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INFLUENCE OF WEATHER ON PREDATOR/PREY RELATIONS: STINKBUGS AND TENT CATERPILLARS

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Abstract.—Cool spring temperatures suppressed the activity of predatory stinkbugs (*Podisus* spp.) but did not prevent the bugs' prey, tent caterpillars (*Malacosoma americanum* (F.)), from feeding and developing rapidly. Thus a cold snap in 1977 temporarily reduced the number of stinkbugs at caterpillar tents near Ithaca, New York, and enabled the prey to escape predation by growing to large sizes before warm weather returned.

Introduction

The physical environment can have an important influence on the effectiveness with which entomophagous insects reduce numbers of their prey. Studies in biological control reveal that climate often limits the effectiveness of both introduced and native natural enemies attacking insect pests: climatic conditions characterizing particular seasons and/or geographic regions often adversely affect the predators more than their prey (Messenger et al. 1976). Connell (1970) has suggested that not just the prevailing climate, but also *fluctuations* in weather may reduce the effectiveness of natural enemies because they are often more vulnerable to such fluctuations than are their prey. Examples include entomophagous insects that experience proportionately greater mortality than their prey during unusually cold winters (e.g., Lord and MacPhee 1953; Clausen 1958). In an intriguing extension of his hypothesis, Connell (1975) suggests that during the growing season, activity of natural enemies may be reduced temporarily during short periods of unfavorable weather. Prey may escape predation by growing to sizes invulnerable to predation during these relatively predator-free periods. Here I present an example illustrating the occurrence of this phenomenon among predatory insects and their prey.

Each spring in eastern North America, colonies of the eastern tent caterpillar (*Malacosoma americanum* (F.), Lasiocampidae) are attacked at the silken tents that they spin by predatory stinkbugs (Hemiptera: Pentatomidae) of the genus *Podisus* (Sullivan and Green 1950; Evans 1982). The following

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observations document the influence of the vagaries of spring weather on this predator/prey relationship.

Methods

In 1977–79 I examined the seasonal abundance of the stinkbugs in relation to the ontogenetic development of the tent caterpillars in a stand of scattered, small black cherry (*Prunus serotina* Ehrh.) and apple (*Malus sylvestris* Mill.) trees near Ithaca, New York. The predators were censused on various dates by counting the number of individuals observed per prey tent in 1977 and per tent-bearing tree in 1978 and 1979. At individual censuses, generally made in the afternoon, 50–250 tents were checked in 1977, 50–100 trees in 1978, and 50 trees in 1979. In all years, the entire surface of trees bearing tents was searched for stinkbugs.

The ontogenetic development of caterpillars was monitored each year by determining the instar and body length (mm) of representative individuals on different dates. Caterpillars were sampled by selecting randomly two caterpillars in 1977 and one in 1979 from the surface of 20–50 tents. A similar procedure was used to collect 150 caterpillars on 20 May 1978; on other occasions in 1978, the average length of prey was estimated by measuring representative individuals in the field.

Daily average air temperatures at 60 inches (152 cm) above ground for Ithaca, New York, were obtained from the Monthly Meteorological Summary for April and May 1977–79 prepared by the Division of Atmospheric Sciences, Cornell University. Voucher specimens of the stinkbugs have been deposited in the Cornell University Insect Collection (Lot No. 1086).

Results and Discussion

Each year stinkbugs first appeared at tents soon after the caterpillars hatched in April; the bugs peaked in numbers in May when the prey averaged 12–14 mm in length and were mostly in the fourth instar (Fig. 1). Three species of stinkbugs (*Podisus maculiventris* (Say), *P. placidus* Uhl., and *P. modestus* Uhl.) appeared at tents; they are treated together here (see Evans 1982 for detailed analyses of each species' exploitation of tent caterpillars). Stinkbug numbers at tents gradually declined after this peak in 1978 and 1979 as the caterpillars matured and abandoned tents in search of pupation sites. In 1977, this seasonal pattern was disrupted by inclement weather in early May. Stinkbug densities at tents during this time were clearly dependent on ambient temperature (Fig. 2). After peaking on 1 May, stinkbug numbers plummeted during the cold snap that followed (all three species' activity was suppressed). On seven of the next ten days, the average air temperature was less than 10°C; the mean temperature during this ten-day period was 9°C (the mean

