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Effects of a Nonpersistent Insecticide (Alsystin®) on Abundance Patterns of Breeding Forest Birds

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The impact of nonpersistent insecticides on abundance patterns of forest birds has been of concern in recent years (Bart 1979). For example, Sevin® (1-naphthyl methylcarbamate) may reduce forest invertebrate populations that are important avian food resources (Moulding 1976), but the effect of this insecticide on singing-male surveys of territorial forest birds is typically negligible or nonexistent (e.g., Conner 1960; Bart 1979). Additional research is needed on the environmental impact of various nonpersistent insecticides on birds, which represent major predators in forest ecosystems (Bart 1979).

The gypsy moth (*Lymantria dispar*) is the most severe insect defoliator in northeast deciduous forests, and birds are among the common predators of this insect (Smith and Lautenschlager 1978). Alsystin® (2-Chloro-*N*-[[[4-(trifluoromethoxy)phenyl] amimo]carbonyl]benzamide, Mobay Chemical Co.), a nonpersistent insecticide that affects chitin synthesis in *L. dispar* and perhaps other Lepidoptera (Anonymous 1982), has been developed recently to control various insect pest populations. However, little information is available on the effects of this insecticide on non-target organisms. The objective of our study was to compare avian abundance patterns in a sector of a deciduous forest in central Pennsylvania, sprayed for gypsy moth control with Alsystin, with patterns in an untreated sector both before and after insecticide application.

MATERIALS AND METHODS

The study was conducted on Moshannon State Forest, Centre Co., Pennsylvania. A 200-ha forested area was sprayed with Alsystin at 0.07 kg/ha on 9 June 1983. Two parallel 1-km transects, separated by 200 m, were established in the sprayed area (hereafter termed transects). In an unsprayed forested area 1.6 km west of the treatment transects, 2 parallel control transects of the same length and spacing were established. Both treatment and control transects were on southwestern slopes. Elevation was 646–732 m and 616–713 m along treatment and control transects, respectively. Dominant overstory trees (≥ 7.5 cm dbh) in the vicinity of treatment and control transects were red maple

(Acer rubrum), chestnut oak (Quercus prinus), northern red oak (Q. rubra), white oak (Q. alba), and sassafras (Sassafras albidum). Dominant ground cover species were mountain laurel (Kalmia latifolia) and blueberry (Vaccinium spp.). A detailed botanical description of the study area is presented in Quinn et al. (in press).

Pre-spray egg mass counts (May 1983) were estimated to be 697 masses/ha and 1378 masses/ha on the unsprayed and the sprayed forested area, respectively; post-spray counts (September 1983) were 1121 masses/ha (61% increase) and 111 masses/ha (92% decrease) on the unsprayed and the sprayed forested area, respectively (W. McLane, pers. commun.). Unsprayed areas had approximately 15% defoliation, whereas sprayed areas had $\leq$ 5% defoliation (W. McLane, pers. commun.). In contrast to 1983, an outbreak year occurred in 1981. Egg mass counts in 1981 exceeded 3700 masses/ha, and defoliation was 80% at Moshannon State Forest (E. A. Cameron, pers. commun.).

Vegetation was quantified in 12 0.04-ha circular plots following the methods of James and Shugart (1970). Plots were located at midpoints and at 200 m from both ends of each transect. Variables measured per plot were density (no./ha) and basal area (m^2/ha) of each individual overstory tree species, dead overstory trees, and combined overstory tree species. In addition, density (no./ha) of shrubs ($\leq$ 7.5 cm dbh), % canopy cover, and % ground cover were determined. Vegetative variables were compared between treatment and control transects using Mann-Whitney tests. All statistical tests are taken from Sokal and Rohlf 1981; significant differences throughout the text are at $P \leq 0.05$.

Eight bird surveys were conducted prior to Alsystin application (25 May - 8 June 1983) and after an 11-day pause following application (21-29 June 1983), giving a total of 16 surveys per treatment and control transects. Surveys were from sunrise to 1000 hours, and each of the 4 transects was covered on the same day. Singing and drumming male birds within 50 m on either side of transects were recorded and mapped as observers traversed the transects at a slow walk (Robbins 1970). The order in which transects were traversed was randomly-selected each day. Migratory species (Wood 1983) were recorded but were not considered in the analyses. Birds that moved into or out of the 50-m lateral distance of transects were recorded, but individuals flying overhead were excluded (Conner and Dickson 1980). The 100 x 1000 m areas surveyed along the treatment and control transects will be referred to as the treatment area (total = 20 ha) and the control area (total = 20 ha), respectively.

