

## Substratum preference of the caddisfly *Helicopsyche borealis* (Hagen) (Trichoptera: Helicopsychidae)

Caryn C. Vaughn

*Department of Zoology, University of Oklahoma, Norman, Oklahoma USA*

*Present address: Department of Biology, Rice University, Houston, TX 77251, USA*

Received 28 August 1986; in revised form 23 March 1987; accepted 5 May 1987

**Key words:** substratum preference, substratum heterogeneity, caddisfly, Trichoptera, current velocity

### Abstract

The position of *Helicopsyche borealis* (Hagen) (Trichoptera: Helicopsychidae) larvae on the substratum surface is dependent on the current regime but varies with larval size. All size classes of larvae chose significantly different positions on the substratum under high versus low current velocities. All size classes preferred exposed surfaces under low current velocities. Small larvae preferred the upper surfaces of substrata under low current velocities and were physically displaced under high current velocities. Larger larvae also occurred on upper surfaces, but were more evenly dispersed over all surfaces than smaller larvae, and tended to aggregate on downstream faces of rocks during high flow.

### Introduction

*Helicopsyche borealis* (Hagen) (Trichoptera: Helicopsychidae) is a cosmopolitan caddisfly (Wiggins, 1977) easily recognized by the snail-like appearance of its sandgrain case (Vaughn, 1985a). Recent studies have examined the life history and microdistribution of this species (Lamberti & Resh, 1983; Williams *et al.*, 1983; Resh *et al.*, 1984a, 1984b; Vaughn, 1985b, 1986). While studying the microdistribution of *H. borealis* in Oklahoma streams I noted distinct, larval size-specific preferences for substratum surfaces which varied naturally with flow rates and were undocumented in the literature. This paper presents results of laboratory and field experiments designed to document these substratum preferences.

### Methods

*Helicopsyche borealis* larvae were collected from

Pennington Creek, a second-order, spring-fed stream in the Arbuckle Mountains of southcentral Oklahoma (Vaughn, 1985b). Instars were determined for live larvae by measuring case diameters and comparing them to head-width frequency histograms (Vaughn, 1985b). Second, fourth and final (i.e. fifth) instars were used in the experiments. Larvae were mass sorted into instars using a circle template; third instars were not used because they were difficult to distinguish with this method.

#### *Substratum position experiments*

##### *General methods*

Laboratory trials were conducted in artificial streams similar to those used by others observing caddisfly behavior (Elliot, 1970; Gallepp, 1974, 1977). Streams consisted of 5.2-l plexiglass chambers with nylon mesh on the upstream and downstream ends to prevent organisms from escaping but allow-

ing water to pass through. These chambers were placed inside 76-l glass aquaria. Aqualogy Corp. Power Plus filtration pumps provided current velocities of  $5 \text{ cm s}^{-1}$  and  $50 \text{ cm s}^{-1}$  10 cm above the substratum. Actual current speeds on the various substratum surfaces were measured by salt tablet dissolution rates (Table 1) (McConnell & Sigler, 1959; Vaughn, 1984). Artificial streams were maintained at  $17^\circ\text{C}$  (the temperature of thermally-constant Pennington Creek) and at a 12L:12D photoperiod in growth chambers. Field experiments were performed in 32-l rectangular plexiglass boxes with mesh on the upstream and downstream faces (Vaughn, 1984). During field trials boxes were placed in areas of Pennington Creek where the flow closely approximated 5 or  $50 \text{ cm s}^{-1}$  as in the laboratory trials.

#### *Position on the substratum*

I conducted a series of laboratory and field experiments examining the actual position on the substratum of *Helicopsyche borealis* larvae exposed to high ( $50 \text{ cm s}^{-1}$ ) and low ( $5 \text{ cm s}^{-1}$ ) current velocities. Concrete bricks ( $19.5 \times 9.2 \times 5.6 \text{ cm}$ ) were used as experimental substrata. The size of these surfaces was similar to those of natural rocks in Pennington Creek. Bricks were left in Pennington Creek for

*Table 1.* Current velocities used in the experiments. Teledyne-Gurley current speeds were measured in the water column 10 cm above the bottom. Slow flow is equivalent to a TG flow of  $5 \text{ cm s}^{-1}$  and fast flow  $50 \text{ cm s}^{-1}$ . Current speeds on the surfaces of the bricks were measured as salt tablet dissolution rates at  $17^\circ\text{C}$ .