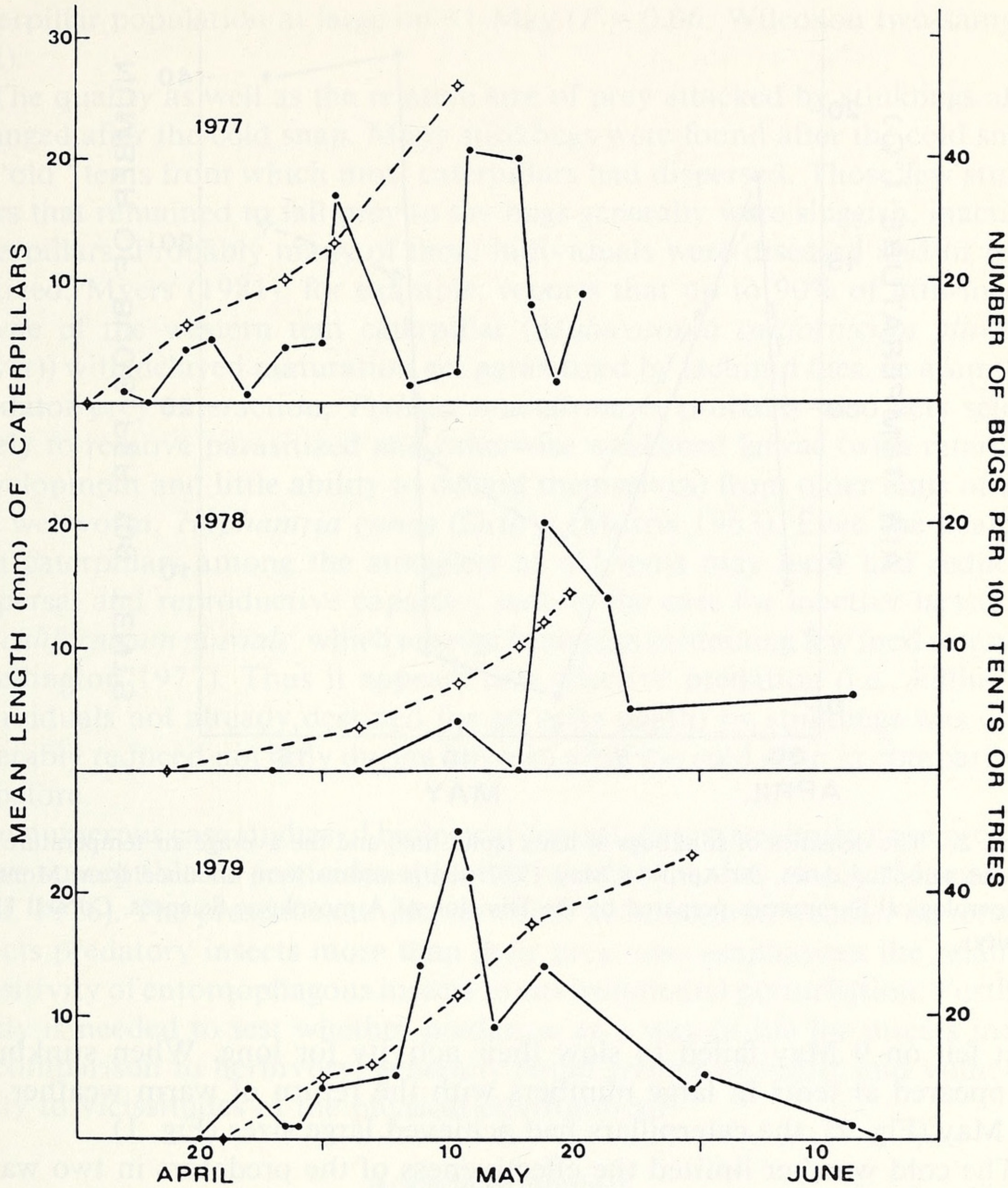

Fig. 1. The densities of stinkbugs at tents (solid lines) expressed as the number of bugs per 100 tents in 1977 and per 100 tent-bearing trees in 1978 and 1979, and the mean length (mm) of tent caterpillars (dashed lines) on various dates each spring.

temperature for 2–11 May was calculated as the mean of the ten daily average temperatures). In contrast, warmer weather prevailed during the same stage of the caterpillars' development in 1978 and 1979; the mean temperatures were 17°C and 14°C during the comparable ten-day periods (i.e., after caterpillars had grown on average to 13 mm in length and were fourth instars) in 1978 and 1979, respectively. Tent caterpillars were observed to feed actively during the cold snap in 1977; even the several inches of wet snow

