populations, it would be prudent that further investigations be carried out to clarify the mechanisms involved. If forest insecticide practices produce long-term instability in avian communities, this effect should be given an important position in the cost-benefit equation for chemical control of gypsy moth.

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Summary

The impact of the insecticide Sevin on a forest bird community was studied within a functional gypsy moth control program in New Jersey in 1971. The only modification for the purpose of the study was the respraying of the study plots to obtain a more even application.

Extensive pre- and postspray bird censuses were conducted in replicate sprayed and control study plots using a strip transect method.

These revealed a consistent, gradual decline in bird numbers, species richness, and diversity during the 8 weeks following spraying. By the end of July, bird abundance was 55% below control levels. Bird populations continued to be depressed in the sprayed plots the following summer, although no further spraying was conducted. The average population level then was 45% lower than in the corresponding period before spraying the previous year. Some evidence suggests the effect was greater in canopy-foraging birds than in ground-foragers.

The mechanisms of these effects are not known. It is hypothesized that they are the result of some combination of opportunistic feeding outside the sprayed area, possible reduced reproductive success and shift in site loyalty in some portion of the avian community. Recent data from other studies indicate that decreases in bird abundance following spraying may be caused by several other short-lived insecticides when used for forest insect control. It is suggested that to clarify the mechanisms of these effects, more data are needed on the behavior of individual adult birds, and on nestling and fledgling survival, particularly in nests that hatch or fledge young within 1 or 2 days of the spray.

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Department of Zoology, Rutgers University, New Brunswick, New Jersey 08903. Present address: Department of Entomology and Economic Zoology, Rutgers University, New Brunswick, New Jersey 08903.
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APPENDIX

BIRD SPECIES IDENTIFIED IN THE STUDY PLOTS
(* = breeding species present in all plots)

Turkey Vulture (*Cathartes aura*)
Red-shouldered Hawk (*Buteo lineatus*)
Broad-winged Hawk (*B. platypterus*)
Ruffed Grouse (*Bonasa umbellus*)
Mourning Dove (*Zenaida macroura*)
Yellow-billed Cuckoo (*Coccyzus americanus*)
Black-billed Cuckoo (*C. erythropthalmus*)
Chimney Swift (*Chaetura pelagica*)
*Common Flicker (*Colaptes auratus*)
Pileated Woodpecker (*Dryocopus pileatus*)
*Hairy Woodpecker (*Dendrocopos villosus*)
*Downy Woodpecker (*D. pubescens*)
*Great Crested Flycatcher (*Myiarchus crinitus*)
Eastern Phoebe (*Sayornis phoebe*)
*Eastern Wood Pewee (*Contopus virens*)
*Blue Jay (*Cyanocitta cristata*)
Common Crow (*Corvus brachyrhynchos*)
*Black-capped Chickadee (*Parus atricapillus*)
*Tufted Titmouse (*P. bicolor*)
*White-breasted Nuthatch (*Sitta carolinensis*)
Red-breasted Nuthatch (*S. canadensis*)
*Brown Creeper (*Certhia familiaris*)
House Wren (*Troglodytes aedon*)
Gray Catbird (*Dumetella carolinensis*)
American Robin (*Turdus migratorius*)
*Wood Thrush (*Hylocichla mustelina*)
Hermit Thrush (*Catharus guttata*)
*Veery (*C. fuscescens*)
Eastern Bluebird (*Sialia sialis*)
Blue-gray Gnatcatcher (*Polioptila caerulea*)
Cedar Waxwing (*Bombycilla cedrorum*)
Yellow-throated Vireo (*Vireo flavifrons*)
*Red-eyed Vireo (*V. olivaceus*)
*Black-and-white Warbler (*Mniotilta varia*)
Worm-eating Warbler (*Helmitheros vermivorus*)
Golden-winged Warbler (*Vermivora chrysoptera*)
Black-throated Blue Warbler (*Dendroica caerulescens*)
Black-throated Green Warbler (*D. virens*)
Cerulean Warbler (*D. cerulea*)
Blackburnian Warbler (*D. fusca*)
Yellow-throated Warbler (*D. dominica*)
Chestnut-sided Warbler (*D. pensylvanica*)
Bay-breasted Warbler (*D. castanea*)
Blackpoll Warbler (*D. striata*)
*Ovenbird (*Seiurus aurocapillus*)
Louisiana Waterthrush (*S. motacilla*)
Common Yellowthroat (*Geothlypis trichas*)
Hooded Warbler (*Wilsonia citrina*)
Canada Warbler (*W. canadensis*)
American Redstart (*Setophaga ruticilla*)
Eastern Meadowlark (*Sturnella magna*)
*Northern Oriole (*Icterus galbula*)
*Brown-headed Cowbird (*Molothrus ater*)
*Scarlet Tanager (*Piranga olivacea*)
*Rose-breasted Grosbeak (*Pheucticus ludovicianus*)
Purple Finch (*Carpodacus purpureus*)
*Rufous-sided Towhee (*Pipilo erythrophthalmus*)
Chipping Sparrow (*Spizella passerina*)
Field Sparrow (*S. pusilla*)