Position of salt tablets on brick	Flow regime	Mean salt tablet current speed ( $\text{cm s}^{-1}$ ) $\pm$ 1 SD (N = 10)
Top	Slow	$15.5 \pm 4.1$
	Fast	$37.3 \pm 5.9$
Sides	Slow	$16.5 \pm 2.4$
	Fast	$37.9 \pm 3.5$
Upstream face	Slow	$19.7 \pm 3.9$
	Fast	$43.0 \pm 1.6$
Downstream face	Slow	$15.0 \pm 1.7$
	Fast	$12.9 \pm 1.5$

4 wks, which was sufficient time for them to become colonized with periphyton. Colonized bricks were brought back to the laboratory, stored in plastic bags, and refrigerated under constant light conditions for up to 2 wks before being used in the experiments.

Bricks were oriented in the field and laboratory streams with the long axis perpendicular to the current. A single brick was used per replicate. Forty larvae were used per replicate in both laboratory and field trials. This number was derived using field census data (Vaughn, 1985b). At the beginning of a laboratory trial, larvae were placed at the downstream end of the brick and allowed to disperse for 2 h with the pumps turned off. The pumps were then turned on and the larvae were left for 24 h before observations were made. In field trials larvae were added to the downstream ends of bricks and left for 24 h before observation. Hourly observations in three-day preliminary runs demonstrated that larvae moved onto all surfaces of the brick within 2 h and within 8 h selected an area of the brick at which they remained for up to 72 h. Larval densities in four substratum locations (T = top, U = upstream, D = downstream, S = sides) were determined. Densities were square-root transformed and analyzed using two-way analysis of variance (Sokal & Rohlf, 1981) to determine the separate and interactive effects of flow rate and substratum surface.

#### *Substratum heterogeneity*

Another set of laboratory experiments tested the effect of substratum heterogeneity on larval position. The first experiment simulated crevices which occur between separate stones in a stream. Groupings of three bricks placed side-by-side were used to create crevices between bricks. These inter-brick crevices measured 5 mm in width. The second experiment simulated the rough surface of many of the limestone rocks in Pennington Creek. Indentations approximately 10 mm across and 5 mm deep were scored in bricks with a chisel. The difference between ranks of mean frequencies of larvae in crevices or indentations under low and high current velocity was analyzed with the Mann Whitney *U* test (Sokal & Rohlf, 1981).

