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SHORT COMMUNICATIONS

THE LIFE CYCLE OF THE DRAGONFLY *LANTHUS VERNALIS* CARLE FROM A MOUNTAIN STREAM IN SOUTH CAROLINA, UNITED STATES (ANISOPTERA: GOMPHIDAE)

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A year-long program of qualitative sampling at Howard Creek, Oconee County, South Carolina, yielded data on instar sizes and the pattern of larval growth for *L. vernalis*. Head-width size ranges were determined for the last 7 instars. In the final instar, female larvae were larger than male larvae. No final-instar larvae were collected from the stream from April through June. Apparently no penultimate larvae reached the final instar during the early summer. This gap in occurrence of final instars corresponds to the flight season based on literature records from South and North Carolina. Final-instar larvae present from mid-summer on appear to overwinter rather than emerge. The lack of a clear pattern in larval growth implies a mixed voltinism. It is suggested that *L. vernalis* is at least semivoltine with the possibility that some larvae take longer to develop in this cool, unproductive stream.

INTRODUCTION

CARLE (1980) recently described *Lanthus vernalis*, a species previously confused with *L. parvulus* (Sel.). *Lanthus vernalis* is distributed in the eastern United States from Maine to Georgia, and the larvae live in small, cold, pristine streams (CARLE, 1980). What little ecological information is known has been summarized by Carle. He judged from the size classes of larvae he collected that the larval stage is two years long, but no data were presented. The flight season is early, starting in April in South Carolina (WHITE et al., 1980) and in May in North Carolina, Virginia, Pennsylvania, and Massachusetts; it seems to terminate in June or mid-July (CARLE, 1980). Presented here are the first data on instar sizes and the pattern of larval growth for this species.

Duke Power Company plans to construct the Bad Creek pumped storage reservoir in the

mountains of South Carolina that will impact Howard Creek. The late R.L. Green carried out a benthic collecting program in 1976, as part of Duke Power's Howard Creek environmental monitoring effort, that was designed to elucidate the life cycles of *Rhyacophila* species (Trichoptera). We were able to finish his study of *Rhyacophila* (MANUEL & FOLSOM, 1982) and also to obtain larvae of *Pteronarcys scotti* Ricker (Plecoptera) (FOLSOM & MANUEL, in press) and *L. vernalis* from his benthic samples. Thus, four years before *L. vernalis* was described, the largest collection of its larvae that we know of had been made.

METHODS

Larvae were collected from several locations in Howard Creek, Oconee Country, South Carolina (25°'N, 83°00'W) (MANUEL & FOLSOM, 1982; Fig. 1). Howard Creek is a small, cool, mountain stream with a closed canopy of trees and shrubs throughout most of its length. Larvae were found primarily in depositional areas with coarse particulate organic matter. The substrate is mixed sand, gravel, cobble, and bedrock. In 1980, the pH was 6-7, the specific conductance ranged from 5-15 μmhos/cm, and the water averaged 96% oxygen saturation (DYSART et al., 1981). Sampling was conducted from mid-January 1976 to mid-January 1977, and water temperatures during that period ranged from 1-18° C (MANUEL & FOLSOM, 1982).

Qualitative samples were taken with an aquatic dip net having a 471 μm mesh size. Starting in August, a net of 180 μm mesh was also used. All *L. vernalis* larvae were picked from the preserved samples under 2X magnification. Larval head capsule widths were measured using an ocular micrometer, then converted to the nearest 0.1 mm. Although sampling was carried out twice monthly at several locations on Howard Creek, we combined the data from locations and dates within months to provide sufficient numbers of larvae for analysis.

We verified the specific identification of the larvae by comparison with larvae from CARLE's (1980) type series. Voucher specimens are located in the Duke Power Environmental Services Section invertebrate collection. A typical full-grown larva is illustrated in Figure 1. Two of the three larval key characters (teeth of labial palp, median abdominal groove) used by CARLE (1980) were highly variable in the specimens we studied (n>200). Only the density of the dorsal papilliform setae on the third antennal segment was found to be consistent. The following, modified from Carle's key couplet 3, will separate *L. vernalis* and *L. parvulus:*

3 Third antennal segments with dorsal papilliform setae short and dense, disc evenly granulated in appearance ..... **vernalis**

3' Third antennal segments with dorsal papilliform setae sparse, disc unevenly granulated in appearance ..... **parvulus**

RESULTS AND DISCUSSION

The headwidth size range for the last seven instars was determined by examination of the frequency distribution of headwidths (Fig. 2). The final instar (F) was distinctly separated from the others. Divisions between instars F-1 and F--6 were chosen as indicated on Figure 2. Instar F-6 may be a composite with F-7, but there were too few larvae of that size range for a clear determination. Final--instar larvae were sexed based on the presence of male secondary penal structures visible beneath the larval cuticle. Females were found to be larger than males, except for overlap in the 4.4 mm size class (Fig. 2).

