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ON THE FEEDING HABITS OF *PHASGANOPHORA CAPITATA* (PLECOPTERA: PERLIDAE)

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ABSTRACT

Gut contents of 230 nymphs of *Phasganophora capitata* (Pictet) from the Pigeon River, Otsego County, Michigan were analyzed in relation to season, current velocity, time of day, predator size and prey abundance. Diet changed seasonally, related in part to seasonal changes in prey abundance. The diet of large and small nymphs was similar except that small nymphs ate smaller individuals. At lower current velocities *capitata* fed primarily on mayflies whereas at higher current velocities they fed primarily on caddis and dipterans.

Studies of the feeding habits of perlid stoneflies (e.g., Siegfried and Knight, 1976a; 1976b) have attempted to elucidate the role of invertebrate predators in the economy of streams. During a recent study of diel changes in stream benthos density (Kovalak, 1975) sufficient numbers of *Phasganophora capitata* (Pictet) were collected to analyze changes in feeding habits in relation to season, current velocity, time of day, predator size, and prey abundance. Because little is known about the feeding habits of *capitata* (see Shapas and Hilsenhoff, 1976) and because its feeding habits differ somewhat from other perlids studied to date, results of this analysis are reported here.

METHODS

This study was conducted at the Pigeon River in the vicinity of the Pigeon River Trout Research Station, Otsego County, Michigan. For a description of the Pigeon River see Kovalak (1976).

The insect fauna colonizing bricks placed in a riffle where current velocity ranged between 50 and 100 cm/sec was sampled on four dates between August and November, 1973. Forty sand-cast bricks were positioned in the riffle with their longitudinal axes parallel to direction of flow and pushed 1 cm into the stream bottom. Bricks were exposed for colonization about four weeks before sampling.

To facilitate sampling and analysis, current velocities on the riffle were grouped into five 10 cm/sec intervals covering the 50-100 cm/sec range. From August to October samples were collected from the 50-90 cm/sec intervals and in November samples were collected from the 50-100 cm/sec intervals. On each date at least two bricks were collected at noon and at midnight from each current interval. Current velocities were measured at both sides of the bricks using a Gurley pygmy current meter (Model 625).

Samples were collected by placing a small hand net (156 μ mesh) immediately downstream of the bricks, and then carefully lifting them free of the bottom. Bricks were taken to the laboratory, soaked for 10-15 minutes in tepid water and the insects scraped from the surface with a toothbrush. Insects were sorted under 10X magnification, identified and counted. Headcapsule width of *capitata* nymphs was measured to the nearest 0.05 mm with an ocular micrometer and then the fore- and midguts were removed and the contents identified and counted. A total of 230 nymphs were examined.

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RESULTS

Over all dates Ephemeroptera comprised 33.8% of the diet of *P. capitata*, Trichoptera 36.6%, Simuliidae 22.9%, and Chironomidae only 3.7%. Prey taken by *P. capitata* changed seasonally with *Baetis* spp. (primarily *B. intercalaris* McDunnough and *B. levitans* McDunnough) and *Chimarra aterrima* Hagen predominating in August, *C. aterrima, Paraleptophlebia mollis* (Eaton) and *Glossosoma nigrior* Banks predominating in September and October, and Simuliidae and *P. mollis* predominating in November (Table 1). These seasonal changes in diet were related in part to seasonal changes in prey abundance. *Baetis* supp. were most abundant in August, *P. mollis, C. aterrima* and *G. nigrior* generally were most abundant in September and October, and Simuliidae were most abundant in November (Table 2).

Comparison of the occurrence of prey species in guts of *P. capitata* with occurrence on the bricks suggested *P. capitata* selected a very restricted portion of the total fauna. For the dominant food items listed above, with the exception of *G. nigrior,* electivity values (Ivlev, 1961) generally were greater than +0.60. The abundant taxa, Hydropsychidae and Chironomidae, were avoided by *P. capitata* (electivity values generally less than −0.50).

Variations in the diet relative to predator size (three size groups: 2.1-3.0, 3.1-4.0, 4.1-5.0 mm head width) were small. In August, large nymphs (4.1-5.0 mm) fed primarily on mayflies and dipterans whereas smaller nymphs (2.1-4.0 mm) fed primarily on caddisflies. Between September and November there were no appreciable differences in diet among size groups.