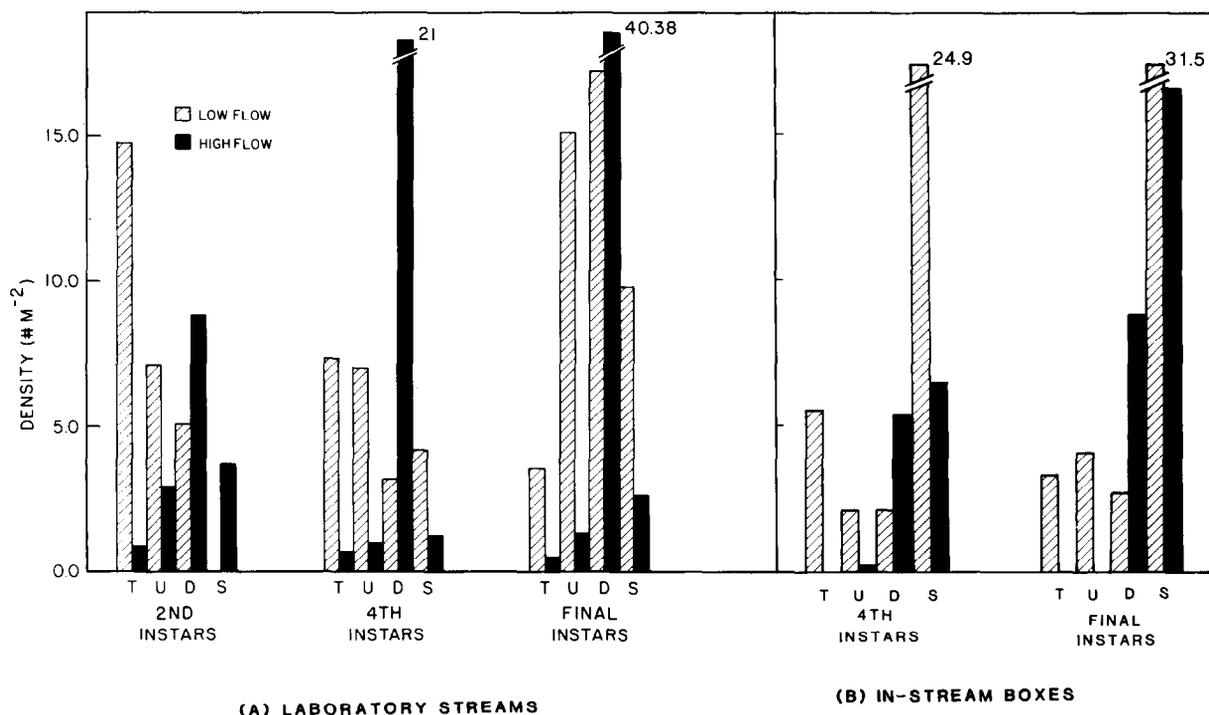


Fig. 1. Mean density of *Helicopsyche borealis* on different brick surfaces (T = top, U = upstream, D = downstream, S = sides) for low ( $5 \text{ cm s}^{-1}$ ) and high ( $50 \text{ cm s}^{-1}$ ) current velocities in (A) laboratory streams and (B) in-stream (field) boxes.

## Results and discussion

### Substratum position

The position of the larvae on the bricks in the laboratory was dependent on the current regime, but varied with larval size. At low current velocities, small larvae were more abundant on the tops of the bricks than larger larvae. At high current velocities, large larvae aggregated on the protected, downstream faces while small larvae were swept away by the current (Fig. 1). Larvae of all size classes chose significantly different positions on the substratum under the two flow regimes (Table 2). These same general results were obtained in the field trials, however in the field final instars were most common on brick sides at high current velocities (Fig. 1).

### Substratum heterogeneity

Larvae chose the protection of crevices and indenta-

tions over exposed, open substratum surfaces at high flow rates. The number of fourth and final instar larvae preferring crevices to open surfaces of the bricks greatly increased with increased current velocity (Fig. 2; 4th instars,  $U = 96.0$ ,  $P < 0.01$ ; final instars,  $U = 94.5$ ,  $P < 0.01$ ).

Second instars could not be seen in the crevices be-

Table 2. Results of two-way analysis of variance of larval densities in four substratum locations under high ( $50 \text{ cm s}^{-1}$ ) and low ( $5 \text{ cm s}^{-1}$ ) flow rates in the laboratory streams.

Size class	Source of variation	F	
2nd instars	Flow regime	212.31	$P < 0.01$
	Substratum	32.86	$P < 0.01$
	Flow $\times$ substratum	77.66	$P < 0.01$
4th instars	Flow regime	18.26	$P < 0.01$
	Substratum	134.77	$P < 0.01$
	Flow $\times$ substratum	244.26	$P < 0.01$
Final instars	Flow regime	29.75	$P < 0.01$
	Substratum	515.80	$P < 0.01$
	Flow $\times$ substratum	177.51	$P < 0.01$

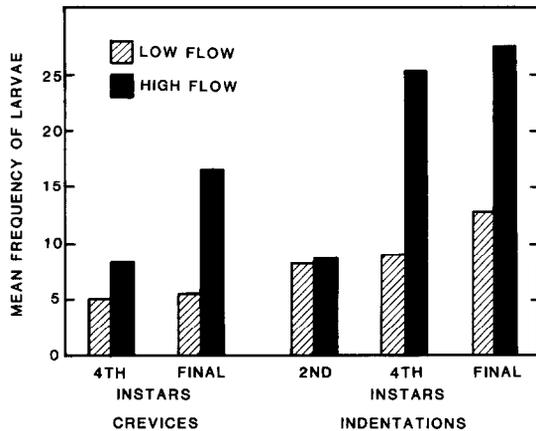


Fig. 2. Mean frequency of *Helicopsyche borealis* in crevices and indentations for low (5 cm s<sup>-1</sup>) and high (50 cm s<sup>-1</sup>) current velocities.

cause of their small size and thus were not tested in crevices. The number of fourth and final instars preferring indentations to open surfaces also increased with increased current velocity (Fig. 2; 4th instars,  $U = 99.5$ ,  $P < 0.01$ ; final instars,  $U = 97.0$ ,  $P < 0.01$ ). Second instars did not prefer indentations to open surfaces, probably because they were physically displaced by the current before they could attach inside indentations ( $U = 55.5$  ns).