The 373 larvae collected were assigned to instars and the percentage of larvae in each instar each month was plotted (Fig. 3). No final instar larvae were collected from April through June. Apparently no penultimate instar larvae reached the

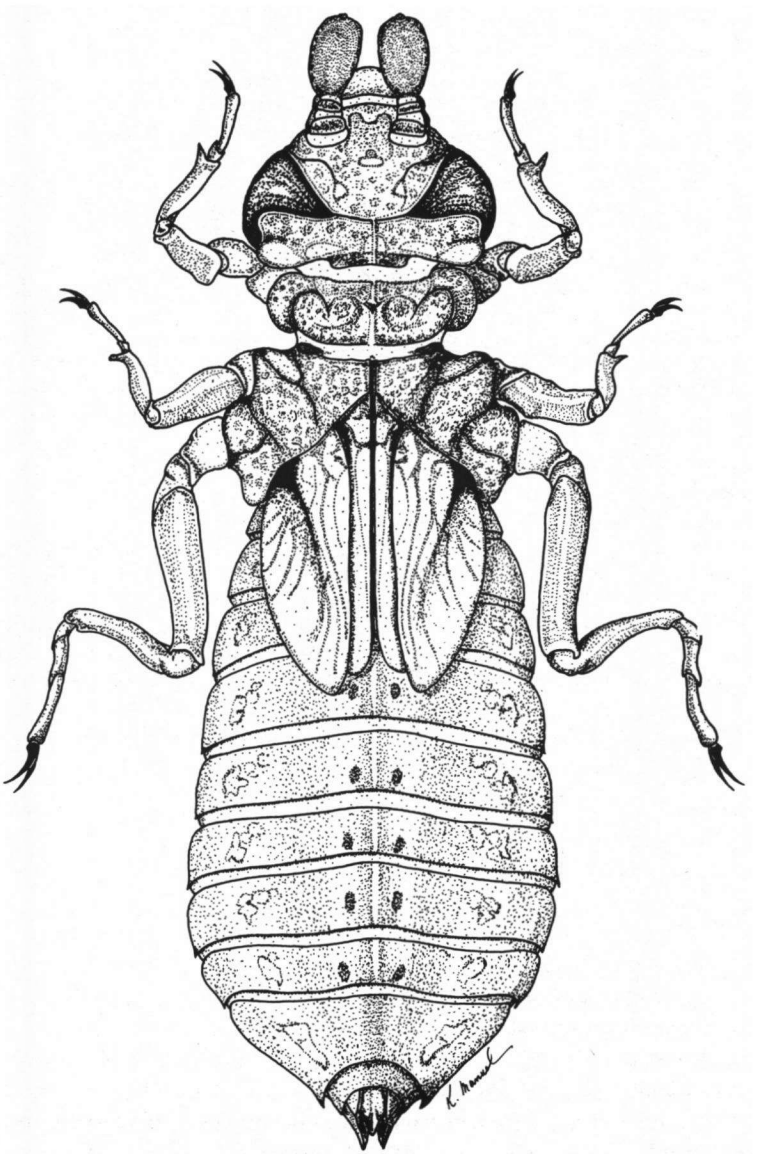

Fig. 1. *Lanthus vernalis* larval habitus. (Body setae omitted).

final instar during early summer. This gap in occurrence of final instars corresponds to the flight season based on North and South Carolina records (CARLE, 1980; WHITE et al., 1980) (Fig.3). Final-instar larvae present from midsummer on appear to overwinter rather than emerge. All other instars collected, except F-6, were present all year.

