



**Life History of *Helicopsyche borealis* (Hagen) (Trichoptera:
Helicopsychidae) in Oklahoma**

Caryn C. Vaughn

American Midland Naturalist, Volume 113, Issue 1 (Jan., 1985), 76-83.

Your use of the JSTOR database indicates your acceptance of JSTOR's Terms and Conditions of Use. A copy of JSTOR's Terms and Conditions of Use is available at <http://www.jstor.org/about/terms.html>, by contacting JSTOR at jstor-info@umich.edu, or by calling JSTOR at (888)388-3574, (734)998-9101 or (FAX) (734)998-9113. No part of a JSTOR transmission may be copied, downloaded, stored, further transmitted, transferred, distributed, altered, or otherwise used, in any form or by any means, except: (1) one stored electronic and one paper copy of any article solely for your personal, non-commercial use, or (2) with prior written permission of JSTOR and the publisher of the article or other text.

Each copy of any part of a JSTOR transmission must contain the same copyright notice that appears on the screen or printed page of such transmission.

American Midland Naturalist is published by University of Notre Dame. Please contact the publisher for further permissions regarding the use of this work. Publisher contact information may be obtained at <http://www.jstor.org/journals/notredame.html>.

American Midland Naturalist
©1985 University of Notre Dame

JSTOR and the JSTOR logo are trademarks of JSTOR, and are Registered in the U.S. Patent and Trademark Office. For more information on JSTOR contact jstor-info@umich.edu.

©2001 JSTOR

Life History of *Helicopsyche borealis* (Hagen) (Trichoptera: Helicopsychidae) in Oklahoma

CARYN C. VAUGHN

Department of Zoology, University of Oklahoma, Norman 73019

ABSTRACT: The life history of *Helicopsyche borealis* was compared for 13 months in two Oklahoma streams that have different thermal regimes. Densities of *H. borealis* were usually higher in the thermally constant stream. The species was multivoltine with overlapping generations in the thermally constant stream and univoltine in the thermally fluctuating stream.

INTRODUCTION

Larvae of *Helicopsyche* (Trichoptera: Helicopsychidae) are unusual in that their sand-grain cases superficially resemble snail shells. In fact, the genus was first described as a snail based on the shape of the case alone (Lea, 1834). There are five species of *Helicopsyche* in North America N of Mexico (Wiggins, 1977; Denning and Blickle, 1979). *Helicopsyche borealis* (Hagen) is the most common species occurring in clear running water, springs and the littoral zone of lakes, and has been found in thermal springs exceeding 34 C (Wiggins, 1977). Mackay and Wiggins (1979) reported the occurrence of *H. borealis* in streams receiving domestic sewage and this species also tolerates petroleum-related pollution (Bugbee and Walters, 1973).

The life history of *Helicopsyche borealis* has only been partially described. Ross (1944) and Williams and Hynes (1974) reported continual emergence of adults from spring to early autumn followed by an egg diapause of 5-6 months in Illinois and Ontario, respectively. Bane and Lind (1978) studied *H. borealis* in a tributary of the Rio Grande in Texas. Biomass was highest in the spring and lowest in the winter. Adults were found only in April.

I collected *Helicopsyche borealis* from two Oklahoma streams with different thermal regimes for 13 months. I report on life history patterns of *H. borealis* in these two streams and present new information on egg masses and early case-building behavior.

METHODS

Study area and sampling method. — Pennington Creek is a second-order, spring-fed, thermally constant stream in the Arbuckle Mountains of S-central Oklahoma. Caney Creek is a third-order, thermally variable stream in the Ozark Mountain foothills of northeastern Oklahoma (Fig. 1). *Helicopsyche borealis* densities were sampled in each of these streams at monthly intervals from May 1981 through May 1982. A modified quadrat sampling technique was used. Stratified random samples of the substratum were collected with a 95 cm² cylinder to a depth of 3 cm. The *H. borealis* were removed from the substratum, counted and assigned to an age class (see below for technique). Fifty samples per month were collected from each stream from May through August 1981, and 25 thereafter for the remainder of the sampling period. Temperature was measured with an Extech meter (model 651).

