Notes and Discussion

Life History and Ecology of Ephemerella funeralis McDunnough (Ephemeroptera: Ephemerellidae) in a Small West Virginia Stream

ABSTRACT: The life history and ecology of *Ephemerella funeralis* McDunnough were investigated in an unnamed branch of Hisey Fork of Fourpole Creek, Cabell Co., West Virginia, from May 1974 through April 1975. A univoltine life cycle was indicated. Except for trap-reared specimens, imagoes were not observed in the field; but field and laboratory observations indicated that imagoes were probably on the wing from mid-May to early June. Ovarian egg counts showed a range from 1709 to 3069 eggs per female; the mean was 2227. A 5-7 week egg diapause was proposed. Eggs hatched in June and July, when water temperatures were highest. Nymphs preferred slow water, and fed predominately on allochthonous leaf detritus. Leaf type preferences were investigated. Growth was rapid through December but was asymptotic from January till emergence. Reared subimagoes survived about 30 hr, and imagoes about 48 hr, in the laboratory. A chi-square test, at the 0.05 level, of 156 male and 167 female nymphs indicated a 1:1 sex ratio. A TL_m96 value of *p*H 3.1 was determined for mature nymphs.

INTRODUCTION

A knowledge of the life history and ecology of each species of aquatic insects in a stream is essential for a more complete understanding of community dynamics. Several investigators, including Maitland (1965), Larsen (1968), Stern and Stern (1969), Clifford *et al.* (1973), Coleman and Hynes (1970), Gose (1971), Radford and Hartland-Rowe (1971), Sukop (1973) and Waters and Crawford (1973), have reported life history data on the genus *Ephemerella*. However, no autecology study was found for *E. funeralis* McDunnough. The primary objectives of this investigation were to study the life history and ecology of *E. funeralis* in a small West Virginia stream.

TAXONOMY AND DISTRIBUTION

The genus *Ephemerella* was established in 1862 by Walsh, and is the largest Ephemeroptera genus (Edmunds and Allen, 1957). Approximately 125 species have been described, with 83 of these occurring in North America (Allen and Brusca, 1973). *Ephemerella funeralis* was placed in the subgenus *Eurylophella* by Allen and Edmunds (1963). McDunnough (1925) originally described *E. funeralis* from female imagoes and nymphs collected at Covey Hill, Quebec. *Ephemerella funeralis* has been reported from Ontario, Quebec, New Brunswick, Nova Scotia, and from 12 eastern states bounded by and including Wisconsin, New Hampshire and Georgia (McDunnough, 1931; Needham *et al.*, 1935; Burks, 1953; Allen and Edmunds, 1963). McDunnough (1931) reported that this species was found in quieter water in small mountain streams.

MATERIALS AND METHODS

The study area was a small, unnamed, spring-fed, first-order stream in Cabell Co., West Virginia, 1.6 km S of Huntington. Map coordinates are 82°26′ E long and 38°23′ N lat. The 920-m long streambed arises at an elevation of 245 m above sea level, but during summer and autumn, surficial water

normally exists only below 220 m and flows NE for 460 m, joining Hisey Fork of Fourpole Creek at 210-m elevation. The stream bottom consists of bedrock covered with silt, sand, rocks and organic debris (primarily allochthonous leaf litter).

Qualitative monthly collections of *Ephemerella funeralis* nymphs were made from 20 May 1974 to 20 April 1975. A long-handled dredge net, having a mesh size of approximately 1 sq mm was held to the stream bottom while the area immediately upstream for 1 m was vigorously disturbed, causing dislodged nymphs to wash into the net. Three or four locations, chosen at random in the low-gradient part of the stream, were sampled each month. The nymphs were preserved in 70% ethanol in the field.

The following chemical parameters were measured with a Hach Chemical Kit, model AL-36-WR: hydrogen ion concentration, dissolved oxygen, total hardness, alkalinity and free carbon dioxide. Ambient air and water temperatures were recorded.

