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PREDATOR STONEFLIES: ROLE IN FRESHWATER STREAM COMMUNITIES

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ABSTRACT

Stonefly nymphs *(Acroneuria)* were observed feeding on immature Shovelnosed Salamanders *(Leurognathus marmoratus)* during holding periods in aquaria. Although this predation did not occur in a natural stream environ (where the predator and its prey occupy overlapping habitats), it did occur independently in 9 of 14 different aquaria. The occurrence of this relationship in stream communities may be important and should be researched further in natural stream systems.

INTRODUCTION

The role of predators in organizing freshwater communities has been reviewed by MaCan (1977). Amphibians are very susceptible to certain types of predators (e.g., fishes) and have evolved a number of antipredator devices (Dodd 1976, Ward and Sexton 1981). This paper describes a possible invertebrate predator/vertebrate prey role in montane stream sytems.

MATERIALS AND METHODS

Larvae (12-35 mm snout-vent length) and subadult (30-36 mm snout-vent length) Shovel-nosed Salamanders *(Leurognathus marmoratus)* were captured from streams of Great Smoky Mountains National Park and placed in 10-gallon aquaria with continuous flow apparatus. Aquatic insects served as food organisms for the salamanders. A continuous flow system at 14° C provided an aquatic environ similar to the stream habitat from which the salamanders and stoneflies were removed.

RESULTS

Within hours, many of the salamanders were found dead. Initially, no reason for salamander mortality was evident; however, closer inspection indicated that the legs of several salamanders were severed. Further observation showed that nymphs of the stonefly *Acroneuria* (14-23 mm total length) were first killing these salamanders and then eating their limbs. This phenomenon was observed independently in 9 of 14 test aquaria where both organisms were present. The stoneflies first pierced the gular region of the salamanders' necks with their mandibles (Fig. 1). The salamanders attempted to throw off the insect predators by vigorously twisting their bodies. Eventually, the salamanders would lie motionless, apparently dead. After a few moments, stoneflies would shear the legs from the salamanders and eat them (Fig. 2).

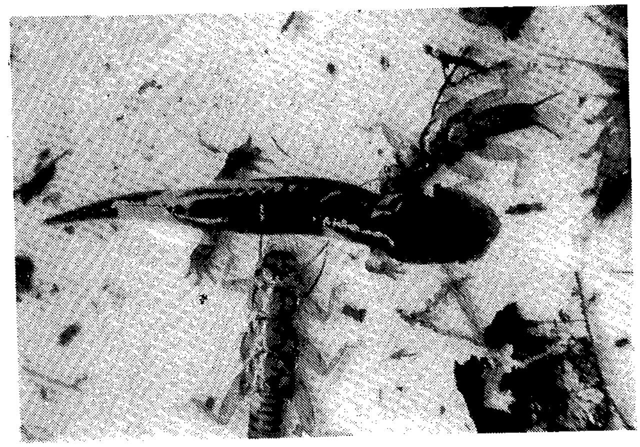

FIG. 1. *Stoneflies (aquatic insects) of the genus Acroneuria, common in clear, fast-flowing mountain streams of Great Smoky Mountains National Park, attack the Shovel-nosed Salamander, Leurognathus marmoratus, from both sides. The stoneflies were supposed to serve as a food resource for the salamanders being acclimated for a bioassay test. Their anticipated roles in this circumstance, however, were reserved.*

FIG. 2. *The hind leg of a Leurognathus being sheared off by Acroneuria.*

Discussion

During a survey of stream-dwelling salamanders in Great Smoky Mountains National Park, adult *Leurognathus* (70-130 mm snout-vent length) were frequently observed feeding on *Acroneuria,* usually from a position where eddying currents between stones would pass insect drift within their grasp. Larval and subadult *Leurognathus* usually occupied habitats ranging from sand/gravel flats to positions under small stones where *Acroneuria* are less frequent. Generally, larger stones attracted larger salamanders and insects.

Although the predaceous action observed occurred in aquaria, the stoneflies appeared well adjusted to this feeding strategy, though I was unable to find reports of this phenomenon occurring in stream habitats from entomological literature. Invertebrate predators on vertebrate prey in streams, however, have been infrequently observed. Fisher Spiders *(Dolomedes triton),* for instance, are predaceous on stream fishes (Bond 1980), and Water Tigers *(Dytiscus* sp.; predaceous diving beetles) feed on tadpoles and small fish (Klots 1966). Predator—prey roles may be reversed as well during different phases of life cycles in stream organisms. Two-lined Salamanders *(Eurycea bislineata)* serve as food for adult Rainbow Trout *(Salmo gairdneri),* though adults of this salamander species have been observed feeding on emerging Rainbow Trout fry and submerged intergravel trout embryos (Harshbarger, Coweeta Hydrologic Station, personal communication).