Development. — The development of 20 egg masses was followed in the laboratory from the time they were laid through pupation of the resulting larvae. Egg masses were obtained from adults reared from pupae collected from Pennington Creek in July and August 1982. Adults were reared in 76-L artificial streams with screen cage tops. Floating pieces of styrofoam were provided as oviposition surfaces. Observations on hatching and early case-making were made in 8 x 2 cm glass finger bowls under a dissecting microscope. Larvae were reared in 3.8-liter glass aquaria. Cases of *Helicopsyche borealis* were measured to determine the range of sand particle sizes used in the

case. Particles within this range (0.02-0.09 mm) were provided for case construction material. Food consisted of periphyton-covered cobble collected from Pennington Creek. Water in all the artificial streams and aquaria was a mixture of one-half Pennington Creek water and one-half distilled water.

I measured 123 egg masses collected from Pennington Creek and a similar, nearby spring-fed stream, Byrd's Mill Spring. For each egg mass I recorded the size of the rock to which the egg mass was attached, the number and location of egg masses on that rock, and the depth of water from which the rock was collected. The maximal and minimal diameters of the egg mass were measured, and the number of individual eggs per mass counted.

Age determination.—The first four instars were readily identifiable by observing molts and measuring head widths of laboratory-reared *Helicopsyche borealis*. Midpoints for head width frequency for each instar for the laboratory-reared specimens were assigned (I = 0.11, II = 0.18, III = 0.27, IV = 0.4 mm) (Fig. 2). The factor of increase between these midpoints is 1.5, which fits Dyar's rule as the typical factor of increase between Trichoptera instars (Mackay, 1978). These values are similar to head-width frequency peaks of field specimens (Fig. 3). Using this factor of increase, I calculated the midpoint for the fifth instar to be 0.6 mm. Although both the field and laboratory specimens had peaks at 0.6 mm, there were also peaks at 0.7 mm (Fig. 2, Fig. 3). This may be the result of several factors. There may be sexual dimorphism in the last instar. There may be a large natural range in the size of the fifth instars due to differential growth. Lastly, larvae may go through six or even seven instars. I have observed larvae with opercula (and thus ready to pupate) with head widths ranging from 0.58 to as large as 0.77 mm. This range is present year-round and, thus, is not a seasonal size dimorphism. Resh (1982) reported that larvae in a population of *Gumaga nigricula* in a California spring would molt as many as 14 times and that larval instars could not be distinguished by head capsule measurement. For the purpose of this study larvae were classified as early instars (head width < 0.5 mm) and late instars (head width > 0.5 mm). Early instars include the first four instars and late instars encompass the fifth and any subsequent instars.

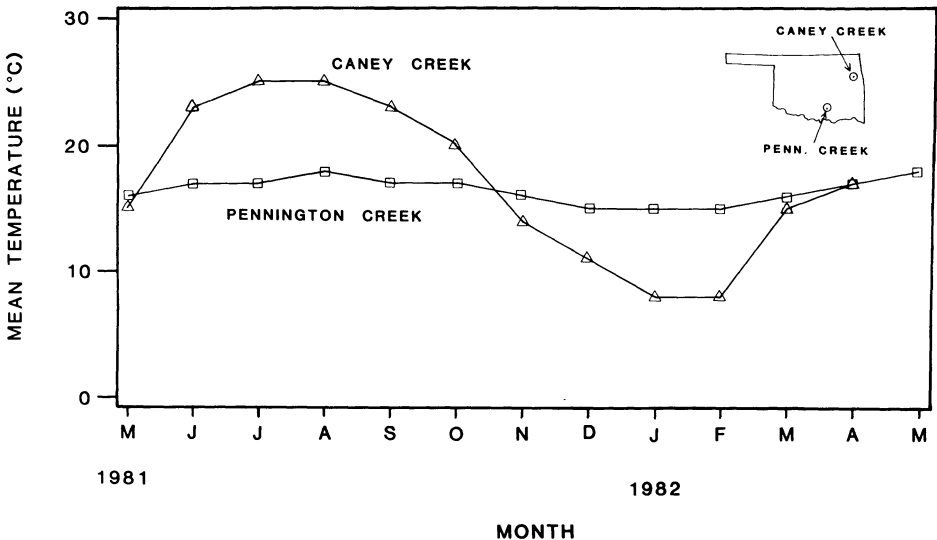


Fig. 1.—Mean monthly temperatures of Pennington and Caney creeks

RESULTS AND DISCUSSION

Development. — Egg masses of *Helicopsyche borealis* were briefly described by Vorhies (1909) and Elkins (1936) as hemispherical yellow masses fastened to an underwater support. In Pennington Creek and Byrd's Mill Spring egg masses occurred on the undersides of partially submerged rocks at the edge of the stream (\bar{X} depth = 5.5 cm). The rocks with egg masses that were measured averaged 8.1 (sd of 2.0) cm maximum by 3.3 ± 1.3 cm minimum diam. In the laboratory, eggs were laid on the undersides of floating pieces of styrofoam as well as on the sides of the aquaria. Egg masses occurred singly or in clusters of up to 35 in the field ($\bar{X} = 1.5 \pm 13.4$) but usually occurred singly or in pairs in the laboratory.