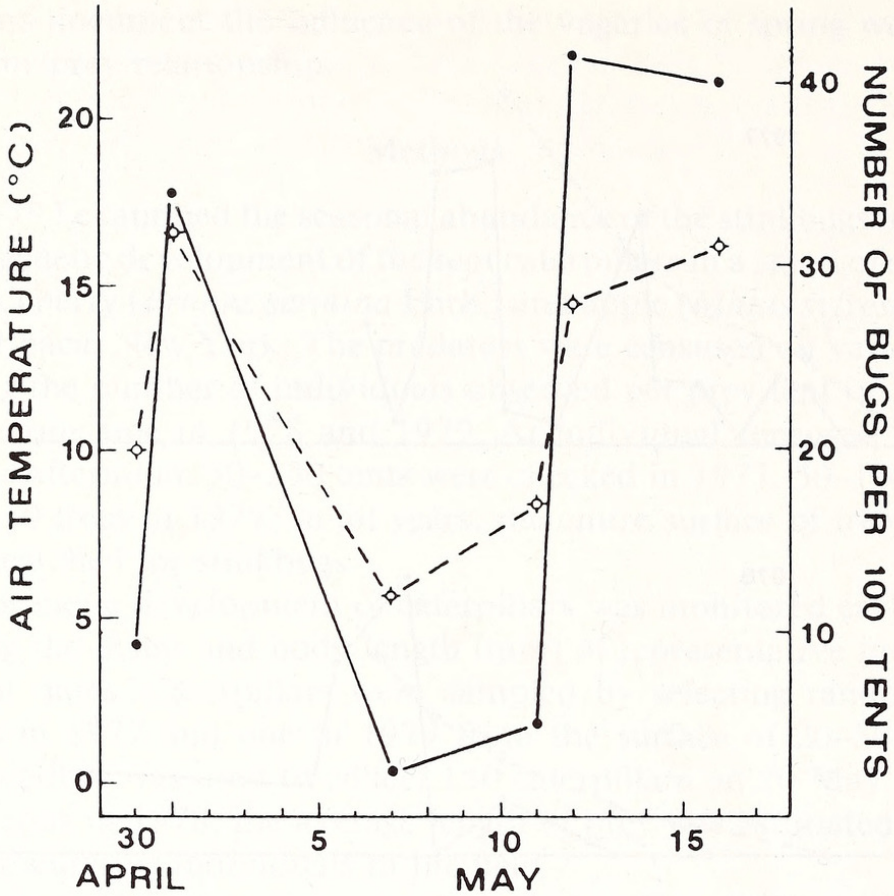

Fig. 2. The densities of stinkbugs at tents (solid line) and the average air temperature for various sampling dates, 30 April–16 May 1977 (temperatures were obtained from Monthly Meteorological Summaries prepared by the Division of Atmospheric Sciences, Cornell University).

that fell on 9 May failed to slow their activity for long. When stinkbugs reappeared at tents in large numbers with the return of warm weather on 12 May (Fig. 2), the caterpillars had achieved large sizes (Fig. 1).

The cold weather limited the effectiveness of the predators in two ways. First, by preventing predators from being active during a period of vigorous growth of the prey, the cold weather reduced the exposure of tent caterpillars to stinkbug attack. Secondly, it also enabled many caterpillars to escape stinkbug predation after warm weather returned. By the time bugs reappeared in large numbers, many prey were too large for the predators to subdue. In field observations of encounters between stinkbugs and healthy caterpillars >25 mm long, the predators (9–12 mm long) were repulsed by the vigorous side-to-side thrashings of the prey and soon abandoned the attack. Unlike earlier in the spring, the prey upon which the predators were found feeding after the cold snap were on average smaller than individuals in the caterpillar population at large: the median length of prey taken from stinkbugs on 11–17 May was 23 mm ($N = 23$) vs. a median of 27 mm ($N = 21$) in the caterpillar population at large on 11 May ($P = 0.06$, Wilcoxon two-sample test).

The quality as well as the relative size of prey attacked by stinkbugs also changed after the cold snap. Many stinkbugs were found after the cold snap at "old" tents from which most caterpillars had dispersed. Those few stragglers that remained to fall prey to the bugs generally were sluggish, inactive caterpillars. Probably many of these individuals were diseased and/or parasitized; Myers (1981), for example, reports that up to 90% of fifth-instar larvae of the western tent caterpillar (*Malacosoma californicum pluviale* (Dyer)) with delayed maturation are parasitized by tachinid flies. In a similar predator/prey interaction, *Podisus maculiventris* probably also acts selectively to remove parasitized and otherwise weakened larvae (with retarded development and little ability to defend themselves) from older tents of the fall webworm, *Hyphantria cunea* (Drury) (Morris 1963). Even the healthy tent caterpillars among the stragglers at old tents may have had reduced dispersal and reproductive capacity; such is the case for inactive larvae of *M. californicum pluviale,* which emerge from eggs containing few food reserves (Wellington 1977). Thus it appears that effective predation (i.e., killing of individuals not already destined for an early death) by stinkbugs was considerably reduced not only during but also after the cold snap in comparison to before.

In numerous case studies of biological control, natural enemies have proven more susceptible to pesticides than the insects that they attack (Messenger et al. 1976). The present example, in which fluctuation in weather adversely affects predatory insects more than their prey, also emphasizes the relative sensitivity of entomophagous insects to environmental perturbation. Further study is needed to test whether predation as a way of life for insects may, in comparison to herbivory, generally entail greater exposure and vulnerability to vicissitudes of the physical environment.

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