Red-Breasted Nuthatches Detect Early Increases in Spruce Budworm Populations

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ABSTRACT. Early suppression of increasing spruce budworm populations is essential to prevent epidemics; however, early changes in budworm numbers are difficult to detect. An effective and inexpensive method to detect early increases is needed. Red-breasted nuthatches eat more spruce budworm larvae and pupae as the insect increases in number. We estimated the number of large larvae in Maine and northern New Hampshire forest stands in 1982 and 1983 by determining the number of these larvae in the birds' stomachs. When the mean number of spruce budworm in the stomach approached 1.7, budworm populations were nearing high density and could be expected to cause severe defoliation the following year.

North. J. Appl. For. 7:81–83, June 1990.

Forest and insect managers need an effective and inexpensive method to detect increases in spruce budworm density while budworm populations are still at low levels. Stedinger (1984) described the importance of early suppression measures to control budworm outbreaks. Detection of changes in egg mass or second instar larvae (L_2) overwintering densities requires many field samples, complex sample handling, and numerous personnel within a short time frame to determine if treatments are necessary. Development of sex pheromone traps offers promise as a more efficient method to monitor early changed in spruce budworm density (Allen et al. 1984, 1986, Sanders and Meighen 1987, Sanders 1988).

Another potential technique for monitoring low-density budworm populations is to determine the numbers of spruce budworm larvae eaten by birds. Birds sample budworms far more effectively than man. A suitable bird species that indirectly assays changes in budworm numbers through stomach contents should (1) show a significant density-dependent response in predation rates, (2) be widely distributed in spruce-fir stands, (3) be numerous, and (4) be easy to collect. In a recent study designed to determine the effect of bird predation on endemic spruce budworm larval and pupal populations (Crawford and Jennings 1989), we clipped and examined two limbs from an average of three host trees to find one fourth instar (L_4) spruce budworm larva. Sample sizes of 130 to 530 limbs were needed to obtain an estimate within ±20% of mean L_4 numbers

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with 95% confidence on 8 ha plots with low-density spruce budworm populations. On these same plots we found numerous large larvae and pupae in the gizzard of many bird species. Can birds provide an adequate assay of changing budworm populations?

METHODS

We used shotguns to collect 987 birds from spruce-fir stands of western Maine and northern New Hampshire during June and July 1982 and 1983. We determined the number of larvae and pupae in their digestive tracts, and regressed this number against the number of fourth instar (L_4) budworm found in the same stands in May of the same year (Crawford and Jennings 1989). The model tested was $\hat{Y}_i = a + b_1 x + b_2 x^2$, where Y = the number of large larvae and pupae found in the stomachs of n bird species and x = the L_4 population of spruce budworm. A total of 17 plots with low budworm densities influenced the shape of the response curve for each species of bird commonly encountered. The species analyzed included black-capped chickadee (*Parus atricapillus*), boreal chickadee (*P. hudsonicus*), red-breasted nuthatch (*Sitta canadensis*), golden-crowned kinglet (*Regulus satrapa*), hermit thrush (*Catharus guttatus*), solitary vireo (*Vireo solitarius*), black-throated green warbler (*Dendroica virens*), magnolia warbler (*D. magnolia*), yellow-rumped warbler (*D. coronata*), Cape May warbler (*D. tigrina*), bay-breasted warbler (*D. castanea*), blackburnian warbler (*D. fusca*), Nashville warbler (*Vermivora ruficapilla*), purple finch (*Cardpodacus purpureus*), and white-throated sparrow (*Zonotrichia leucophrys*).

RESULTS AND DISCUSSION

Of the total collection of birds, 56 were red-breasted nuthatches. It was the only species that showed a significant ($P = 0.027$, $r^2 = 0.40$) density-dependent response when budworm populations were low (Fig. 1). The relationship was $Y = -0.109452 + 3.106\ (10^{-6})\ (x) + 1.059\ (10^{-12})\ (x^2)$.

Predation by the red-breasted nuthatch is relatively light at low populations of spruce budworm and increases as budworm increase in number; thus, it is a good indicator of budworm increase. However, it is not as effective a predator as those species, such as the blackburnian warbler, that specialize on low-density spruce budworm populations. Thus, some loss of the nuthatch population would not cause the budworm population to increase substantially.