Egg masses were a yellow-green gelatinous matrix measuring 5.2 ± 1.0 mm maximum by $4.4 \pm .8$ mm minimum diam ($N = 143$). On the average, 184 ± 40 eggs were evenly spaced within this matrix. This number is lower than the 250 eggs per mass reported by Davis (1965) for *Helicopsyche borealis* in an Ohio stream. Differences in fecundity between populations of a species can usually be attributed to local en-

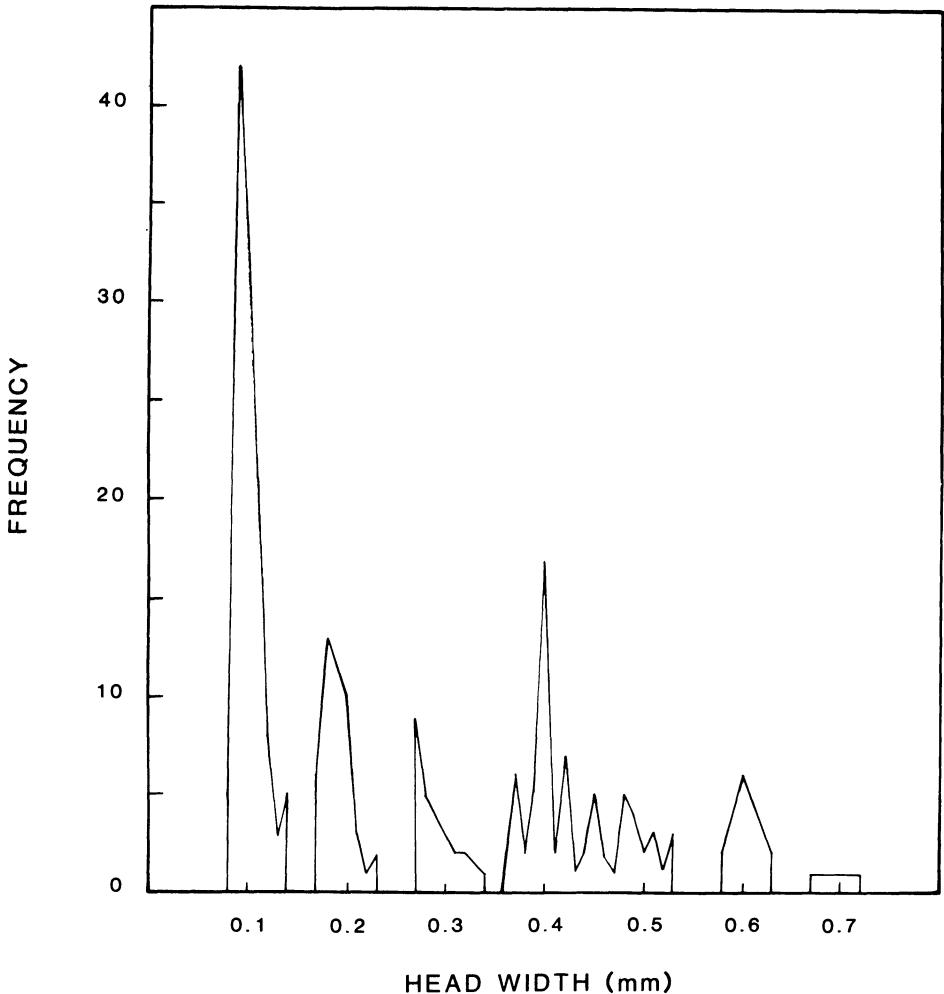


Fig. 2.—Head widths of laboratory-reared *Helicopsyche borealis*

vironmental conditions such as food quality and temperature (Sweeney and Vannote, 1978; Anderson and Cummins, 1979).