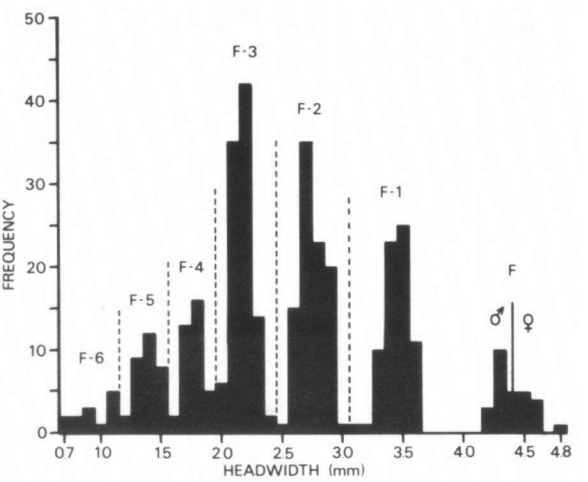

Fig. 2. Frequency of larvae (n=373) in each 0.1 mm head-width size class with divisions into final (F) to F-7 instars.

The occurrence of F-6 larvae from September to December may represent larvae that hatched that summer. If their growth is fast, they may reach F-1 to F-3 the following summer and emerge in their second spring for a semivoltine pattern. The presence of F-6 larvae in April and May, at the start of the flight season, means that these larvae hatched the year before. They cannot emerge until at least the next flight season (semivoltine pattern). If growth is slow, these larvae may overwinter as F-2 to F-4 instars and grow to the final instar in their third summer, overwinter, then emerge in the fourth summer: a three-year larval duration.

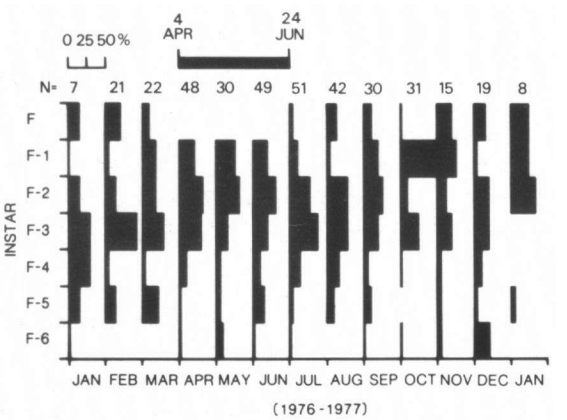

Fig. 3. *Lanthus vernalis:* instar frequency histogram. (N is the number of larvae collected each month. The solid bar represents the adult flight period based on literature records for North and South Carolina).

The lack of a clear pattern in larval growth implies a mixed voltinism. We suggest that *L. vernalis* is semivoltine with the possibility that some larvae take longer to develop in this cool, unproductive stream.

We lack information on the adult flight season and seasonal distribution of the very smallest larvae at Howard Creek. Such data could answer the questions of when hatching occurs and whether final-instar larvae present from July on can emerge that year or must overwinter. It is likely that larval rearing will be necessary to answer the question of voltinism. It is interesting to note that the complex pattern of asynchronous development in *Lanthus* is similar to that of several species of *Rhyacophila* in Howard Creek, which are also predaceous insects (MANUEL & FOLSOM, 1982).

Carle (1979) has suggested that rare species of Odonata have environmental monitoring potential because, in part, many rare species are limited to undisturbed environments and the high vagility of adults insures rapid re-establishment in suitable habitats. *Lanthus vernalis* is rare and apparently limited to pristine habitats, but may not rapidly re-establish after disturbance. In 1976--77, 273 larvae were removed from one upstream stretch of approximately 50 m at Howard Creek. An average of 11 larvae were obtained per sampling occasion, but on one occasion in 1982, four man-hours of sampling yielded only three *Lanthus*. Other sampling efforts at this site in 1982 yielded no larvae. There have been no obvious environmental changes at this site, so this anecdotal evidence suggests that *L. vernalis* may require a very long time to re-establish once a population has been decimated.

The mere presence of a rare species at a formerly disturbed site does not seem sufficient to indicate environmental recovery when chance occurrence cannot be dismissed. Given the intensive effort necessary to quantitatively sample a rare species like *L. vernalis*, it may be appropriate to use a more abundant species for environmental monitoring. Such a species may have the high vagility and population growth rate that would permit rapid re-establishment after environmental recovery.

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