Variations in diet relative to current velocity were greater (Table 1). In August, at higher current velocities, *P. capitata* fed primarily on mayflies whereas at lower current velocities mayflies and caddisflies were of subequal importance. In September and October, at lower current velocities, *P. capitata* fed primarily on mayflies, but at higher current velocities they fed on caddisflies and dipterans. In November, at lower current velocities, mayflies were of primary importance, whereas at higher current velocities Simuliidae were of primary importance.

Over all dates the mean number of prey consumed per predator was 2.60 (range 0.0-8.0). Prey consumption decreased between August (3.10) and November (2.10) and the number of prey per predator was always slightly greater during the day than at night, but this difference was not significant (t-test). There was no consistent pattern to number of prey consumed per predator relative to current velocity or predator size. In August consumption was greatest in the 50-59 cm/sec current interval and for nymphs with 3.1-4.0 mm head width whereas in November consumption was greatest in the 90-99 cm/sec current interval and for nymphs with 4.1-5.0 mm head width.

Only a small percentage (12.6%) of the nymphs examined had empty guts. There was no significant difference in the percentage of empty guts between day and night but the percentage of empty guts increased between August (7.4%) and November (20.2%). This seasonal increase in the percentage of empty guts accounts for most of the decrease in the mean number of prey consumed per predator between August and November.

DISCUSSION

Overall the diet of *P. capitata* was similar to those reported for other perlids (e.g., Hynes, 1941; Brinck, 1949; Jones, 1949; 1950; Mackereth, 1951; Minshall and Minshall, 1966; Sheldon, 1969; Richardson and Gaufin, 1971; Tarter and Krumholz, 1971; Siegfried and Knight, 1976a) and included large numbers of mayflies, caddisflies, and dipterans. In marked contrast to results of earlier workers (Hynes, 1941; Brinck, 1949; Jones, 1949; Richardson and Gaufin, 1971; Tarter and Krumholz, 1971; Siegfried and Knight, 1976a), *P. capitata* consumed very few Chironomidae and Hydropsychidae although together these taxa constituted as much as 53% of total fauna. The small number of chironomids consumed by *P. capitata* may be related to the size range of nymphs examined (2.1-5.0 mm head width) because Sheldon (1969) reported that dipterans were consumed primarily by small *Acroneuria californica* Banks (> 3.0 mm intraorbital head width). In general, the diet of large and small *P. capitata* was similar

Table 1. Monthly percent contribution of various prey taxa to diet of *P. capitata* in relation to current velocity (cm/sec).

	August				September				October				November				
Taxon	50-59	60-69	70-79	80-89	50-59	60-69	70-79	80-89	50-59	60-69	70-79	80-89	50-59	60-69	70-79	80-89	90-99
Plecoptera									6.9	3.5	4.0				3.7		3.4
Baetis spp.	51.9	60.0	43.2	73.2	18.2	3.0					2.0		5.9	2.1	3.7		
Paraleptophlebia mollis			4.5		45.4	30.3	6.5		51.7	31.0	14.0	14.0	23.5	34.1	14.8	15.1	17.3
Ephemerella subvaria				3.8		1.5	1.6	6.2	3.5				17.6	2.1		2.7	3.4
Other Ephemeroptera				3.8	9.1	3.0			17.2		6.0	4.0			3.7	1.4	
Hydropsychidae	7.4	20.0	6.8	7.7		9.1	3.2		3.5	6.9	6.0	6.0	11.8	6.4			
Chimarra aterrima	33.3	10.0	13.6		27.3	28.8	27.4	12.5	6.9	20.7	10.0	20.0		6.4		2.7	
Glossosoma nigrior		10.0	2.3			13.7	48.4	56.3	10.3	37.9	46.0	32.0		2.1			6.9
Simuliidae			4.5	7.7			11.3	18.8			10.0	16.0	5.9	38.3	70.4	75.3	62.1
Chironomidae	3.7		20.5			7.6	1.6	6.2			2.0	6.0	5.9	8.5	3.7	1.4	6.9
Other	3.7		4.6	3.8		3.0						2.0	29.4			1.4	

Table 2. Monthly mean density (± 1 SD) of selected taxa on bricks in the Pigeon River.