At laboratory water temperatures of 19-21 C, development proceeded as follows. The body was visible after 10 days and the head distinct after 14-15 days. Eggs began to hatch at 16-17 days. Hatching took 2-3 days from the time the first larvae emerged until the last had hatched. Hatching of field-collected eggs has been described in detail by Davis (1965). Upon hatching, larvae would crawl over the surface of the egg mass. They began to build cases as soon as they encountered sand particles, whether these were clinging to the egg mass or on the bottom of the finger bowl.

Davis (1965) stated that larvae first built a straight tube case and later began to spiral the case. I found that the case was curved from the beginning and became progressively more helical simply by the larvae adding onto the case tube in a spiral fashion (Fig. 4). Larvae built cases at different rates. Most larvae had built a half circle ranging from 0.56-0.77 mm in length by an age of 7 days and a complete circle by 2 weeks. Development time was variable and became more variable with age. Most larvae underwent their first molt between 3 and 4 weeks, their second molt between 5 and 6 weeks and their third between 6 and 8 weeks. No fourth molts were observed. Most larvae pupated between 9 and 12 weeks in laboratory rearings.

Population dynamics.—Densities of *Helicopsyche borealis* were usually higher in thermally constant Pennington Creek than in variable Caney Creek. *Helicopsyche borealis* was the most abundant macroinvertebrate inhabiting stony substrata in Pennington Creek. In contrast, *H. borealis* was not dominant in Caney Creek except for a short

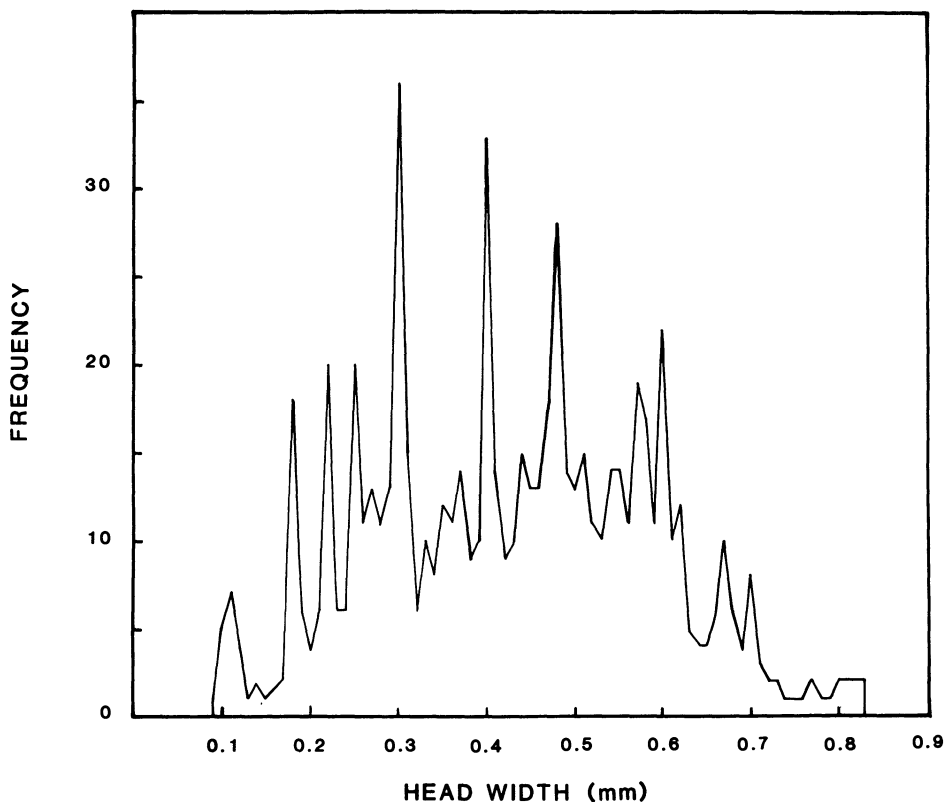


Fig. 3.—Head widths of field-collected *Helicopsyche borealis*

period in the spring. Populations in both streams were greatly reduced by a heavy flood in October 1981 (Fig. 5). Severe floods in autumn are rare in Oklahoma.

Helicopsyche borealis was multivoltine with overlapping generations in Pennington Creek. Early instars were found 8 months out of 12 but densities were highest in late spring and early summer (Fig. 5). Adults were present year-round but were not quantified. Ross (1944) and Williams and Hynes (1974) reported continual spring-autumn emergence of *H. borealis* in N temperate streams. During the winter egg masses were found in Byrd's Mill Spring but not in Pennington Creek. Early instars were present year-round in Byrd's Mill Spring. The temperature of this spring is approximately 17 C all year.

