NYMPHAL GROWTH AND DEVELOPMENT OF *EULEUCTRA GENICULATA* STEPHENS, 1835 (Plecoptera: Leuctridae) IN THE SIERRA MORENA MOUNTAINS, SOUTHERN SPAIN

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ABSTRACT

The growth and development of *Euleuctra geniculata* Stephens has been studied under natural conditions in a permanent stream in the Sierra Morena Mountains. Nymphal growth occurs during spring and summer, and nymphs with head width smaller than wing-pad length (final instar) are found in September and October mainly; after the autumnal equinox every nymph collected shows such distinctive shape. Though the duration of the nymphal stage has to be usually less than 1 year, exceptionally some nymphs can spend a second winter and then emerge the following spring. The externally visible changes in the wing pads of the final-instar nymphs were recorded.

INTRODUCTION

In most of watercourses existing in the Sierra Morena Mountains, the flow is interrupted in summer and early autumn; only on some streams like that here studied, because of especial geological conditions in their catchments, always have a current. Most aquatic insects occuping these environments are usually different to those present in seasonal streams, and show distinct strategy in their life cycles.

The stonefly *Euleuctra geniculata* Stephens is widely distributed in central and western Europe and North Africa, and has been found in numerous localities of the Iberian Peninsula (AUBERT, 1963; ILLIES, 1978; PUIG-GARCIA, 1983; SANCHEZ-ORTEGA & ALBA-TERCEDOR, 1987); in the Sierra Morena it only seems to occupy permanent streams with deciduous trees on their banks (PUIG-GARCIA & FERRERAS-ROMERO, 1983).

THE STUDY SITE

The field study was carried out in the Sierra Morena Mountains in a 150 m long section of Bejarano Stream (37° 56'N, 4" 52'W) a permanent watercourse situated about 400 m a.s.l., close to Sta. María de Trassierra, Córdoba. At the sampling site the stream's width is 2-5 m and its mean water depth is 35 - 50 cm. Alder, *Alnus glutinosa* L., elm, *Ulmus minor* Miller, chestnut, *Castanea sativa* Miller, and hazel, *Corylus avellana* L., grow along the banks. The stream contains no fish. On 13 June, 1990 properties of the water were: conductivity 0.5 mS/cm, HCO_3^- 303.78 mg/l, $SO_4^=$ 55.68 mg/l, $CO_3^=$ 30.18 mg/l, Cl^- 14.90 mg/l, Ca^{++} (soluble) 77.66 mg/l, Mg^{++} 24.12 mg/l, Na^+ 11.73 mg/l and K^+ 0.39 mg/l.

E. geniculata was the most common stonefly in Bejarano Stream for the four year when this study was carried out; other stoneflies seen there comprised: *Isoperla* sp and *Leuctra* sp found occasionally (from February to early May and in October, respectively) as nymphs; *Protonemura* sp found once as an male adult (May) and once as a nymphs (March); *Nemoura* sp found once as female adult (early August) and *Hemimelaena flaviventris* (Pictet) found once as a nymph (February).

METHODS

The stream was monitored at regular intervals (at least monthly) from January 1989 to October 1992 (except June and July 1992). At each visit water temperature, measured to the nearest 1/2°C, was recorded between 0900 and 1100 G.M.T.

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Every benthos sample was taken using two different hand nets (390 and 225 cm^2) (mesh size = 0.25 mm) during two hours. In the field, nymphs were fixed in 70% alcohol. Size-frequency distributions of head-width measurements were obtained for each sample. It should be noted that the smaller instars are not adequately sampled by sweep-nets (LAWTON, 1970); therefore, samples during the period when small nymphs are present in the benthos (especially late winter and spring) undoubtedly underestimate the frequency of the small size-classes (see JOHNSON, 1986).

According to ZWICK (1991), in *Leuctra* spp external metamorphosis signs, essentially wing development, appear in the three last instars. In nymphs of final instar, ZWICK (1991) shows for *Leuctra prima* Kempny four steps of morphological changes, useful to detect the successive stages of metamorphosis, from freshly moulted nymph to nearing adult emergence. For the final-instar nymphs these morphological changes have been recorded in present work. So head capsule width, length of meso-thoracic wing pads measurements, and changes in the wing development inside the wing pads in the final-instar nymphs (with head width smaller than meso-thoracic wing-pad length) are characteristics here used as indicators of nymphal growth and development.