The life cycle of *Ephemerella funeralis* was determined by measuring nymphal head capsule widths from each monthly collection. Monthly variations were shown by plotting the ranges, means, standard deviations and standard errors of the mean.

To determine if a food preference existed, 10 leaves representing 10 species of deciduous trees found along the study stream were placed in a 5-gal aquarium with 30 nymphs. Species used were sugar maple (*Acer saccharum* Marshall), buckeye (*Aesculus* sp.), tupelo (*Nyssa sylvatica* Marshall), hickory (*Carya* sp.), slippery elm (*Ulmus rubra* Muhlenberg), yellow poplar (*Liriodendron tulipfera* L.), sycamore (*Platanus occidentalis* L.), beech (*Fagus grandifolia* Ehrhart), chestnut oak (*Quercus prinus* L.) and black oak (*Q. velutina* Lamark). Percent of leaf skeletonization was visually estimated after 42 days. In addition, nymphs from each monthly collection were opened and their foregut contents examined microscopically to determine the relative value of diatoms and filamentous algae as a food source.

To determine the low *p*H tolerance of the nymphs, a TL_m96 (median tolerance limit, 96 hr) test was designed using a modification of McIlvaine's standard buffer system (Hodgman, 1959). The buffer system used 0.1 M citric acid and 0.2 M disodium phosphate. Values were set at *p*H 3.0, 4.2 and 7.0 as a control. A Corning Model-5 *p*H meter was used. The TL_m96 value at which 50% of the nymphs survived was calculated according to the procedure described in *Standard Methods* (APHA, 1965) using graphical interpolation.

Sexual dimorphism became evident with the October collection. A chi-square test at the 0.05 confidence level was applied to verify the expected 1:1 sex ratio.

Fecundity was determined by direct counts of ovarian eggs from 10 specimens of the female subimagoes and imagoes. Eggs were measured to the nearest 0.01 mm with an ocular micrometer, and egg volume was calculated according to Clifford (1969).

RESULTS AND DISCUSSION

Stream environment.—Dissolved oxygen was above 100% saturation at all times, ranging from 107-154% (9-15 mg/liter). Hydrogen ion concentration fluctuated from *p*H 7.0-7.5; the average was 7.3. Carbon dioxide content values were 20-45 mg/liter, alkalinity values were 34-68 mg/liter and total hardness values were 68-120 mg/liter. Water temperatures ranged from 5 C in January to 26 C in July. Ambient air temperatures during stream sampling ranged from −0.6 C in January to 30.6 C in May and June.

Development of nymphs.—Based on nymphal head capsule widths, *Ephemerella funeralis* has a univoltine life cycle (Fig. 1). Eggs hatched when water temperatures were highest, beginning in late June. Nymphs collected in July and August were almost fully formed, resembling mature nymphs except for lack of sexual dimorphism. They grew most rapidly from July through December (Fig. 1) when water temperatures were steadily falling. This partly conforms with Ulfstrand's (1967) observation that leaf consumers grow rapidly during the autumn and winter. The apparent size decrease from December to January probably is a result of too small sample sizes; only 16 nymphs were collected in December and 17 in January. Nymphs grew little from January through April as temperatures increased. Allochthonous leaf detritus, which served as the major food for nymphs, was abundant and of good quality throughout the autumn. This allowed the nymphs to attain penultimate dimensions, despite falling temperatures. Food abundance and quality declined during the winter and spring months.

Food habits and preference of nymphs.—Examination of foreguts indicated that *Ephemerella funeralis* was almost exclusively a detritivore with diatoms and filamentous algae serving as incidental food sources. Deciduous leaves contributed most to the detrital material. Diatoms were a small-to-medium part of the diet for later instar nymphs, and were seldom consumed by early instar nymphs. Except for the relative composition of ingested food, this diet corresponded with the feeding regimen of a western species of *Ephemerella,* as reported by Chapman and Demory (1963).

