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Agricultural Practices Affect Botfly (Cuterebridae) Prevalence in Gray-tailed Voles (*Microtus canicaudus*)

Abstract

We examined the effects of an organophosphorous insecticide (azinphos-methyl) and mowing of alfalfa on larval botfly (Cuterebridae) prevalence in gray-tailed voles (*Microtus canicaudus*) in enclosed populations. Twelve of 24 enclosures were mowed, and three concentrations of an insecticide (Guthion 2S[®]) were applied three weeks after mowing. We captured 3,529 voles between 17 July and 27 August 1993, and 88 had at least one botfly parasite (overall prevalence = 2.5%). We found the prevalence of botflies in male voles (3.25%) to be significantly greater than in females (1.82%; $X^2 = 6.06$, $P < 0.015$). The interaction of mowing and insecticide application was a significant factor in determining botfly prevalence ($X^2 = 5.88$, $P < 0.055$); prevalence of botfly infection was lower in mowed than in unmowed enclosures except at the highest insecticide concentration, which reduced the number of infections in both mowed and unmowed enclosures. We suggest the reduction in botfly prevalence resulted from the direct effect of both mowing and insecticide application on adult botflies and botfly eggs, whereas differences in prevalence between genders was related to the voles' activity patterns.

Introduction

Botfly parasites of the family Cuterebridae are common among new world rodents, and may affect activity patterns (Smith 1978a) and survival of the host (Miller and Getz 1969, Boonstra et al. 1980). Botfly larvae exert varying physiological stresses associated with subcutaneous feeding (Smith 1977) that may cause a decrease in non-maintenance activity (Smith 1978a) or survival (Boonstra et al. 1980) or increase susceptibility to predation (Smith 1978b), but the infections usually do not cause death of the host. Thus, parasite and host have evolved physiological adaptations permitting survival of both (Timm and Cook 1979).

No studies have examined how agronomic activities may alter botfly-host relationships. Agricultural practices may alter botfly habitat, causing a reduction in botfly populations or botfly egg viability and thereby reducing their prevalence in host populations. Botfly infection occurs when the host comes in contact with eggs, but except for host-specific site oviposition in pocket gopher (*Thomomys talpoides*) burrows (Capelle 1970) and dusky-footed woodrat (*Neotoma fuscipes*) houses (Catts 1967), most evidence suggests oviposition in the immediate area of host activity (Baird 1974).

Our objective was to examine the effect of an organophosphorus insecticide and mowing on the prevalence of botfly in gray-tailed voles (*Microtus canicaudus*). We hypothesized that mowing and insecticide application would have no effect on botfly prevalence.

Materials and Methods

This study was conducted in the Willamette Valley, at the Oregon State University Hyslop Crop Sciences Field Laboratory (~10 km north of Corvallis, Oregon [44° 38' N; 123° 12' W]). The site contained 24 0.2-ha enclosures, bordered by galvanized sheet metal ~1 m above and ~0.6 m below the ground surface. All enclosures were planted with alfalfa (*Medicago sativa*) in the spring of 1991. A 1-m-wide strip along the inside perimeter of each fence was regularly mowed to minimize vole activity near the perimeter and reduce activity near abnormally high concentrations of insecticide dripping down the fence (Edge et al. 1996). Each enclosure had seven breeding pairs of gray-tailed voles introduced in April 1992, and on 4-6 April 1993, enclosed populations were mixed to increase genetic variability and densities were equalized.

Each enclosure contained 100 traps; 75 Sherman live traps (7.5 x 9.5 x 25.5 cm; model LFATG; H. B. Sherman Traps, Inc., Tallahassee, Florida) and 25 pitfall traps (45 cm deep, 15 cm in diameter). Traps were arranged in a 10 x 10 grid, each 5 m apart with pitfalls located at all odd stations (i.e., 1-1, 3-3, 9-9). When not in use, pitfall traps were covered and Sherman traps were locked open. Four or five days before the start of each trap period, all Sherman traps were prebaited with oats. When trapping, all traps were opened in the evening; Sherman traps were baited with oats while pitfall traps were not baited. Traps were checked the following morning, and closed or covered during the day.

