

**PRELIMINARY DATA ON THE LIFE HISTORY OF *CERCION LINDENI*
(SELYS) IN SOUTHERN SPAIN (ZYGOPTERA: COENAGRIONIDAE)**

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A preliminary study of larval development in *C. lindeni* was carried out in 3 streams in the Sierra Morena, southern Spain; 2 of them are regulated rivers. In the area studied, this sp. is bivoltine. The final instar was not encountered after September or before January. Metamorphosis occurs in winter-spring and also in summer. The relationship between developmental stage and larval head width varied seasonally in the populations analyzed. Final-instar larvae contributing to the first wave of emergence were larger than those contributing to the second wave.

INTRODUCTION

Life histories of odonates have been analyzed using different body measurements of larvae. Head width, wing-sheath length, hind tibia and body lengths are those most used. However, averages for such variables can not be used in populations with asynchronous development (BENKE, 1970). Also, head width and wing-sheath length, within a particular instar, have been found to vary between sites (PICKUP et al., 1984). Within a given site, head width and body length within an instar can vary seasonally (INGRAM & JENNER, 1976; PRITCHARD & PELCHAT, 1977). It has long been recognised by some odonatologists that the number of larval instars can vary among larvae from the same batch of eggs; and, therefore, except at the beginning and end of larval life (CORBET, 1957a, 1957b), it is not useful to assign a number to an instar. As a result several authors have used instead the designations: F-0, F-1, F-2 etc., where F-0 is the final instar and F-1 is the penultimate instar (LUTZ, 1968; PAULSON & JENNER, 1971). In order to overcome such difficulties, developmental stages can be defined by the relative size of the wing-sheaths (see BAKER 1986).

The present paper discusses the results of a preliminary study of the life history

of *Cercion lindeni* (Sélys) in three rivers in southern Spain. The species ranges from northern Africa to Central Europe and is usually considered to be univoltine (see D'AGUILAR et al., 1987); its larvae live in slow streams, ponds and reservoirs (AGUESSE, 1968; ASKEW, 1988). In the area studied, the flying season extends from mid-March until September, and occasionally until October (FERRERAS-ROMERO, 1982); in the more northerly part of its range (GERMANY), the flight period extends only from the end of June until early September (BEUTLER, 1982).

STUDY AREA AND METHODS

The field study was carried out in three tributaries of the Rio Guadalquivir in the Sierra Morena, two of which are regulated. Two localities were selected on the regulated Rio Retortillo (60 m above m.s.l.; 37°43' N, 5°18' W) (site A) and Rio Guadiato (80 m above m.s.l.; 37°49' N, 5°03' W) (site B), and two more sites on the non-regulated Rio Yeguas: Montoro (200 m above m.s.l.; 38°02' N, 4°22' W) (site C) and Azuel (550 m above m.s.l.; 38°22' N, 4°19' W) (site D). The width of the stream channels varied from 10 m at Rio Yeguas-Azuel to about 30 m elsewhere. These stations were monitored for

Table I
Seasonal variations of water temperature and dissolved oxygen levels at sites A-D

Sampling dates	Water		Water	
	temperature (°C)	Oxygen (mg/l)	temperature (°C)	Oxygen (mg/l)
	(A) Rio Retortillo		(B) Rio Guadiato	
Nov. 10, 1977	13.0	6.0	16.0	6.2
Dec. 14, 1977	12.5	6.0	16.0	6.1
Jan. 24, 1978	11.0	6.9	11.0	7.2
Feb. 14, 1978	10.0	6.7	12.0	7.7
Mar. 9, 1978	14.5	6.7	17.0	7.3
Apr. 10, 1978	15.5	7.4	15.5	8.3
May 11, 1978	18.0	5.4	19.0	6.1
Jul. 3, 1978	21.5	4.2	25.0	4.9
Aug. 24, 1978	23.0	6.6	25.0	7.0
Oct. 6, 1978	17.0	5.2	19.0	6.8
	(C) Rio Yeguas-Montoro		(D) Rio Yeguas-Azuel	
May 25, 1983	20.0	7.0	22.0	6.8
Jun. 29, 1983	27.0	6.8	19.0	6.0
Jul. 27, 1983	25.0	7.9	24.0	3.0
Aug. 31, 1983	23.0	7.2	18.0	6.2
Sep. 30, 1983	24.0	8.5	20.0	7.4
Oct. 31, 1983	18.0	10.8	12.0	9.8
Nov. 29, 1983	15.0	8.7	11.0	9.5
Dec. 27, 1983	13.0	9.7	10.5	10.4
Jan. 28, 1984	12.0	11.4	9.0	11.5
Feb. 28, 1984	11.0	9.3	4.0	11.4
Mar. 30, 1984	16.0	7.9	10.0	9.1
Apr. 30, 1984	16.5	7.6	15.0	8.1