RESULTS

The highest water temperature (C°) recorded was 19 (August 21, 1989, September 4, 1990, August 3 and 18, 1992) and the lowest was 10 (January 22, 1992).

From 1989 to 1992, 440 nymphs belong to *E. geniculata* were collected (94, 190, 78 and 78 respectively); one exuvia of final-instar nymph was found on October 12, 1992. No one adult belong to *E. geniculata* was found. Smallest nymphs (head capsule width < 0.75 mm) have been collected in late winter and early spring (from February to April). Nymphs with head capsule width smaller than length of meso-thoracic wing pad (final-instar) have been collected in September and October, except two nymphs (2.1%) on June 4, 1990. No one nymph was found between October and February.

Seasonal variation in head capsule width and presence of nymphs with head capsule width smaller than length of meso-thoracic wing pad are shown in Figs. 1-4. Every year from winter to autumn a practically synchronous growth taken place in nymphal population. 98.9% nymphs with head capsule width smaller than length of meso-thoracic wing pad have got head width between 1.37 and 2.00 mm; only one nymph with head capsule width smaller than length of meso-thoracic wing pad, found on October 10, 1989, has less head width (1.07 mm).

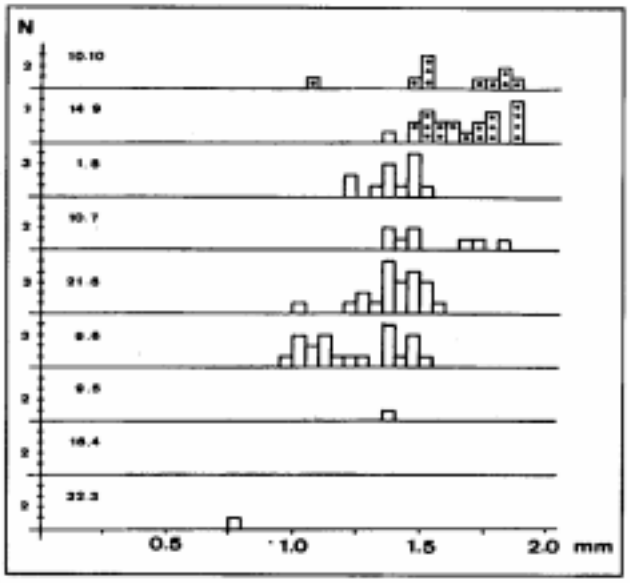

FIG. 1.- E. geniculata, nymphs. Seasonal change of head-width frequency during the year 1989. Frequencies are expressed as number of individuals (N). * nymph with head width smaller than wing-pad length.

FIG. 1.- Variación a lo largo del año 1989 de las frecuencias de anchura de cabeza en las ninfas de E. geniculata. Las frecuencias están expresadas en número de individuos (N). * ninfa con anchura de cabeza menor que la longitud de los estuches alares.

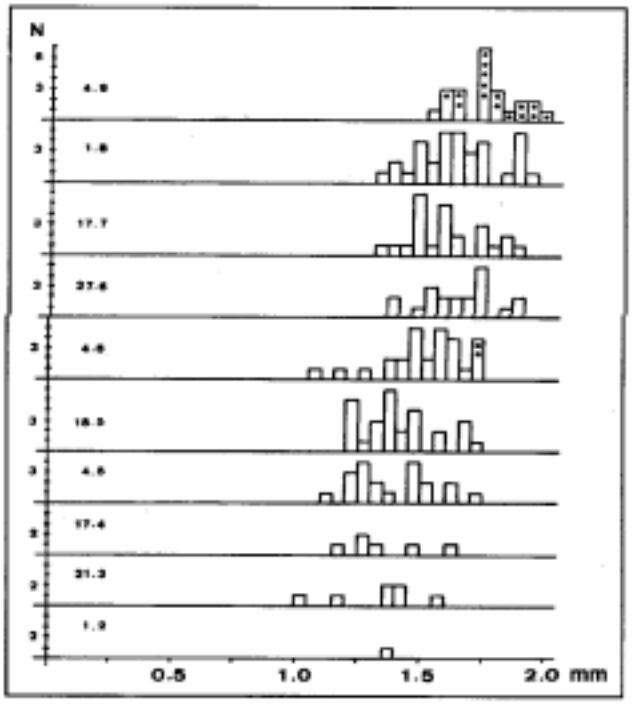

FIG. 2.- E. geniculata, nymphs. Seasonal change of head-width frequency during the year 1990. Details as in Figure 1.