We trapped four consecutive nights every two weeks (trap period) from 18 May through 27 August 1993. All trapped animals were sexed, weighed, and ear-tagged, and the number and location of botfly larvae present were recorded. Animals with multiple simultaneous botfly infections were each counted as one infected individual during each trap period. Animals with botfly infections in the same location during consecutive trap periods and no larval exit wound were considered infected animals only during the earlier of the two trap periods.

Four enclosures were randomly assigned to each of six insecticide-mowing treatment combinations: 0.0 kg/ha-mowed, 0.88 kg/ha-mowed, 3.61 kg/ha-mowed, 0.0 kg/ha-unmowed, 0.88 kg/ha-unmowed, and 3.61 kg/ha-unmowed. Enclosures were mowed on 22 June 1993 to a height of approximately 15 cm; cuttings were not removed. The insecticide Guthion 2S® (azinphos-methyl; *O,O*-dimethyl *S*-[4-oxo-1,2,3-benzotriazine-3(4*H*)-yl]methyl]ester; Mobay Corporation, Agricultural Chemical Division, Kansas City, Missouri, USA) was applied on 14 July 1993 by a licensed applicator using a four-wheel all-terrain vehicle pulling a trailer tank with 7.6-m spray booms (Schauber et al. 1995). Enclosures were sprayed in order of increasing application rate; controls received an equal volume of water.

Only animals trapped during the period of botfly infection, from 17 July to 27 August 1993 (four trap periods), were used in this analysis. We combined replicate enclosures for statistical analysis because there were insufficient botfly larval-infected voles in all enclosures throughout the study. We used logistic regression and the Statis-

tical Analysis System (SAS Institute, Inc. 1987) to identify the explanatory variables (gender, mowing, insecticide, and interactions) accounting for the prevalence of botfly infections.

Results

Of the 3,529 voles we captured between 17 July and 27 August 1993, 88 had at least one botfly parasite (overall prevalence = 2.5%). Mean intensity of botfly infections was 1.4 parasites per host, and ranged from one to four; 76% of the infected animals had one larval parasite, while 16% had two, 2% had three, and 6% had four. The subcutaneous locations of the larval parasites were predominantly inguinal (79%); other locations included the chest and stomach (12%), hind-quarters (8%) and face (1%).

Botfly prevalence was affected by both agricultural practices and gender of the host. Prevalence in male voles (3.25%; $n = 1,663$) occurred at almost twice the rate as in female voles (1.82%; $n = 1,866$) ($X^2 = 6.06$, 1 d.f., $P < 0.015$). The interaction of mowing and insecticide application was also a significant factor affecting botfly prevalence ($X^2 = 5.88$, 2 d.f., $P < 0.055$). In control and 0.88 kg/ha concentration enclosures, the number of infected voles in mowed enclosures ($n = 1,880$) was considerably lower than in unmowed enclosures ($n = 1,649$). In the unmowed 3.61 kg/ha concentration enclosures, there was a sharp decrease in the number of infected animals, resulting in almost no difference in the prevalence of botfly between the mowed and unmowed enclosures (Figure 1).

Discussion

Variations in the prevalence, location, and intensity of botfly larvae may reflect differences in the life history of the host or botfly, or they may result from seasonal differences in infection or from differential survival of the host. Many studies of botflies in small mammals have found higher prevalence of the parasite than we found in this study. Getz (1970) found 16% of adult meadow voles (*M. pennsylvanicus*) in unmowed habitat infected. Studies of deer mice (*Peromyscus* spp.) have found 12-40% of adult males and 16-38% of adult females infected (Miller and Getz 1969, Seaman and Nash 1976). We found the majority of botfly larvae in gray-tailed voles in the inguinal