The number of singing or drumming male birds of an individual species (A), the total number of individuals of all species combined (N), and species richness (S) observed per census area during each survey were calculated. Hence, 8 pre-spray and 8 post-spray values of A, N, and S were obtained per area. The number of pre-spray and post-spray territories on each area was determined for each species and for all species combined. Territories with $\geq$ 50% of their boundaries within an area were counted as whole territories for analyses; territories with < 50% of their boundaries inside an area were excluded from analyses.

A, N, and S were compared between areas and spray periods by 2-way analyses of variance. When variances were heterogeneous and could not be stabilized by square root or logarithmic transformations, nonparametric tests were used. These included sign tests to compare avian variables between areas both within each spray period and over the 2 areas combined, and median tests to compare avian variables between spray periods both within each area and over the 2 areas combined. To test indirectly for interactions between area and spray periods in A, N, or S with heterogeneous variances, deviations of a given avian variable for each of the 8 post-spray surveys from the median of that variable obtained for the 8 pre-spray surveys in a respective area were calculated. Distributions of deviations for a given avian variable then were compared between areas using sign tests. Dependency of the number of territories of individual bird species or of all species combined per area (treatment versus control) on time of spraying (pre-spray versus post-spray) was determined by Fisher's exact test.

RESULTS AND DISCUSSION

None of the vegetative variables differed significantly between treatment and control transects. A total of 32 bird species was observed on the 2 areas combined (see Quinn et al. in press), and 18 species established $\geq$ 2 territory in either or both areas (Table 1). The number of territories per area was not dependent on spray period for individual bird species or for all species combined. Thirteen species had values of A that were significantly higher during the pre-spray than during the post-spray period in both areas (Table 1). In addition, N and S declined from the pre-spray to the post-spray periods. Only A of downy woodpeckers (see Table 1 for scientific names) and rose-breasted grosbeaks differed between areas, with both species being more abundant on the treatment than on the control area during each spray period; a similar trend occurred with S. There were no significant interactions between area effects and spray-period effects with any avian variables.

The application of Alsystin had no detectable effect on breeding forest birds in our study, based on analyses of singing or drumming males that were presumed to be territorial. The decline in values of A, N, and S from pre-spray to post-spray periods is attributed principally to temporal changes in the frequency of singing during the breeding season. The pre-spray period coincided with events in the nesting cycle, such as territory establishment, nest building, egg laying, and incubation, when rates of singing in most bird species are high (Pettingill 1970). The post-spray period corresponded with the time when parental care of young was common to most species; most males vocalize

Table 1. Mean ± standard deviation of A, N, and S and frequency of territories (in parentheses) on treatment and control areas during pre- and post-spray periods.

	Treatment Area		Control Area	
	pre-spray	post-spray	pre-spray	post-spray
Individual Species, A:				
Pileated woodpecker	0.8±0.7[a]	0.1±0.4	0.8±0.5	0.1±0.4
(*Dryocopus pileatus*)	(1)	(0)	(1)	(0)
Downy woodpecker	0.8±0.7[b]	0.6±0.5	0.4±0.5	0.1±0.4
(*Picoides pubescens*)	(1)	(0)	(1)	(1)
Great crested flycatcher	0.8±0.5[a]	0.4±0.7	1.5±0.9	0.3±0.5
(*Myiarchus crinitus*)	(2)	(1)	(1)	(0)
Eastern wood-pewee	2.8±1.6[a]	2.4±0.5	3.9±1.0	2.1±0.6
(*Contopus virens*)	(5)	(3)	(4)	(3)
Blue jay	0.8±0.5[a]	0.1±0.4	0.6±0.5	0.1±0.4
(*Cyanocitta cristata*)	(1)	(0)	(1)	(0)
Black-capped chickadee	1.9±1.0[a]	0.3±0.5	2.0±1.9	0.8±0.7
(*Parus atricapillus*)	(4)	(0)	(3)	(0)
White-breasted nuthatch	1.6±0.7[a]	0.6±0.7	2.3±0.7	0.9±1.1
(*Sitta carolinensis*)	(3)	(1)	(2)	(1)
Red-eyed vireo	3.6±1.2[a]	2.9±0.6	4.4±0.9	3.1±1.8
(*Vireo olivaceus*)	(7)	(5)	(5)	(4)
Black-and-white warbler	1.9±1.4[a]	0.1±0.4	3.0±1.1	0.0±0.0
(*Mniotilta varia*)	(5)	(0)	(3)	(0)
Worm-eating warbler	2.4±1.8[a]	0.0±0.0	2.0±1.2	0.1±0.4
(*Helmitheros vermivorous*)	(5)	(0)	(5)	(0)
Chestnut-sided warbler	2.3±1.2	1.9±0.6	1.6±1.1	2.0±1.3
(*Dendroica pensylvanica*)	(2)	(3)	(3)	(2)
Ovenbird	6.9±1.7[a]	3.0±1.1	6.1±2.2	3.3±1.4
(*Seiurus aurocapillus*)	(9)	(6)	(8)	(4)
Common yellowthroat	6.3±2.1[a]	3.8±1.7	6.4±1.4	4.5±0.8
(*Geothlypis trichas*)	(10)	(8)	(10)	(8)
American redstart	1.8±1.6	0.4±0.5	1.8±1.6	0.4±0.5
(*Setophaga ruticilla*)	(3)	(0)	(3)	(2)
Brown-headed cowbird	1.0±1.3[a]	0.0±0.0	1.3±1.7	0.0±0.0
(*Molothrus ater*)	(2)	(0)	(1)	(0)
Scarlet tanager	1.0±0.8[a]	0.1±0.4	0.6±0.7	0.0±0.0
(*Pirangea olivacea*)	(1)	(0)	(2)	(0)
Rose-breasted grosbeak	3.6±1.7[b]	2.6±1.2	0.6±0.5	0.0±0.0
(*Pheucticus ludovicianus*)	(1)	(0)	(4)	(4)
Rufous-sided towhee	4.4±1.4	4.8±0.9	4.6±1.0	5.8±1.2
(*Pipilo erythrophthalmus*)	(6)	(8)	(7)	(6)
Total species, N:	47.4±15.2[a]	26.6±5.1	46.1±13.4	24.5±5.8
Species richness, S:	18.5±3.7[a]	10.9±1.8	16.8±3.9	8.9±1.6

