The Larval Retreat and Feeding Net of
Macronema carolina Banks
(Trichoptera: Hydropsychidae)

by

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ABSTRACT

Larvae of the caddisfly *Macronema carolina*, which is widely distributed in the eastern United States, construct chambers on and in the bark and outermost wood of submerged tree limbs in large streams. Each chamber consists of two main parts, a feeding chamber and a larval retreat. A feeding net 10—11 mm² in area is spun diagonally across the inside of the open ended, tubular feeding chamber, the anterior end of which opens directly into the current. This feeding net has a very fine mesh with openings of approximately 5 x 40 μ and is used to strain microseston (fine particulate organic matter, phytoplankton and bacteria) upon which the larva grazes while situated in a retreat opening into the side of the feeding chamber. This larval retreat has a small opening posteriorly which is apparently used as an exit for feces and water passing over the gills. We propose that the Holarctic distribution of *Macronema* spp., as inhabiting large streams, may be influenced more by feeding habits of the species, than the conventional water quality parameters often used by aquatic biologists to account for distribution.

INTRODUCTION

Larvae of Hydropsychidae (Trichoptera) are well known to aquatic biologists for using nets spun with their silk glands to capture drifting food particles in streams. There are published details of net structures of the genera *Hydropsyche* (SATTLER, 1955, 1958; KAISER, 1965; SCHUHMACHER, 1970), and *Diplectrona* (SATTLER, 1963a). A *Macronema* sp. described from the Amazon Basin constructs a U-shaped tube of sand grains on the bottom of sandy streams and uses an extremely fine meshed net that captures "mikrodrift"; the openings of this net are much smaller than those of other

hydropsychid genera (SATTLER & KRACHT, 1963; SATTLER, 1963b; SATTLER, 1968).

In this paper we report structure and function of the larval nets and retreat of *Macronema carolina*, a widespread species in the eastern United States (Ross, 1944).

METHODS

Larvae, with their nets and retreats intact, were collected from the Apalachicola River in northern Florida by removing portions of submerged branches of fallen trees, the larval habitat of *M. carolina* in this area. Orientation of the limbs relative to current direction was noted at time of collection. Several sections of limb were immediately preserved in a 6% formaldehyde solution. Other sections of limb received no preservative, and were allowed to air dry. Stream velocity (101 cm/sec) was measured adjacent to the limbs with a rubber bag current meter (GESSNER, 1955).

Both preserved and dried limbs containing the larvae were used to elucidate net and retreat construction details. Portions of the nets were mounted on slides in glycerine for microscopic examination, drawing and photographing.

Slides for gut analysis of *Macronema* larvae were prepared using the Millipore Filter (0.45 μ) Technique described previously (CUMMINS, 1973). Large sclerous lamellae in the posterior portion of the proventriculus of these larvae have been described previously (JUDD, 1947; HARRIS, 1971). We feel that these lamellae aid in breaking up ingested food and may possibly alter the size of food particles in the mid- and hindgut. Since we were interested in both types and size of ingested food particles we prepared separate slides from material in (1) the crop and anterior end of the proventriculus and (2) mid- and hindgut. Fixed, stained slides of crop materials

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Figures 1—5. Fig. 1. diagramatic view of the larval retreat and feeding net of *Macronema carolina*. A, entrance hole for inflowing water; B, feeding or capture net; C, exit hole for water flowing through the net; D, larval retreat housing the larva; E, exit hole for feces and water passing over the gills; F, typical portion of the capture net and G, an unusal "atypical" portion of the capture net where two strands of silk converge. Arrows indicate the main path of water through the chamber. Fig. 2. External photograph of larval chamber on a submerged limb. A, entrance hole for water; B, feeding chamber; C, exit hole for water passing through the net; D, larval retreat and E, exit hole for feces and water passing over the gills. Fig. 3. Crevices in outer wood showing the site of previous larval chambers. Fig. 4. Photograph of a portion of the larval net. Fig. 5. Portion of larval net with adhering bacteria.

were also made using crystal violet (PELCZAR & REID, 1958) to assist in detecting any bacteria which might be present.