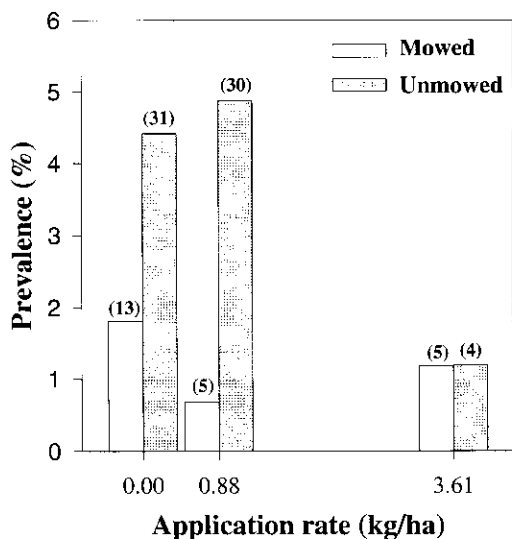


Figure 1. Prevalence of botfly larvae in gray-tailed voles by mowing and insecticide application rate. Numbers in parentheses are number of animals infected.

region, whereas larval infections of meadow voles in Wisconsin were in the same body regions, but were more evenly distributed: 37% inguinal, 26% sides, 22% chest, 10% back, and 5% head (Getz 1970). Infections in deer mice have been found solely on their sides and backs (Llewellyn 1978), predominantly on their rump (Seaman and Nash 1976), and predominantly inguinal (Miller and Getz 1969). Differences in the life histories of botflies or host physiology may account for such variation (Catts 1982), but the health and activity of the host may also influence variation in warble location.

Although most individual small mammals usually bear only one larval infection at a time, multiple simultaneous botfly infections have been found in meadow voles (Getz 1970), deer mice (Seaman and Nash 1976), and gray-tailed voles (this study). However, the number of individuals with multiple infections is relatively low, probably because of decreased activity (Smith 1978a) or survival (Boonstra et al. 1980) of individuals with more than one warble.

Physical and chemical habitat manipulation may reduce the activity and survival of both the host and the botfly. In our study, the difference in botfly prevalence between mowed and unmowed enclosures, and the decline in prevalence in unmowed high-dose enclosures, suggest that

mowing and insecticide application each has a negative effect on the incidence of botfly infection. In a uniformly non-woody marsh in Wisconsin, Getz (1970) reported higher prevalence of botfly in the unmowed than in the mowed habitat, and suggested that the presence of a litter layer in the unmowed habitat was the main physical difference between the two habitats. All enclosures in this experiment were mowed in 1992; thus differences in the litter layer presumably would not account for higher prevalence in unmowed enclosures than in mowed enclosures. The differences in prevalence between mowed and unmowed enclosures was possibly the result of a change in the micro-climate surrounding oviposited eggs. Mowing may have subjected botfly eggs to increased direct sunlight resulting from reduced cover. Botfly eggs in environments with temperatures $>35^{\circ}\text{C}$ and in environments with low humidity were both found to have reduced survival (Catts 1967). Whereas the individual effects of mowing and insecticide applications cannot be isolated, the reduction in botfly prevalence could be the result of increased mortality of adult botflies and oviposited eggs, and reduction of favorable botfly habitat for oviposition.

Insecticide effects on botfly prevalence may be a function of vegetation density. In unmowed enclosures, alfalfa structure and height affected the vertical distribution of insecticide, resulting in 70-87% decreases in concentrations at the soil surface and on the lower vegetative structures (Bennett et al. 1994) where botflies oviposit. In mowed enclosures, the insecticide reaching the lower layers of vegetation significantly reduced arthropod communities (J. Miller, Department of Entomology, Oregon State University, unpublished data) and was probably sufficient to kill botfly eggs. In 3.61 kg/ha concentration enclosures, the concentration of insecticide near lower plant structures was probably sufficient to kill botfly eggs and adults regardless of vegetation cover.

The relationship between the voles' gender and the prevalence of botfly larvae may be related to size of home range and activity patterns of the host. Male gray-tailed voles have significantly larger home ranges than females (Wolff et al. 1994). Because botflies generally lay eggs at multiple sites in scattered patterns (Catts 1967, Baird 1974), the probability of infection should increase with increased range of activity.

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