Helicopsyche borealis was univoltine in Caney Creek with densities peaking in April (Fig. 5). Adults were only collected in the summer. Bane and Lind (1978) found that *H. borealis* biomass peaked in the spring and adults were found only in April in a tributary of the Rio Grande. They did not report densities. A peak of early instars did occur in January in Caney Creek. Ross (1944) and Williams and Hynes (1974) reported egg diapause for *H. borealis* in some N temperate streams. No egg masses were ever observed in Caney Creek. However, it is likely that they occur, as in other localities, on partially submerged rocks in very shallow water. If this is the case, then a succession of warm days, as sometimes occurs in Oklahoma in January, may have

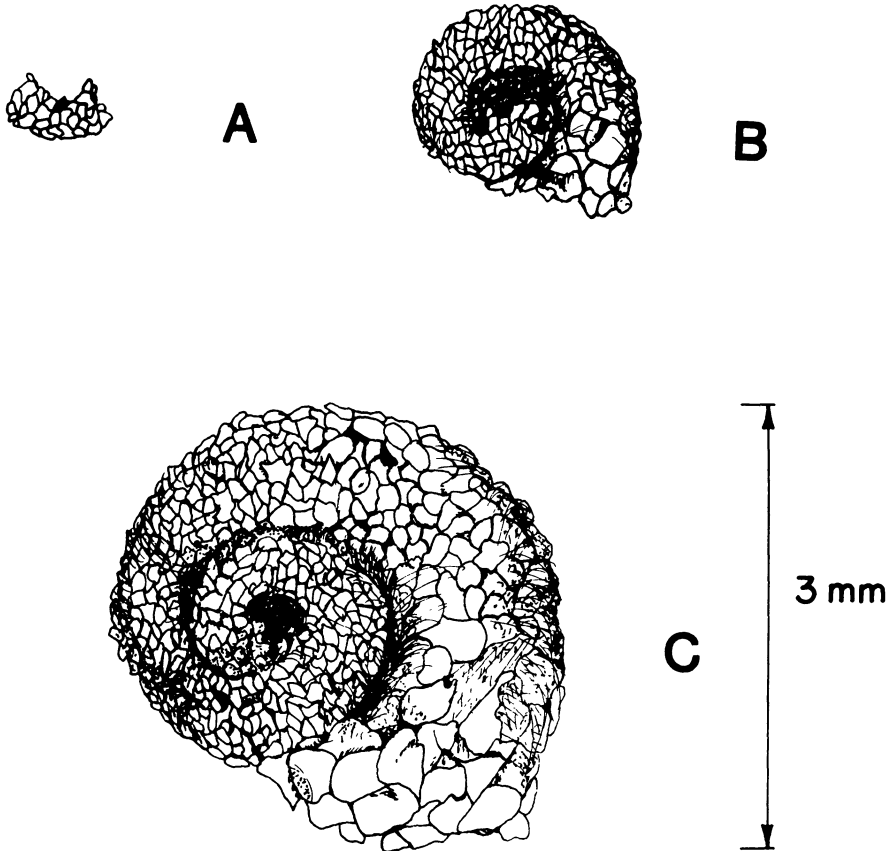


Fig. 4. — Comparison of *Helicopsyche borealis* case size and shape at (a) 4 days; (b) 3 weeks, and (c) 7 weeks

caused the eggs to hatch. Densities were much lower in Caney Creek than in Pennington Creek and, thus, it is possible that this January peak may be due to sampling error. The much higher densities of *H. borealis* in Pennington as opposed to Caney Creek, and differences in voltinism in the two streams may be due to both direct and indirect effects of the constant vs. variable thermal regimes. Adult body size and fecundity depend largely on thermal conditions during the larval period (Sweeney and Vannote, 1978). Gose (1970) found that the amount of accumulated temperature can influence the number of generations of scrapers and probably affects maximum size attained by an individual cohort. Gray (1981) studied five species of caddisflies, including *H. borealis*, in a lower Sonoran desert stream. These species reproduced continuously, although total development time was only slightly less than that of univoltine temperate species. The greater number of potential generations was probably related to the warmer stream temperatures.