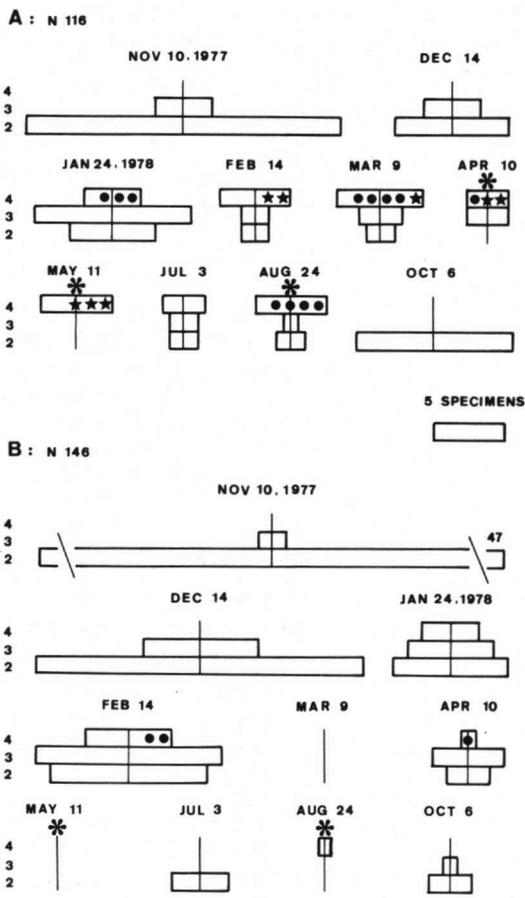


Fig. 1. *C. lindeni*: developmental stage-frequency distribution in regulated streams at sites A and B. N: sample size; — *: adults captured; — •: larvae with the distal ends of the fore wing-sheaths visible when viewed dorsally, the first external sign that metamorphosis has begun, interecdysial stage W.2; — ★: larvae showing advanced metamorphosis, interecdysial stages W.3 and W.4 (CORBET & PROSSER, 1986).

successive stages of metamorphosis; such stages are shown in the frequency distribution presented. The histograms of larval head width (BENKE, 1970) and of seasonal variation of head width frequencies with indication of developmental stages were calculated. Concurrent values of temperature (measured in the dark) and dissolved oxygen of water are presented in Table I.

one year at regular intervals (see Tab. I).

Larvae were collected by hand net (mesh size = 1 mm measured along one side of the square aperture), and identified according to CARCHINI (1983). Only those of late instars (F-0 to about F-5) were considered for this preliminary study. Larvae pertaining to the first few instars were not collected due to the mesh size. In the laboratory the head width (maximum across the eyes) of each larva was measured to the nearest 0.06 mm, using a binocular microscope with an eyepiece micrometer. The sex and relative length of the wing-sheaths were also noted.

Frequency distributions of developmental stages (BAKER, 1986) were calculated. Following Baker, larvae were classified into four developmental stages. For *C. lindeni*, stage-1 larvae had no wing-sheaths (none in this study); stage-2 larvae had metathoracic wing-sheaths that did not reach past the posterior end of abdominal segment 1; stage-3 larvae had metathoracic wing-sheaths extending past the posterior end of segment 1 but not as far as the posterior end of segment 3; stage-4 larvae were in the final instar, the wing-sheaths reaching the posterior end of segment 3 or the beginning of segment 4.

In larvae of the final instar, externally visible changes in the wing-sheaths (e.g. CORBET & PROSSER, 1986) are useful to detect the onset as well as

RESULTS

Figures 1 and 2 show stage-frequency distributions of larvae in stages 4 to 2 at all sites studied. By early October no final-instar larvae were found at any site. A few larvae attained stage 3 in the autumn and by the end of November there were

larvae in stages 3 at all sites.