The red-breasted nuthatch is widely distributed and relatively abundant (Erskine 1977, Crawford and Titterington 1979, Dawson 1979, Temple et al. 1979). It is also easily collected because it calls noisily and frequently while feeding and decoys readily to calls replayed on a tape recorder. When L_4 density was 500,000/ha, the approximate density where budworm populations first begin to escape the control of predators (Crawford and Jennings 1989), the mean number of budworm per stomach was 1.71 and the population could defoliate substantial portions of the stand the next year. To estimate within ±20% of mean numbers of budworm consumed using our sample values of $\bar{x}$ = 1.39 and standard deviation = 1.72 and iteratively calculating $n = s^2\ t^2/d^2$ (Freese 1967), where d = the desired proportion of $\bar{x}$, approximately 150 birds would have to be collected. If populations of red-breasted nuthatch are similar to those found in our study—a family group of 7 to 8 birds/5 ha—150 birds could easily be collected in less than 20 man days, well within the 40-day period that larvae and pupae of the spruce budworm are present. Sampling should be extended over at least 10 days in late June and early July to be representative. Stomach analyses, after training, requires approximately twice as much time as field collection. This technique requires obtaining the appropriate collecting permits.

In contrast, approximately 270 limbs would have to be collected to achieve the same level of accuracy in sampling L_4 populations ($\bar{x}$ = 8.54, s.d. = 14.25). Limb sampling and counting larvae can probably be done in equal or less time than it takes to sample red-breasted nuthatches and analyze stomach content. However, one person can easily collect birds and analyze stomach contents, but it is much more difficult for one person to collect limbs and obtain an accurate count of larvae. Additionally, birds are sampled when they are eating L_6 larvae, and this life stage gives a better prediction of spruce budworm populations the following year than does the L_4 sample. Pupae numbers would give an even better indication of the subsequent year's budworm population, but pupal numbers are so low in endemic budworm populations that an impractable number of limbs or birds would have to be sampled.

APPLICATION

This technique can be applied to any stand considered susceptible to budworm infestation in any year. However, it would be more efficient for use in situations where budworm irruptions are most likely to occur first and in years that budworm are expected to be a threat. Some stands have a known history of early budworm infestation. Spruce budworm has the potential to reinfest stands on an approximate 35-year cycle (Royama 1984). Also, managers should closely watch stands that have a large mature fir component and tend to be even-aged and one-storied. These stands generally have poor populations of spruce budworm predators.

Try to obtain samples representatively throughout the stand, regardless of stand size. Record sample location, because you may have to return to subsample suspected centers of infestation.

Shotguns with variable chokes and number 12 size shot are recommended. Use the edge of an open-choke pattern when birds are close. Tighten the choke for longer shots. Wait until the birds approach the edge of the canopy before shooting, unless you enjoy climbing trees to retrieve samples.

Collecting permits will be required. Contact your state or provincial wildlife agency for information. States or provinces might want to assume sam-

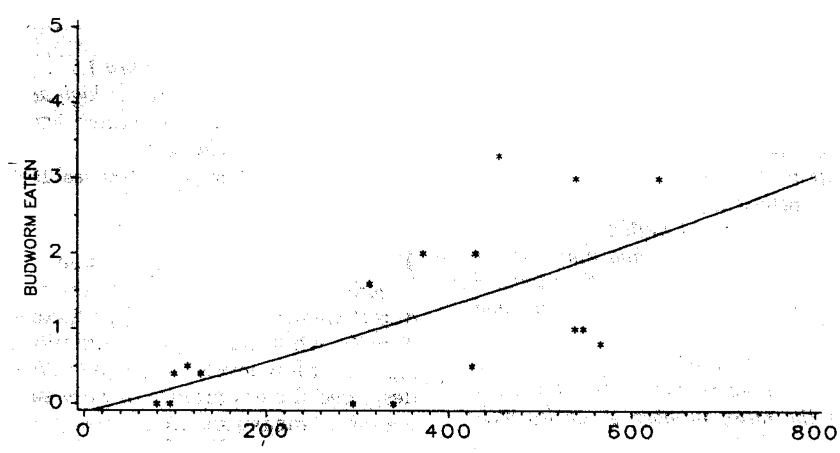

Fig. 1. Quadratic regression of mean numbers of spruce budworm larvae and pupae found in red-breasted nuthatch stomachs on fourth-instar larvae/ha.

pling responsibility as a joint function of the wildlife and forestry agencies.

Stomach analysis to determine budworm consumption requires some knowledge of the insect's anatomy. The most definitive parts for identifying individual larvae are the remains of head capsules and mandibles. The cremaster is the most definitive part for pupal identification. Refer to Miller (1950), MacKay (1953), and Crawford and Jennings (1982) for more information. □

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