Conclusions

The importance of salamanders within watershed populations is poorly known. At Hubbard Brook Experimental Forest in New Hampshire, the biomass of salamanders was about twice that of birds during the birds' peak breeding season and about equal to the biomass of small mammals (Burton and Likens 1975). Aquatic insects are almost universally thought of as food organisms, and little consideration is given to predacious and other functional roles they perform in stream ecosystems (Cummins 1974). Two conclusions seem evident from the observations presented here: (1) Our knowledge of some predator—prey relationships in streams is limited, yet their role may be important in consideration of overall stream population dynamics; and (2) some of these findings have occurred by accident in cases where predator feeding opportunity was optimized.

Acknowledgments

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Literature Cited

Bond, C. 1980. The swift spider that is nature's smallest angler. Smithsonian 11(4):78-81.

Burton, T. M., and G. E. Likens. 1975. Salamander populations and biomass in the Hubbard Brook Experimental Forest, New Hampshire. Copeia 3:541-546.

Cummins, K. W. 1974. Structure and function of stream ecosystems. BioScience 24(11):631-641.

Dodd, C. K., Jr. 1976. A bibliography of anuran defensive mechanisms. Smithsonian Herpet. Inf. Serv. 37.

Klots, E. B. 1966. The new field book of freshwater life. G. P. Putnam's Sons Publishers, New York. Pp. 221-235.

MaCan, T. T. 1977. The influence of predation on the composition of freshwater animal communities. Biol. Rev. 77:45-70.

Ward, D., and O. J. Sexton. 1981. Anti-predator role of salamander egg membranes. Copeia 3:724-726.

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DISPERSAL OF AUTUMN OLIVE SEEDS BY FOXES ON COAL SURFACE MINES IN EAST TENNESSEE

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Abstracts

Monthly scat collections and seed germination tests suggested that foxes may be important in the dispersal of autumn olive *(Elaeagnus umbellata)* seeds on reclaimed coal surface mines. Analysis of 117 fox scats collected once monthly from November to April on a Campbell County, Tennessee, minesite indicated that the average number of autumn olive seeds per scat ranged from 0.3 seed in April to 218.0 seeds in November. The highest number of seeds recorded in a scat was 622. Germination tests of seeds removed from fox scats and a control seed lot from the same site resulted in germination percentages of all seed groups increasing with longer lengths of stratification. The highest percentage germination occurred at 12 weeks in the fox group and at 16 weeks in the control group. Although germination of seeds from fox scats averaged 17 percent lower than the control group, percentage germination in the fox seed lot was sufficiently high (up to 75 percent) to allow dissemination of large quantities of viable seeds by foxes.

Introduction

Autumn olive *(Elaeagnus umbellata),* originally introduced into the United States from Asia in 1830 (Allan and Steiner, 1959), is widely used to improve wildlife habitat on reclaimed coal surface mines (Fowler and Adkisson, 1980). This hardy shrub is adaptable to a wide range of spoil conditions and produces berries in the second or third year after planting. The berries, leaves, and twigs of autumn olive are readily consumed by wildlife. Engle (1962) observed songbirds, black bears *(Ursus americanus)*, woodchucks *(Marmota monax)*, chipmunks *(Tamias striatus)*, raccoons *(Procyon lotor)*, opossums *(Didelphis virginia)*, and wild turkeys *(Meleagris gallopavo)* foraging in autumn olive plantings in western Virginia. Davison (1942) found autumn olive berries in the stomachs of nine species of birds collected near autumn olive plantings in North Carolina and Georgia. Yearsley and Samuel (1980) observed numerous autumn olive seeds in fox scats collected during late summer and early fall in West Virginia surface mine habitat.

In November 1979, a large number of fox tracks and scats were observed beneath autumn olive plantations on the Ollis Creek coal surface mine in Campbell County, Tennessee. Broken autumn olive branches indicated that foxes had climbed the shrubs to obtain the fruits, and closer examination revealed large numbers of autumn olive seeds in the scats. Because both gray *(Urocyon cinereoargenteus)* and red foxes *(Vulpes vulpes)* occur in the region and both species are highly herbivorous during the fall (Hamilton et al., 1937), either or both species may have been using the autumn olive plantations.