The appearance of larvae in stage 4 (final instar) is not synchronous at all localities; F-0 larvae first appear in January in warm waters (sites A-B), but in the cold locality (site D) they first appear in March.

Observation of changes in the wing-sheaths in F-0 larvae (sites A, C, D) and of the presence of adults (site B) permits the inference that a first wave of emergence occurs between March and June, and a second wave of emergence between the end of July and the beginning of September. Possibly, the phenology is similar to that described for *Enallagma aspersum* (Hag.) in North Carolina by INGRAM & JENNER (1976). In that population the first emergence group consisted of larvae that had hatched the previous summer, overwintered, and emerged approximately one year after hatching; the second

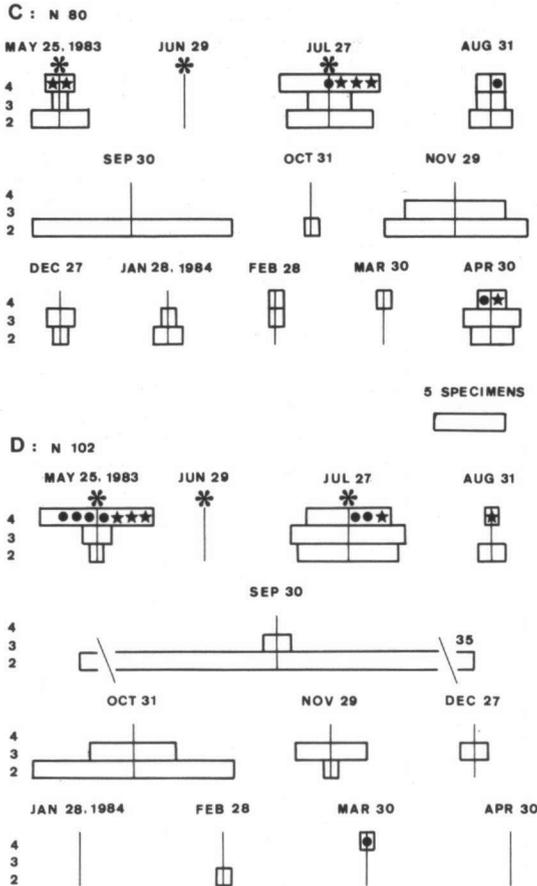


Fig. 2. *C. lindeni*: developmental stage-frequency distribution in sites C and D. — Details as in Figure 1.

group consisted of individuals that had hatched in spring from eggs laid by the earliest emerging adults, had grown rapidly and, within a single summer, had completed development and emerged; in the other members of this same generation a developmental retardation occurred, such that they were destined to overwinter and then emerge the following year.

Figures 3 and 4 show the frequency histograms of head widths for each site. Sizes between 2.90 and 3.02 mm are attained as often by F-0 larvae (S 4) as by those of the preceding stage (S 3). The results of collection of final-instar larvae are given in detail in Table II. The head width of F-0 larvae collected during

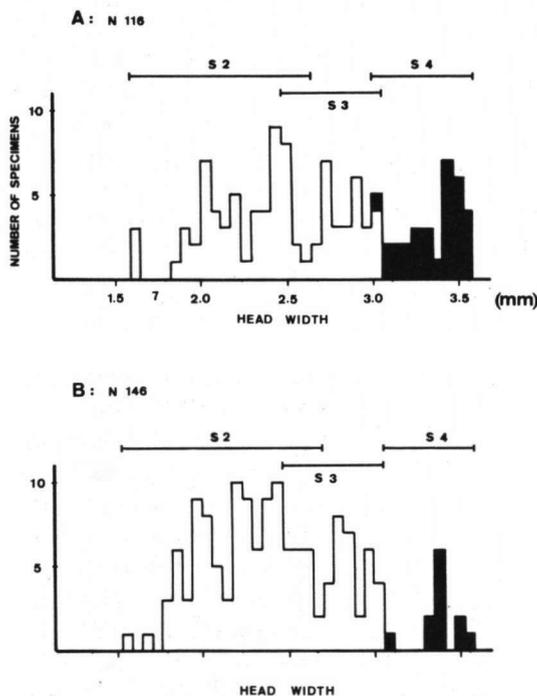


Fig. 3. *C. lindeni*: histograms of head widths and size intervals in different developmental stages (S₂-S₄) at sites A and B. — Shaded area: F-0 larvae.

