Spatial Distribution of the Goldenrod Ball Gall Insects

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ABSTRACT

The goldenrod ball gall fly, *Eurosta solidaginis* (Diptera: Tephritidae), is parasitized by two eurytomid wasps and preyed on by a mordellid beetle, and two bird species. The birds are known to prey most intensively near a forest edge. The proportion of fly larva parasitized and preyed on by insects was examined, and a decline in the proportional abundance of beetle larvae near the forest was noted. The possible role of birds as the selective force for this distribution is considered.

The life histories of the ball gall insects of goldenrod[2] have been described (Uhler 1951, 1961). The gall fly, *Eurosta solidaginis* (Fitch) (Diptera: Tephritidae), emerges in spring and lays its eggs in the growing tip of the goldenrod, and its larvae stimulate the formation of all ball galls. A fly larva may be parasitized by either of two wasps, *Eurytoma obtusiventris* Gahan or *E. gigantea* Walsh (Hymenoptera: Eurytomidae). Larvae of a beetle, *Mordellistena unicolor* Lec. (Coleoptera: Mordellidae), are omnivores and may eat any of the above insects or co-develop in the same gall with the other insects. Studies of population dynamics showed that ball gall density increased linearly with plant density, and ball gall parasitoids increased linearly with gall density (Abrahamson et al. 1983).

Avian predators of ball gall insects include the Downy Woodpecker, *Picoides pubescens*, and the Black-capped Chickadee, *Parus atricapillus* (Confer and Paicos 1985). The intensity of predation by these birds is quite variable, but at any given site bird predation near the forest edge exceeds that in mid-field. At one site in Ontario birds preyed on 81% of the galls near a forest edge and 60% of the galls in mid-field (Schlicter 1978). For three sites in upstate New York, birds preyed on 9–25% of the galls near a forest edge, but only 0–10% of the galls in mid-field (Confer and Paicos 1985). Also from upstate New York, avian predation in mid-field averaged 2.3% of all galls over 14 years (Uhler 1961), considerably lower than the rates near a forest edge.

In this study we describe the distribution of ball gall insects relative to a forest edge in fields of goldenrod. Some preliminary samples collected with an ecology class showed a very strong change in the proportion of fly larvae parasitized or preyed on by insects at different distances from the forest edge, while other samples showed no difference at all. Insect distribution in these preliminary samples was compatible with the hypothesis that the difference between samples was related to

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[2]The taxonomy of the host genus, *Solidago*, is complicated by at least three ploidy forms (Melville and Morton 1982). *Solidago altissima*, formerly commonly called *S. canadensis*, may be the dominant form in the Ithaca area (P. Marks pers. comm.).

the presence or absence of shade from a contiguous forest edge. We hypothesized that the percentage of galls attacked by parasitic and predatory insects would increase with distance from a forest into a field when the forest was on the southern edge, but not when the forest was on the northern edge.

We did not hypothesize that the fly, itself, would avoid the forest edge. Although avian predation is greatest close to a forest edge, the preliminary samples had suggested that the frequency of parasitism plus predation by the other insects was greatest farther from a forest edge. Since avian predation and insect parasitism and predation occurred with about equal intensity in our samples, there would be no net advantage related to the sum of all predation for the fly to seek or avoid the forest edge.

MATERIALS AND METHODS

Ten sets of samples were collected, five each from the southern and northern edge of the goldenrod field with a well-developed and abrupt forest edge. All samples were collected in Tompkins County, New York in October, 1988. Four separate fields were sampled. For each set of samples we collected all galls from three transects parallel to the forest edge. For each set, the transects were located 0–5.5, 8.2–14, and 16.4–22m from the forest edge. The length of the transect was adjusted for differences in gall density and ranged from 7–17m. All gall insects, *E. solidaginis, E. gigantea* and *E. obtusiventris*, and *M. unicolor*, were identified according to Uhler (1951). Galls with no insect occupant were omitted from calculations. A Chi-square 3×4 contingency value was calculated for each set. Within each sample set, the proportional abundance of each insect species for the transect closest to the forest was compared to the value for the two other transects of that set. Increases or decreases in the value with distance from the forest edge were summed for all sets.

RESULTS AND DISCUSSION

The first two sets of samples contained 59 and 68 galls. Thereafter, the transect length was increased from 7 to 17m and sample size for each set ranged from 105 to 519 galls. One of the later sets, collected in an area of exceptionally high gall density, was also collected from 7m transects. The density of ball galls varied considerably from site to site (Table 1). Parasitism plus predation was high with 69–100% of the fly larvae attacked in mid-field. Avian predation, which does not begin until late October (Confer and Paicos 1985), was noted in only 3 galls.

Testing if the proportion of fly, wasp, wasp and beetle was equal in each transect of a set (Table 1), the resultant Chi-square contingency values with 6 df were 84.9, 73.2, 42.7, 33.8, 22.9, 18.0, 18.4, 17.5 (p <0.01), 12.9 (p < 0.05), and 3.3 (p > 0.10). Even excluding the two sets with smaller sample size, 7 of 8 sets had significant Chi-square values. Clearly the distribution of these insects among the transects is not random. The one sample set which did not show patchiness was collected along the northern edge of a field. However, the four other sets along a northern edge were not randomly distributed, and patchiness probably regularly occurs throughout goldenrod fields.