In thermally constant springs, species which are often univoltine in "natural" streams behave with plasticity to warm water by producing overlapping summer generations (Hynes, 1970). Resh (1982) found that populations of *Gumaga nigricula* were univoltine in some California streams and multivoltine in nearby thermal springs. Caney Creek actually experiences more annual degree days than Pennington Creek (6162 to 5880 for May 1981 through April 1982). However, much of the time Caney Creek experiences extremes while Pennington Creek maintains a mild temperature all year (Fig. 1). Thus, it is probably not annual degree days that are important in this case, but the length of time at an optimum temperature for reproduction. For *Helicopsyche borealis* in Oklahoma, this temperature appears to be ca. 17 C, although early seasonal peaks are probably also related to photoperiod and food changes.

Temperature may also be related to food quality and quantity, which in turn will affect total densities and voltinism. Parker and Voshell (1982) attributed differences in voltinism in *Hydropsyche* life cycles in two Virginia rivers to an interaction between food quality and temperature regime. Anderson and Cummins (1979) found that

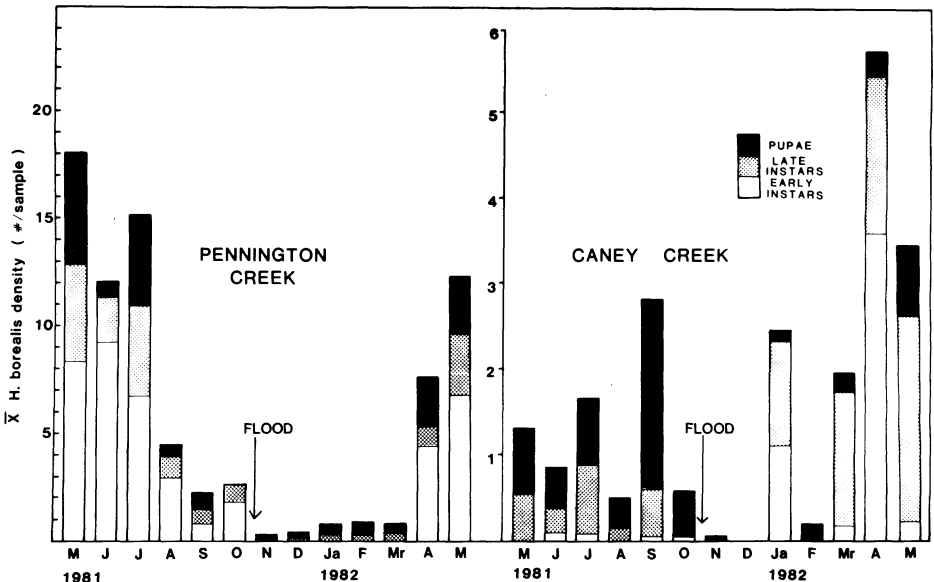


Fig. 5. — Mean monthly density of pupae and early and late instar *Helicopsyche borealis* in Pennington and Caney creeks. Note that Caney creek is on a different, expanded scale

temperature and food quality and quantity interact in their effect on voltinism and growth. Low diversity in streams below hypolimnetic release reservoirs has been attributed to seasonal and diurnal thermal constancy which decreases potential niches and thus the number of species (Ward and Stanford, 1979; Ward and Dufford, 1979). In a constant stream, such as Pennington Creek, food may be available year-round while in a fluctuating stream food availability exhibits great temporal variability (Ward and Stanford, 1979). A year-round optimal temperature for reproduction combined with continuous food availability would favor the dominance of a species most prolific in this stable habitat. In Pennington Creek, this species appears to be *Helicopsyche borealis*. In fact, *H. borealis* may normally reproduce continuously in Pennington Creek, as it does in nearby thermally constant Byrd's Mill Spring. During the study there was a rare autumn flood which severely depleted the population for several months and could have suppressed reproduction. Fluctuating temperatures and food levels would be more likely to produce a pattern in which species were dominant only for short periods of time. This inconstancy appears to be the situation in Caney Creek.

Acknowledgments.—This project was funded by the University of Oklahoma Department of Zoology and by a Sigma Xi Grant-in-Aid of Research. I am grateful to Joe T. Vaughn and Shirley J. Starks for field assistance. Joe Vaughn also built rearing cages and drafted the figures. Much advice was provided throughout this study by Alan P. Covich, Harley P. Brown, Lois Pfister, Gary D. Schnell and Frank J. Sonleitner. I thank Glen B. Wiggins for commenting on the original proposal for this research and for verifying the identification of *Helicopsyche borealis*. The manuscript was improved by the comments of Vincent H. Resh and an anonymous reviewer.