Composition and abundance of microseston in the stream water was determined using Millipore filter techniques similar to those of MACIOLEK & TUNZI (1968).
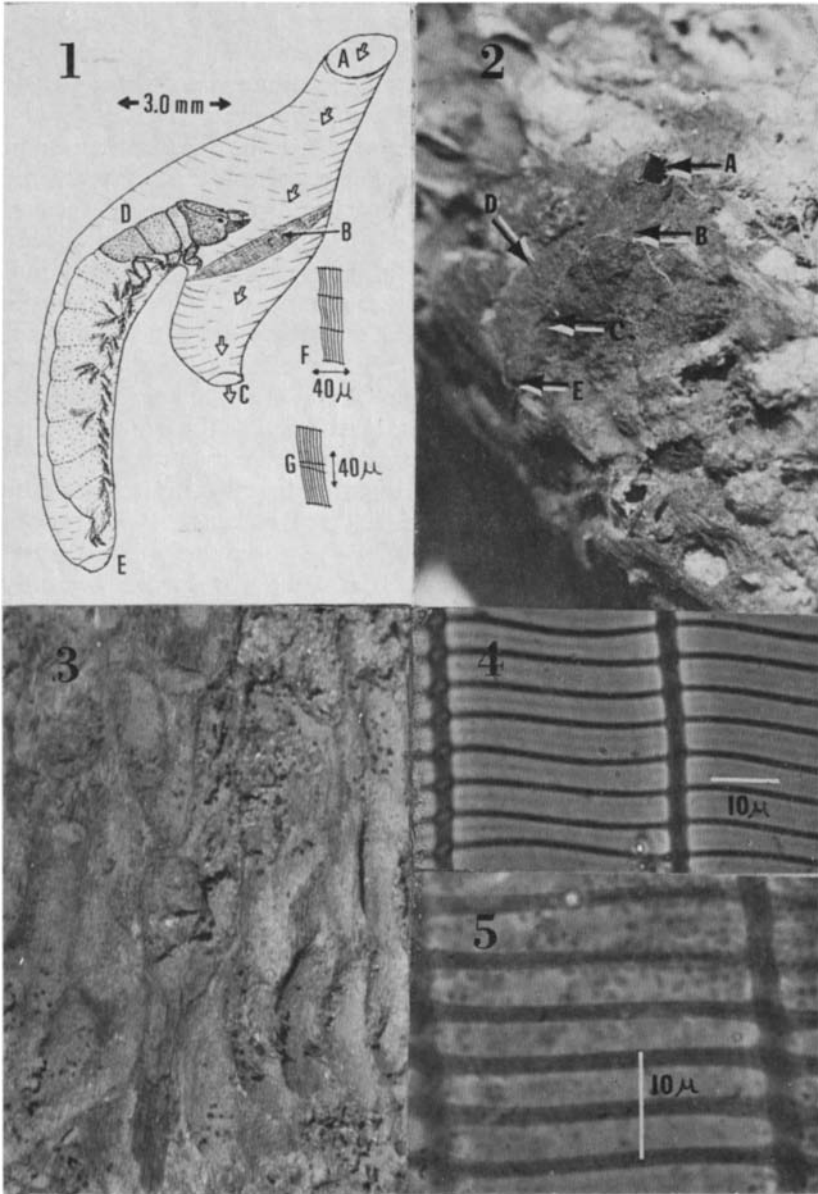
Larval chambers are constructed as tunnels and grooves excavated in both the bark and outermost wood of fallen submerged tree limbs. Grooves are covered with thick debris (larval frass?), reinforced with silken threads. A "typical" construction is shown in Figs. 1 and 2; it consists of two main parts, a feeding chamber and a larval retreat. The opening for water flowing into the feeding chamber (Fig. 1, A) faces into the current; water passes through the feeding net (Fig. 1, B), and out of the exit opening (Fig. 1, C). The net is constructed diagonally across the chamber rather than perpendicular to the flow, thus increasing the filtering area. The larval retreat opens into the feeding chamber in front of the net (Fig. 1, D). An opening at the rear of the retreat (Fig. 1, E) probably serves both to allow some water flow over the larva's abdominal gills and as a waste disposal for feces. Arrows (Fig. 1) indicate the directions of water flow. All larval chambers examined followed this basic pattern; however, the shapes of individual chambers demonstrated considerable variation. A few chambers are curved as much as 90° from the entrance hole (Fig. 1, A) to the exit hole (Fig. 1, C). In some instances, the entrance hole is located at the apex of a silk reinforced, debris ladened tube extending 2—3 mm above the substrate surface (Fig. 2, A). Larval densities reach 1 per cm² of limb surface, resulting in portions of the chambers of individual larvae being separated from those of adjacent larvae by only thickened silk walls. The remains of old larval retreats are visible on exposed limbs projecting above the water surface (Fig. 3).

The feeding net (Fig. 1, B, F, and G; Figs. 4 and 5), spun with the larval mouthparts (Sattler 1958, 1968; Kaiser 1965), is very similar to that constructed by a *Macronema* from the Amazon Basin (SATTLER, 1963b, 1968). The rectangular net openings are relatively constant in size, each being approximately 5 by 40 μ. Rarely, we encountered small isolated areas of net where the strands at the short ends of the retangular mesh would run together (Fig. 1, G) resulting in openings of both larger and smaller dimensions. Total net area of a mature larva is approximately 10 to 11 mm²; thus there are about 50,000 openings per feeding net. The larvae have densely pilose brushes on the fore tibiae, labrum, labium and oral opening similar to those previously described (SATTLER, 1963b), which are used for grazing on food particles trapped in the net. Proventricular gut analyses of *M. carolina* revealed, in addition to fine detritus previously reported as the major food of this genus (SATTLER, 1963b,) some phytoplankton as well as bacteria. That the small, heavily shaded, acid stream occupied by the South American

Macronema contained large amounts of fine particulate organic matter and little phytoplankton (Sattler, 1963b), probably accounts for more plankton found in the guts of our larvae. However, the predominant food present in the proventriculus was fine particulate organic matter in the range of 2 to 45 μ diameter with most between 10—30 μ. Crystal violet stains of materials removed from the proventriculi of the larvae revealed the presence of small rods and spheres in the 1—2 μ range; presumably these were bacteria. These bacteria may be associated with the fine particulate organic matter ingested by the larvae or adhere to the larval nets (as seen in Fig. 5) and be consumed as the larva grazes on the food trapped in the net. It is interesting to note that the mesh openings of *M. carolina* feeding nets are about 6x smaller (in μ^2) than the finest plankton nets available commercially.