January to May is greater (3.32-3.56 mm for 96% of the larvae) than that of F-0 larvae collected during July and August (2.90-3.26 mm for 100% of the larvae). When developmental stages and head-width frequency are grouped in size classes (class width 0.178 mm, three micrometer units), in every population seasonal variations in head width are observed (Figs 5-8). The F-0 larvae during winter to spring fall in the two upper classes (12-13), except for one larva in class 11. Those from summer mainly fall in classes 10 and 11, only two larvae (collected on 3 July) being in class 12. Likewise, stage-3 larvae collected during autumn to winter have, in general, head widths in classes 8-10 (2.50-3.02 mm), but the larvae of this same stage collected during summer have smaller head widths (2.31-2.66 mm), and fall in classes 7 and 8. Only from the cold locality of site D were there as many stage-3 larvae of class 7 captured in autumn to winter as in summer (Fig. 8).

DISCUSSION

In southern Europe bivoltine or multivoltine life cycles are common in several species. In southern France, *Ischnura pumilio* (Charp.) and *I. elegans* (Vander L.) have, respectively, two and three generations per year (AGUESSE, 1955). *I. graellsii* (Ramb.) has two generations in northwestern Spain (CORDERO-

Table II
C. lindeni: dimensions and numbers of final-instar larvae collected at sites A-D

Site	Date	N	Head Width	
			\bar{x}	Range
(A) Río Retortillo	Jan. 24, 1978	4	3.47	3.38-3.56
	Feb. 14	5	3.47	3.32-3.56
	Mar. 9	6	3.44	3.26-3.56
	Apr. 10	3	3.34	3.14-3.44
	May 11	5	3.43	3.32-3.50
	Jul. 3	3	3.24	3.20-3.26
	Aug. 24	5	3.10	3.02-3.20
(B) Río Guadiato	Jan. 24, 1978	4	3.48	3.38-3.56
	Feb. 14	6	3.36	3.32-3.38
	Apr. 10	1	3.38	—
	Aug. 24	1	3.08	—
(C) Río Yeguas-Montoro	May 25, 1983	2	3.44	3.38-3.50
	Jul. 27	7	3.02	2.96-3.08
	Aug. 31	2	2.93	2.90-2.96
	Feb. 28, 1984	1	3.32	—
	Mar. 30	1	3.38	—
	Apr. 30	2	3.35	3.32-3.38
(D) Río Yeguas-Azuel	May 25, 1983	8	3.48	3.38-3.56
	Jul. 27	6	3.06	2.96-3.14
	Aug. 31	1	3.08	—
	Mar. 30, 1984	1	3.56	—

-RIVERA, 1987), and up to three in southern Spain (MONTES et al., 1982). In southern France *Sympetrum fonscolombi* (Sél.) is bivoltine (AGUESSE, 1968), and in southern Spain it many have three generations per year (MONTES et al., 1982). *Crocothemis erythraea* (Brullé) has two generations per year in southern France and southern Spain (AGUESSE, 1960; MONTES et al., 1982). Also bivoltinism may occur in several populations of *Sympetrum striolatum* (Charp.) from southern Spain (TESTARD, 1972).

In Sierra Morena *C. lindeni* has a bivoltine life cycle; each year adults from two different generations fly successively. The emergence period is prolonged by rapidly growing individuals whose larval development is completed in a single summer, and that emerge in late summer.

The occurrence of several growing "types" characterized by a particular number of instars is, apparently, a frequent occurrence in odonates (PELLERIN & PILON, 1977; RIVARD & PILON, 1977; FONTAINE & PILON, 1979; PILON & MASSEAU, 1983). At a single locality the length of the life history may vary among members of the same species, in Zygoptera as well as Aniso-

ptera (e.g. CORBET, 1957; NORLING, 1984).

In the present study the demonstration of bivoltinism in *C. lindeni* is based on seasonal variation in head width of larvae from all populations investigated. According to INGRAM & JENNER (1976), seasonal variations in head width should be related to the number of larval moults.

The greater head width of overwintering larvae (first wave of emergence) may be caused by extra moults; the smaller sizes of the summer larvae (second wave of emergence) may be related to the absence of extra moults.

The existence of different growth patterns between species of odonates presumably reflects the action of adaptive factors (AGUESSE & TESTARD, 1967); in the same way, the occurrence in populations of one species of different growth rates may be considered as an adaptation to environmental changes in the habitat. During the year rivers in southern Spain show very marked changes with respect to many fluvial and biological parameters (temperature, flow, dissolved oxygen, primary production etc.).