The proportion of ball galls occupied by the various insects, as well as the number of ball galls, varied greatly among the sets (Table 1). For example, the proportion of ball galls containing flies for the transects closest to a forest for the shaded, southern sample sets ranged from 13 to 62%. The environmental factors that caused this variation remain unexplained. With such high variation, parametric analyses for a difference in the mean proportion of flies attacked at the three distances from a forest edge showed no significant difference.

We then compared the proportional abundance of each insect species for the

Table 1. — The number of ball gall insects collected in five sample sets each of three transects for the northern and for the southern edge of a goldenrod field with a forest edge. Transects as described in Methods. Abbreviations are as follows: Es, Eo, Eg, and Mu for *Eurosta solidaginis*, *Eurytoma obtusiventris*, *Eurytoma gigantea*, and *Mordellistena unicolor*, respectively.

	Northern			Southern		
	0–5.5m	8.2–14m	16.4–22m	0–5.5m	8.2–14m	16.4–22m
Es	24	22	7	9	2	4
Eo	5	10	9	15	2	2
Eg	26	18	28	5	3	0
Mu	25	21	30	6	8	12
Es	18	19	1	5	1	0
Eo	11	11	2	3	2	1
Eg	25	19	23	7	4	4
Mu	26	24	6	4	8	20
Es	63	44	49	7	1	1
Eo	46	46	63	6	1	6
Eg	40	23	23	21	9	6
Mu	25	67	60	20	20	10
Es	29	47	29	120	37	14
Eo	21	52	20	31	16	19
Eg	33	55	26	36	20	33
Mu	16	33	18	5	16	28
Es	11	19	9	71	2	0
Eo	11	26	5	30	3	4
Eg	25	16	37	20	16	19
Mu	3	19	33	1	6	9

transect closest to the forest to its proportional abundance in the other two transects of the same data set. Changes in the proportion were determined for each sample set and summed for all sets (Table 2). For sample sets from the northern edge of a goldenrod field, there were no detected trends for any of the insect species. However, for sample sets from the southern edge, there were two distinct trends. The proportion of ball galls containing flies for the transect closest to the southern forest edge was greater than the proportion for any transect of the same sample farther from the forest edge. The proportion of galls containing the beetle increased in every comparison of the forest edge transect to all other transects of the same set. For two representative sample sets, for the transects closest to and farthest from the forest edge, the fly proportion declined from 26 to 22% and 63 to 17%. For the same pairs of transects, the proportion of beetle predation increased from 17 to 66% and from 2.6 to 33%. Since all ball galls are initiated by a fly and spontaneously aborted galls were excluded from calculations, a decline in the proportion of galls containing a fly could only occur if the sum of insect parasitism and predation increased. Since the proportional abundances of the two wasp species did not change systematically with increasing distance from the forest edge, the systematic decline in fly proportion was caused by the systematic increase in the proportional abundance of the beetle.

This study of the distribution of ball gall insects was inspired by an interest in avian predation. We hypothesized that the parasitic and predacious insects would have been selected to avoid the forest edge due to greater avian predation. Only the beetle responded as hypothesized, and this occurred only along the southern, forested edges of the fields. In hindsight, we noted that the predation intensity by birds

Table 2. — Changes in the proportional abundance of *Eurosta solidaginis, Eurytoma obtusiventris, Eurytoma gigantea,* and *Mordellistena unicolor* at three distances from a forest edge into a field of goldenrod. The proportion of galls containing each species in a transect close to the forest edge was compared to two transects farther into the field. Five sample sets each of three transects were collected near both the northern and southern forested edge. Abbreviations are as in Table 1.

	northern		southern	
	increases	decreases	increases	decreases
Es	6	4	0	10
Eo	5	5	3	7
Eg	4	6	5	5
Mu	5	5	10	0

near the forest edge and by beetles in mid-field was similar for the two eurytomid wasps, as well as the fly. Bird predation near the forest edge, as cited earlier, can range from 9 to 81%. In this study, the proportion of galls with beetles for the transect farthest from the southern, forest edge ranged from 28 to 80%. Although beetles do not always eat co-inhabiting wasp larva, they usually do so. Thus, predation intensity by the birds and the beetle is similar, and there may be no gradient in predation that would select for wasps that avoid a forest edge.

In this study we have not experimentally documented either the proximate or ultimate factors producing the beetle distribution. The shaded, southern edge of a field with a forest boundary is colder and wetter than the northern edge. If avian predation is the selective force that led to beetle avoidance of this edge, one can wonder if detection of the shadow, the temperature, or the humidity is the proximate clue. Since avian predation occurs along both the northern and southern forest edge of a goldenrod field (pers. obs.), one can wonder why the beetle responded to a forest only on the southern edge. Avian predation is irregular and perhaps has not been sufficiently consistent to select for beetles that avoid the forest edge. It is possible that humidity or temperature are the ultimate factors that directly affect success. Regardless of the uncertainty about cause, the trend is clear. In all sample sets along the southern edge of a goldenrod field with a forest boundary, *Mordellistena unicolor* occurs in lower proportion near the forest and higher proportion out from the edge.

ACKNOWLEDGMENTS

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