The broad, flat head set off by an extensive carina has been used as a key character to separate *Macronema* larvae from other hydropsychid genera (e.g. Ross, 1944). This unusual shaped head is probably important to these larvae in serving the following functions: (1) by withdrawing into the larval retreat the larva can use the head as a "stopper" across the larval retreat chamber (Fig. 1, D) thus directing more water flow through the net (Fig. 1, B) and less through the larval retreat, thereby controlling to some extent the water flow through the net, (2) the head can be used as a "scoop" in cleaning out debris from the chamber, and (3) the large sclerotized head could also be important as a "stopper" at the entrance hole (Fig. 1, A) as a defense against a potential predator or to reduce water flow entering the chamber when adverse sediments are present in the water, i.e. flood periods.

Distribution of *Macronema* may be influenced more by the feeding habits of the genus than by the strict water quality parameters often used by aquatic biologists. For example, in northern Georgia, below an impoundment on the Tugaloo River, there are large numbers of *Macronema zebratum* Hagen larvae. Their feeding nets are identical to those of *M. carolina* (Fig. 4) except *M. zebratum* larvae construct their retreats in sand grain tubes on the lower sides of large rocks (Wallace & Sherberger, unpublished data). In Panther Creek, a large unimpounded stream flowing into the Tugaloo, there are no *Macronema* larvae, although this is within 200 yards of the concentrations of *M. zebratum*. Chemical and physical parameters, including substrate, are remarkably similar between those two locations (Gordon & Wallace, 1973). There are two major differences between these stations that usual water quality parameters do not indicate: 1). The impoundment acts as a settling basin where larger organic and inorganic particles settle out. Water filtered through a

membrane filter with openings of 0.45 μ revealed many large (greater than 300 μ) particles in Panther Creek water whereas these large particles are sparse in Tugaloo water. Table I illustrates the relative difference in the number of particles greater than 100 μ. 2). Conversely, water from the Tugaloo contained many more organic particles less than 50 μ in size (the size on which *Macronema* predominately feeds) than the Panther Creek water.

TABLE I

Comparisons of the approximate number of particles greater than 100μ in size per liter of stream water in the Tugaloo River and Panther Creek based on a series of 50ml water samples filtered through 0.45 μ membrane filters.

	Maximum diameter			
	100—200μ	200—300μ	300—400μ	400$^+\mu$
Panther Creek	560	320	120	100
Tugaloo River	200	40	20	0

The interaction between distribution and food size probably explains CHUTTER's (1963) observations on several streams below South African reservoirs. When detached plankton were very abundant in these streams, *Cheumatopsyche tomasseti* (ULMER) dominated; when less plankton were present there were *Macronema capense* WALKER. We have examined the nets of several species of *Cheumatopsyche* larvae and found the smallest mesh size to be 79 μ by 80 μ in a half grown early 3rd instar specimen. One plausible explanation for the observation of CHUTTER (1963) is that *Macronema* is a more efficient food gatherer when only moderate amounts of detached phytoplankton are present. Conversely, the presence of very large amounts of detached plankton could thoroughly clog the minute openings of the nets and render inoperable the entire feeding mechanism of *Macronema* (Fig. 1) as would, quite possibly, large amounts of large size particulate matter as found in Panther Creek.

It is difficult to compare published data on stream microseston as related to headwater or downstream areas due to the following factors: 1). the work was done in geographically diverse areas, 2). most of the earlier work utilized rather coarse meshed plankton nets (e.g. CUSHING, 1964) and 3). different methods of gathering and reporting data have been used (e.g. WEBER & MOORE, 1967; MACIOLEK & TUNZI, 1968). Usually, higher amounts of detached phytoplankton are found in the larger and/or slower downstream areas rather than in the headwater regions or streams (e.g., GREEN-BERG, 1964), except in heavily polluted waterways (WILLIAMS, 1972). In addition, it seems probable that in these larger and slower downstream areas the larger and heavier suspended materials

would readily settle because of the decrease in velocity. This concept is possibly supported by *Hydropsyche orris* Ross, which is generally found only in large rivers. The net mesh size of mature *H. orris* is 109 x 80 μ, the smallest we have found in *Hydropsyche* spp. to date.

We infer from the above data, that at least the Holarctic distribution of *Macronema* spp. as inhabiting these large streams (Ross, 1944; LEPNEVA, 1964) may, in fact, be partially explained by the development of microsestonic feeding habits in their larvae.

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