Taxon	August	September	October	November
Baetis spp.	66.1 ± 31.6	5.2 ± 2.7	2.2 ± 1.6	2.6 ± 1.6
Paraleptophlebia mollis	13.8 ± 15.5	46.7 ± 25.1	19.8 ± 13.7	15.4 ± 9.4
Hydropsychidae	178.4 ± 48.4	121.3 ± 43.8	26.8 ± 17.0	10.8 ± 6.5
Chimarra aterrima	50.3 ± 25.0	47.4 ± 34.0	10.6 ± 10.4	0.8 ± 1.2
Glossosoma nigrior	44.1 ± 22.7	179.0 ± 102.4	159.1 ± 109.2	62.2 ± 32.3
Simuliidae	8.6 ± 12.7	6.7 ± 7.1	2.3 ± 2.2	63.8 ± 52.5
Chironomidae	236.6 ± 75.4	273.1 ± 126.4	255.5 ± 132.7	210.9 ± 79.5
Total Fauna	789.8 ± 226.5	1014.5 ± 355.3	695.9 ± 322.1	473.2 ± 198.3

except that small nymphs ate smaller individuals following the observations of Jones (1950), Tarter and Krumholz (1971), Sheldon (1969), and Siegfried and Knight (1976a).

Seasonal diet changes of *P. capitata* differed from those reported for *A. californica* (Sheldon, 1969; Siegfried and Knight, 1976a) and *Paragnetina media* (Walker) (Tarter and Krumholz, 1971). These differences are undoubtedly related to specific, seasonal and geographic differences in prey abundance.

Although seasonal changes in diet were related in large part to seasonal changes in prey abundance, changes in prey availability also were important. *G. nigrior* was preyed on most intensively in September and October during a period of rapid growth (Kovalak, unpublished). As *G. nigrior* grows, it must periodically leave its case to construct a new, larger one making the unprotected larvae highly vulnerable to predation. *P. mollis* also was preyed upon most intensively during a period of rapid growth (Kovalak, unpublished). During this growth period, *P. mollis* probably reached some minimal size for predation by *P. capitata* (cf. Siegfried and Knight, 1976a).

P. capitata swallowed their prey whole and prey recovered from *P. capitata* collected at midnight were intact and undigested whereas prey from *P. capitata* collected at noon were at least partially digested. These observations, coupled with the fact that the number of prey per predator was only slightly greater for *P. capitata* collected at noon, suggested that most of the feeding occurred early in the evening, before midnight. This period of feeding corresponds to the period of maximum drift activity of prey species (Water, 1972) and suggests drift may in part result from predator avoidance. This seems plausible because perlids locate prey thigmotactically, using their antennae (Hynes, 1941; Brinck, 1949). To escape, prey touched by the antennae may release their hold from the substrate and swim upward where they are caught by the current and drifting ensues.

Thigmotactic prey location also may account for some of the more subtle differences in prey selection relative to current velocity. Efficient use of antennae for prey location probably depends on foraging on the open, exposed surfaces (top and sides) of stones. Consequently, prey availability depends on the proportion of the fauna present on the exposed faces. Scott (1958) and Kovalak (1976; in press) observed that there was an inverse relationship between the proportion of various species on exposed faces of stones and bricks and current velocity. Greater consumption of taxa of Ephemeroptera and *C. aterrima* at lower current velocities probably was attributable to greater occurrence of these taxa on exposed faces of bricks at lower current velocities. At higher current velocities, particularly between September and November, *P. capitata* fed primarily on *G. nigrior* and Simuliidae, taxa which normally occur on exposed faces of stony substrates regardless of current velocity. These observations question the validity of using Ivlev's (1961) electivity index to assess prey selection (e.g., Seigfried and Knight, 1976a) because a simple comparison of the frequency of occurrence of prey in areal bottom samples and in the predators guts ignores changes in prey availability on a microhabitat scale.

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