LITERATURE CITED

- ANDERSON, N. H. AND K. W. CUMMINS. 1979. Influence of diet on the life histories of aquatic insects. *J. Fish. Res. Board Can.*, **36**:335-342.
- BANE, C. A. AND O. T. LIND. 1978. The benthic invertebrate standing crop and diversity of a small desert stream in Big Bend National Park, Texas. *Southwest. Nat.*, **23**:215-226.
- BUGBEE, S. L. AND C. M. WALTERS. 1973. The response of macroinvertebrates to gasoline pollution in a mountain stream, p. 725-731. *In*: Proc. conf. prevention oil spills. U.S. Environmental Protection Agency, Cincinnati, Ohio.
- DAVIS, C. C. 1965. A study of the hatching process in aquatic invertebrates XVIII. Eclosion in *Helicopsyche borealis* (Hagen) (Trichoptera, Helicopsychidae). *Am. Midl. Nat.*, **74**:443-450.
- DENNING, D. G. AND R. L. BLICKLE. 1979. New species of *Helicopsyche* (Trichoptera, Helicopsychidae). *Pan-Pac. Entomol.*, **55**:27-33.
- ELKINS, W. A. 1936. The immature stages of some Minnesota Trichoptera. *Ann. Entomol. Soc. Am.*, **29**:656-681.
- GOSE, K. 1970. Life history and instar analysis of *Stenophylax griseipennis* (Trichoptera). *Jap. J. Limnol.*, **31**:96-106.
- GRAY, L. J. 1981. Species composition and life histories of aquatic insects in a lowland Sonoran desert stream. *Am. Midl. Nat.*, **106**:229-242.
- HYNES, H. B. N. 1970. The ecology of running waters. Univ. Toronto Press, Toronto. 555 p.
- LEA, I. 1834. Observations on the Naiades and descriptions of new species of that and other families. *Trans. Am. Phil. Soc.*, **4**:63-121.
- MACKAY, R. J. 1978. Larval identification and instar association in some species of *Hydropsyche* and *Cheumatopsyche* (Trichoptera: Hydropsychidae). *Ann. Entomol. Soc. Am.*, **71**:499-509.
- AND G. B. WIGGINS. 1979. Ecological diversity in the Trichoptera. *Annu. Rev. Entomol.*, **24**:185-208.
- PARKER, C. R. AND J. R. VOSHELL, JR. 1982. Life histories of some filter-feeding Trichoptera in Virginia. *Can. J. Zool.*, **60**:1732-1742.
- RESH, V. H. 1982. Age structure alteration in a caddisfly population after habitat loss and recovery. *Oikos*, **38**:280-284.
- ROSS, H. H. 1944. The Caddisflies, or Trichoptera, of Illinois. *Ill. Nat. Hist. Surv. Bull.*, **23**:290-311.
- SWEENEY, B. W. AND R. L. VANNOTE. 1978. Size variation and the distribution of hemimetabolous aquatic insects: two thermal equilibrium hypotheses. *Science*, **200**:444-446.

- VORHIES, C. T. 1909. Studies on the Trichoptera of Wisconsin. *Trans. Wis. Acad. Sci. Arts Lett.*, **16**:647-738.
- WARD, J. V. AND R. G. DUFFORD. 1979. Longitudinal and seasonal distribution of macroinvertebrates and epilithic algae in a Colorado springbrook-pond system. *Arch. Hydrobiol.*, **86**:284-321.
- AND J. A. STANFORD. 1979. Ecological factors controlling stream zoobenthos with emphasis on thermal modification of regulated streams, p. 35-55. *In*: J. V. Ward and J. A. Stanford (eds.). *The ecology of regulated streams*. Plenum Press, New York.
- WIGGINS, G. B. 1977. Larvae of the North American Caddisfly Genera (Trichoptera). Univ. Toronto Press, Toronto. 401 p.
- WILLIAMS, D. D. AND H. B. N. HYNES. 1974. The occurrence of benthos deep in the substratum of a stream. *Freshwater Biol.*, **4**:233-256.

SUBMITTED 26 SEPTEMBER 1983

ACCEPTED 3 FEBRUARY 1984