[a] Significant difference between spray periods.
[b] Significant difference between areas.

less often at this stage of the nesting cycle. Thus, we believe that the same individuals were present on the areas during both pre- and post-spray periods, as attested by no major change in the number of territories between periods on either area. However, birds that were present were less conspicuous to observers because they sang less often.

Of the 13 species that were heard less often (lower A) in the post-spray period compared to the pre-spray period, perhaps only the common yellowthroat produced $\geq$ 1 brood on the census areas during the study (Harrison 1975). A likely factor accounting for declines in A of brown-headed cowbirds from pre- to post-spray periods was this possible reduction in the occurrence of 2nd broods and nests with eggs of other species during the post-spray period. Density of cowbirds is correlated with the number of host nests available in a given area (Lown 1980). Therefore, we suspect that compared to the other 12 species showing declines in A over time periods, cowbirds were simply not less conspicuous (reduced rates of singing), but rather were less abundant in the post-spray period due to the presence of fewer host nests to parasitize than in the pre-spray period.

Gypsy moths and other lepidopterans are eaten by a variety of forest bird, including many species showing declines in A in our study (Smith and Lautenschlager 1978; Holmes et al. 1979). Alsystin probably depressed populations of these insects in the treatment area, as noted in other studies that have examined the effects of nonpersistent insecticides on foliage- dwelling arthropods in forest ecosystems (e.g., Moulding 1976; Bart 1979). Thus, arthropod food supplies perhaps varied between areas subsequent to spraying as resident arthropod populations were destroyed by the insecticide. But because the area sprayed at Moshannon State Park was relatively small, air currents conceivably could carry arthropods into the treatment census area from contiguous, unsprayed areas subsequent to the application of Alsystin (see Bart 1979). Thus, dramatic, long-term food shortages for insectivorous birds may not have occurred during the post-spray period on the treatment area.

Most studies dealing with the effects of birds on gypsy moth populations have been conducted when moth populations are near or at outbreak levels (Smith and Lautenschlager 1978). Our study was made 2 years after an outbreak year in Moshannon State Park (E. A. Cameron, pers. commun.). Thus, the possible effects of spraying on avian food resources and, hence, on avian abundance patterns, may be much different had the study been conducted during an outbreak. For example, yellow-billed cuckoos and black-billed cuckoos (Coccyzus erythropthalmus) are species attracted to high-density moth areas (Smith and Lautenschlager 1978). During an outbreak year of gypsy moths, abundance patterns of these 2 bird species may have been much different between the treatment and the control areas. Further, during an outbreak year, we would predict that spraying of an insecticide, such as Alsystin, would have some positive effects on habitat use by birds because of the potential defoliation caused by gypsy moths. Many insectivorous foliage gleaners select breeding habitat on the basis of various vegetative characteristics, such as % canopy closure (e.g., James 1971). Bird populations have been shown to decline in areas severely-defoliated by gypsy moths compared to areas lightly-defoliated or not affected by moths (DeGraaf and Holland 1978; Lautenschlager et al. 1978).

In conclusion, abundance patterns of breeding forest birds differed little or not at all between a lightly-defoliated area and an area sprayed with Alsystin. In small sprayed areas, this insecticide appears to have no dramatic effect on the availability of adequate avian food resources. However, we have no data to compare fledging success of nests established in the 2 areas.

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