Passage of seeds through the digestive tracts of mammals can effectively overcome seedcoat dormancy in some plant species and, in some cases, increase germination percentage (Krefting and Roe, 1949). Consequently it was hypothesized that foxes were dispersing autumn olive shrubs by depositing seed-laden scats some distances from the surface mine plantations. This study was designed to measure the germination percentage of autumn olive seeds recovered from fox scats and based on these data, to conclude whether or not autumn olive shrubs could be spread by foxes.

METHODS

On November 30, 1979, 35 fox scats containing a total of 7,635 autumn olive seeds was collected from autumn olive plantations on the Ollis Creek mine. In addition, 1-liter samples of autumn olive berries were collected from each of 25 randomly selected shrubs within the same plantations to serve as a control group. A sieve and running water were used to separate the seeds from pulp and other scat material. A total of 1,500 seeds was then randomly selected from both the fox scat and control lots. Seed lots in both groups were placed between two pieces of moistened filter paper within large petri dishes and stratified for 0, 8, 12, 16, and 20 weeks at 5° C. For each stratification treatment, there were six replications of 50 seeds each. After stratification, seeds were placed in a germination chamber at 20°-30° C (as recommended by Olson, 1974) for 10 weeks. Seeds were checked for germination on Monday, Wednesday, and Friday of each week.

Seasonal use of autumn olive fruits was estimated from November 1979 to April 1980 by collecting all fox scats once monthly within the autumn olive plantations on the Ollis Creek mine. Seeds within each scat were counted, and monthly averages of seeds per scat were calculated.

RESULTS AND DISCUSSION

Germination of autumn olive seeds in both fox scat and control groups was lowest (23 percent and 37 percent, respectively) without stratification. This result was expected because cold stratification (or other types of pregermination treatments) is required to overcome embryo dormancy in *Elaeagnus* (Olson, 1974). Treatment with cold stratification significantly ($p < .05$) increased germination percentage of both fox and control seeds (Fig. 1). Highest percentage of germination was achieved at 12 weeks' stratification in the fox group and 16 weeks' stratification in the control group. There were 11 weeks (79 days) in which the average ambient temperature was 5° C or below and 23 weeks (162 days) in which ambient temperature fell below 5° C (from October 1979 to April 1980) in the Ollis Creek area, according to National Weather Service at Oneida, Tennessee. Thus the optimum stratification length indicated by this study approximated the length of stratification that seeds received under natural conditions on the Ollis Creek site. Germination of seeds from fox scats averaged 17 percent lower than germination in the control group, possibly due to seedcoat damage incurred during the digestive process (Fig. 1).

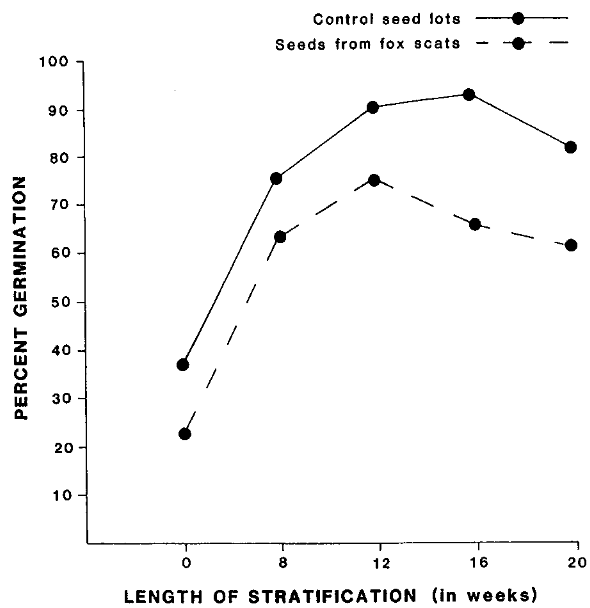

FIG. 1. *Germination percentage of autumn olive seeds removed from fox scats and from a control seed lot on a coal surface mine in Campbell County, Tennessee. Seeds were stratified 0-20 weeks and germinated at 20-30° C for 10 weeks.*

However, germination of seeds recovered from scats was still sufficiently high (75 percent at 12 weeks' stratification) to support the idea that foxes may be a significant factor in the dispersal of autumn olive seeds.

Evidence of high use of autumn olive berries by foxes was obtained by collecting fox scats from November 1979 to April 1980 (Table 1). Highest mean numbers of seeds per scat per month were observed in November (218 seeds). The least number of scats and the lowest average seeds per scat were observed in April. This was expected because seeds were rarely present on autumn olive shrubs by April. Foxes may have consumed more autumn olive berries in February than indicated by the data; heavy rains and snow prior to the scat collection for that month washed away or