FIG. 2.- Variación a lo largo del año 1990 de las frecuencias de anchura de cabeza en las ninfas de E. geniculata. Símbolos como en figura 1.

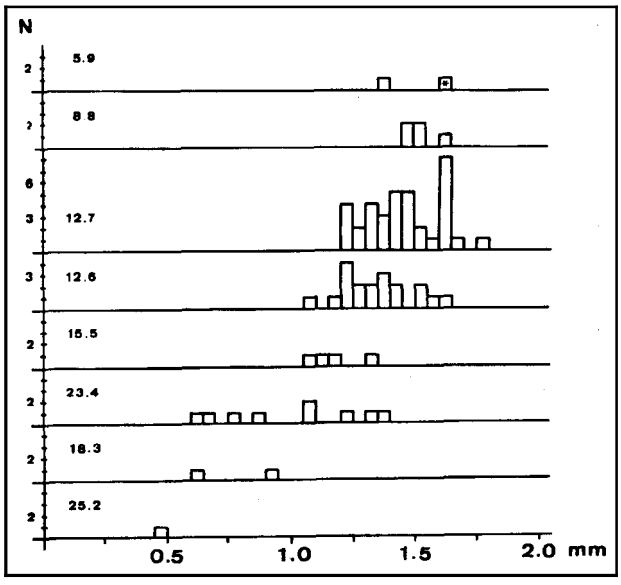

FIG. 3.- E. geniculata, nymphs. Seasonal change of head-width frequency during the year 1991. Details as in Figure 1.
FIG. 3.- Variación a lo largo del aiio 1991 de las frecuencias de anchura de cabeza en las ninfas de E. geniculata. Simbolos como en figura 1.

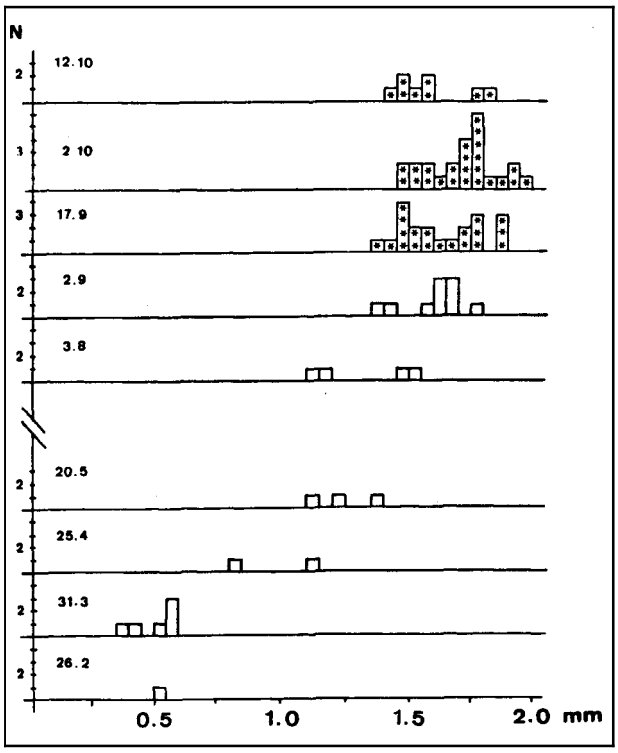

FIG. 4.- E. geniculata, nymphs. Seasonal change of head-width frequency during the year 1992. Details as in Figure 1.
FIG. 4.- Variación a lo largo del año 1992 de las frecuencias de anchura de cabeza en las ninfas de E. geniculata. Símbolos corno en figura 1.