These findings support the work of Williams *et al.* (1983) in an Ontario stream, who examined the distribution of fifth instars on 10 rocks from fast (75 cm s<sup>-1</sup>) and slow (25 cm s<sup>-1</sup>) areas. In fast water larvae were most numerous on surfaces not exposed to the current, whereas in slower water larvae occurred on the exposed surfaces. Similar behavior has been observed for the mineral case-builder *Glossosoma* (Scott, 1958).

The preference of all larval size classes for exposed surfaces at low flow is probably related to the availability of periphyton food on these surfaces. Studies have shown that *H. borealis* larvae aggregate on periphyton patches with high standing crops (Lamberti & Resh, 1983) and prefer periphyton-rich as opposed to periphyton-depleted surfaces in both laboratory and field studies (Vaughn, 1986). The different substratum preferences of large and small larvae under high current regimes is probably related to the greater physical ability of older instars to seek

shelter and maintain their position in the current (Vaughn, 1985a).

### Acknowledgements

I am grateful to A. P. Covich for his continual advice and encouragement. I thank J. T. Vaughn for field assistance and for drafting the figures. Much advice was provided throughout this study by H. P. Brown, L. Pfiester, G. D. Schnell and F. J. Sonleitner. This paper is derived from a portion of a doctoral dissertation for the University of Oklahoma Department of Zoology and was funded by the former as well as by a Sigma Xi Grant-in-Aid of Research.

### References

- Elliot, J. M., 1970. The diel activity patterns of caddis larvae (Trichoptera). *Zool. J. Lond.* 160: 279–290.
- Gallepp, G. W., 1974. Diel periodicity in the behavior of the caddisfly *Brachycentrus americanus* (Banks). *J. Freshwat. Ecol.* 4: 193–204.
- Gallepp, G. W. 1977. Responses of the caddisfly larvae (*Brachycentrus* sp.) to temperature, food availability and current velocity. *Am. Midl. Nat.* 98: 59–84.
- Lamberti, G. A. & V. H. Resh, 1983. Stream periphyton and insect herbivores: an experimental study of grazing by a caddisfly population. *Ecology* 64: 1124–1135.
- McConnell, W. J. & W. F. Sigler, 1959. Chlorophyll and productivity in a mountain river. *Limnol. Oceanogr.* 4: 335–351.
- Resh, V. H., G. A. Lamberti & J. R. Wood, 1984a. Biology of the caddisfly *Helicopsyche borealis* (Hagen): a comparison of North American populations. *Freshwat. Invert. Biol.* 3: 172–180.
- Resh, V. H., G. A. Lamberti & J. R. Wood, 1984b. Biological studies on *Helicopsyche borealis* (Hagen) in a coastal California stream. *Ser. Entomol. (The Hague)* 20: 315–319.
- Scott, C., 1958. Ecological studies on the river Dean, Cheshire. *Arch. Hydrobiol.* 54: 340–392.
- Sokal, R. R. & F. J. Rohlf, 1981. *Biometry*. W. H. Freeman Co., San Francisco. 859 pp.
- Vaughn, C. C., 1984. Ecology of *Helicopsyche borealis* (Hagen) (Trichoptera: Helicopsychidae): Life history and microdistribution. Ph.D. dissertation, Univ. of Oklahoma, Norman, OK. 93 pp.
- Vaughn, C. C., 1985a. Evolutionary ecology of case architecture in the snailcase caddisfly, *Helicopsyche borealis*. *Freshwat. Invert. Biol.* 4: 178–186.
- Vaughn, C. C., 1985b. Life history of *Helicopsyche borealis* (Hagen) (Trichoptera: Helicopsychidae) in Oklahoma. *Am. Midl.*

- Nat. 113: 76–83.
- Vaughn, C. C., 1986. The role of periphyton abundance and quality in the microdistribution of a stream grazer, *Helicopsyche borealis* (Trichoptera: Helicopsychidae). Freshw. Biol. 16: 485–493.
- genera (Trichoptera). Univ. Toronto Press, Toronto. 401 pp.
- Williams, F. S., A. T. Read & K. A. Moore, 1983. The biology and zoogeography of *Helicopsyche borealis* (Trichoptera: Helicopsychidae): a Nearctic representative of a tropical genus. Can. J. Zool. 61: 2288–2299.