In the laboratory, nymphs preferred some leaves to others. Sugar maple, buckeye and tupelo were 100% skeletonized; hickory, 90%; slippery elm, 50%;

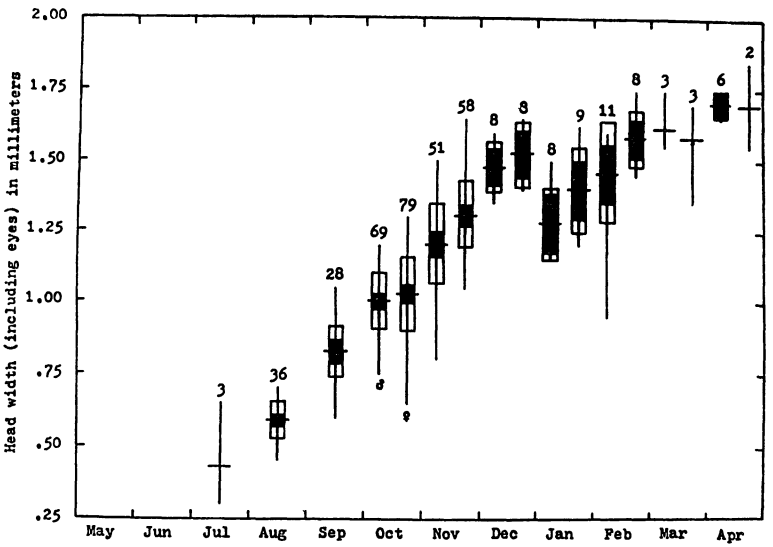

Fig. 1.—Monthly variation of head widths of *Ephemerella funeralis* nymphs taken from unnamed branch of Hisey Fork of Fourpole Creek, Cabell Co., W. Va., May 1974 through April 1975. Vertical lines = ranges; horizontal lines = means; dark rectangles = 2 SE of the mean; open rectangles = 1 SD from the means; and numbers = sample sizes.

and yellow poplar, 10%. Sycamore, beech, chestnut oak and black oak were not used. This experiment suggested that forest composition might determine *Ephemerella funeralis* distribution, other factors being similar. Except for yellow poplar, leaf types rejected were those which normally are slow to decompose, possibly due to heavy cuticles.

Low pH tolerance of nymphs.—A TL_m96 *p*H value of 3.1 was determined for mature nymphs. This value was unexpected, since mayflies are considered to be indicators of good water quality (Leonard and Leonard, 1962). The environmental *p*H for *Ephemerella* species is generally near neutral to slightly alkaline (Wright and Berner, 1949; Gaufin, 1959; Stern and Stern, 1969). Warner (1971) took *Ephemerella* nymphs from Roaring Creek in eastern West Virginia where *p*H ranged from 3.1 to 6.6. Bell (1971) reported a 30-day TL_{50} of *p*H 5.38 for *E. subvaria* McDunnough and suggested that mayflies in water with *p*H values lower than 5.3 would be under continual stress and probably would not survive and reproduce.

Sex ratio of nymphs.—Monthly collections of nymphs from October through April yielded 156 males and 167 females. No significant deviation from the 1:1 sex ratio was found at the 0.05 level.

Observations on adults.—The only subimagoes or imagoes seen in the field were several which were reared in an emergence trap in the stream. The first reared subimago emerged 12 May 1975.

Under laboratory conditions (24-27 C) subimagoes survived an average of about 30 hr, after which they either died or developed into imagoes. Imago emergence usually occurred near midday. The imagoes survived an average of about 48 hr.

Egg counts from 10 specimens ranged from 1709 to 3069 eggs per female; the mean was 2227. Eggs were oval, 0.21 mm long and 0.14 mm wide, and had a reticulate chorion; mean volume was 0.002 mm^3. Since adults were apparently on the wing from mid-May through early June, an egg diapause of 5-7 weeks was suggested.

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