Some nymphs with wing-pad length smaller than head width but this bigger than 1.75 mm were collected from late June to early September (see Fig. 2). After the autumnal equinox (22-23 September) every nymph collected have head width smaller than wing-pad length, they were in final instar.

In every nymph with head width smaller than wing-pad length, we have recorded the step corresponding to distinct morphological changes of wing development inside the wing pads (ZWICK, 1991, page 526). Percentages of nymphs to each step are shown in table I. Nymphs in penultimate and last steps were only collected in samples taken out during October.

Also we have got a set of ten nymphs (M. T. Aguayo-Corraliza leg.) belong to E. *geniculata* collected from Bejarano Stream on May 3 and 20, 1987; six and four nymphs respectively. Their head capsule widths are between 1.47 and 1.95 mm. Except the smallest (3 nymphs collected on May 3), these nymphs show head width smaller than wing-pad length; the three nymphs of final instar collected on May 3 are in penultimate step; in nymphs collected on May 20, three are in penultimate step and one in last step of wing development inside the wing pads. All these ten nymphs are notably more dark than nymphs with these sizes collected by us from 1989 to 1992.

Table I. Nymphs with head capsule width smaller than wing- pad length: percentages for each morphological step of wing development inside the wing pads (ZWICK, 1991). N, sample size; n, number of nymphs with head capsule width smaller than wing-pad length.
Tabla I. Porcentajes de ninfas con anchura de cápsula cefálica menor que la longitud de los estuches alares para cada una de las etapas morfológicas de desarrollo alar descritas por ZWICK (1991). N, tamaño de la muestra; n, número de ninfas con anchura de cápsula cefálica menor que la longitud de los estuches alares.

Data	N	n	Step 1	Step 2	Step 3	Step 4
14.09.89	20	17	–	100.0	–	–
10.10.89	10	10	–	30.0	70.0	–
04.06.90	28	2	100.0	–	–	–
04.09.90	23	16	–	100.0	–	–
05.09.91	2	1	–	100.0	–	–
17.09.92	20	20	90.0	10.0	–	–
02.10.92	24	24	37.5	29.2	33.3	–
12.10.92	8	8	–	12.5	50.0	37.5

DISCUSSION

In Galicia (NW Spain) E. *geniculata* is a species with wide vertical and longitudinal distribution (MEMBIELA-IGLESIA, 1984, 1991) and, as in other areas of Iberian Peninsula (AUBERT, 1963), autumnal flight period. In Catalonian rivers (NE Spain) it appears associated to calcareous areas and its nymphal development occurs during the summer (PUIG, 1984). In Sierra Morena (SW Spain) its distribution seems restricted to perma-

nent streams of middle size with decidous trees on their banks (PUIG-GARCIA & FERRERAS-ROMERO, 1983).

According to our results, in southern Spain ***E. geniculata*** has univoltine life history, and nymphal growth on the stream bed during spring and summer. Its emergence period have to be autumnal mainly, although a small first wave of emergence could occurs during the summer (Fig. 2).

On the other hand, dark, quite big nymphs found in May 1987 suggest that, at less occasionally, a part of nymphs which in autumn are in penultimate and final instar, instead of carry out the adult molt, can have a developmental retardation (splitting of year-class cohort), such that they are destined to overwinter as nymph, perhaps in a state of quiescence, and then emerge the following spring.

Life-history pattern shown by ***E. geniculata*** in the Sierra Morena Mountains is not similar to the patterns known for other stoneflies in southern Spain (SANCHEZ-ORTEGA & ALBA-TERCEDOR, 1988, 1990, 1991; PUIG ***et al.***, 1990a). In this study no one nymph was found between late autumn and early winter. Egg diapause has been demonstrated in Plecoptera, but is not as common as direct development (BRITTAIN, 1990). So either in southern Spain ***E. geniculata*** is a species with overwintering egg, or, more probably, smallest, just hatched nymphs spend the winter in hyporheic zone. In NE-Spain, the life history of *Leuctra fusca* (L.) has been studied by PUIG ***et al.*** (1990b). This species spends a major part of its nymphal cycle in the hyporheos; nymphs are only captured in the benthos from July to September, always large specimens; and adults in September and October. Life history of ***E. geniculata*** in southern Spain could be very similar to that one showed by *L. fusca*.

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