These variations may be related to the existence of bivoltinism in *C. lindeni*. This strategy may be very useful for the development of populations that are occupying regulated rivers.

Detailed studies with concurrent laboratory investigations are now needed. Additionally, because of the wide distribution of *C. lindeni*, which is very common in rivers in the Iberian Peninsula, more information on possible variations of the life history in populations from different latitudes would help to place the present result in a broader context.

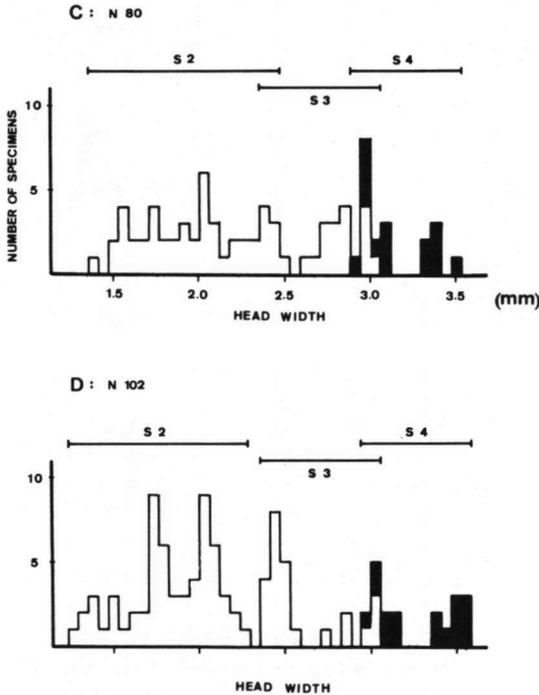


Fig. 4. *C. lindeni*: histograms of head widths and size intervals in different developmental stages (S_2 - S_4) at sites C and D. — Shaded area: F-0 larvae.

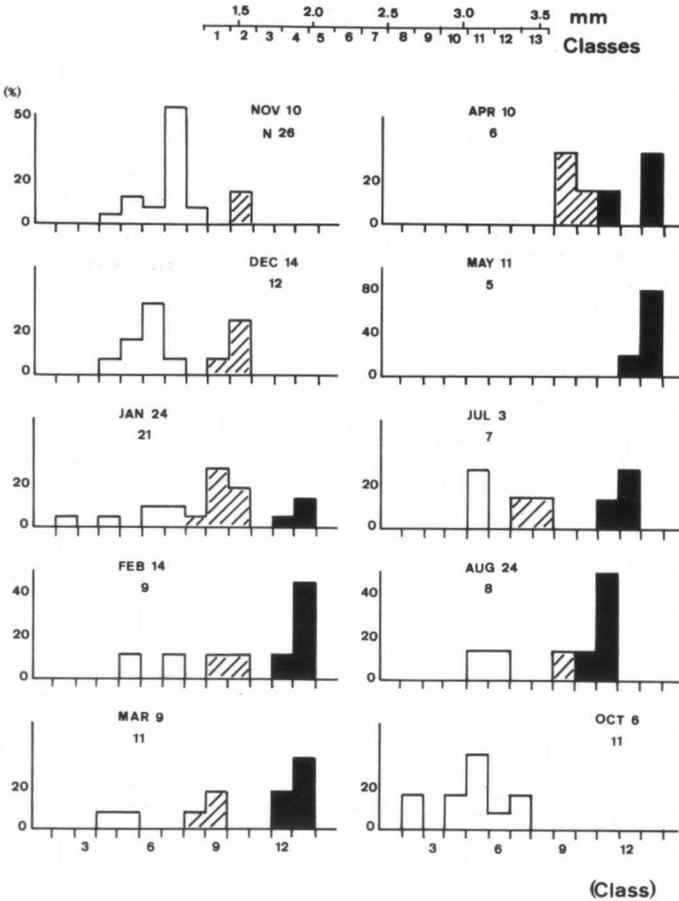


Fig. 5. *C. lindeni*: seasonal change of head-width frequency at site A. Frequencies are expressed as percentages of different size classes. — Dark bars: stage 4 (= final instar); — hatched bars: stage 3 (= F-1 and F-2 instars); — clear bars: stage 2 (= smaller instars).

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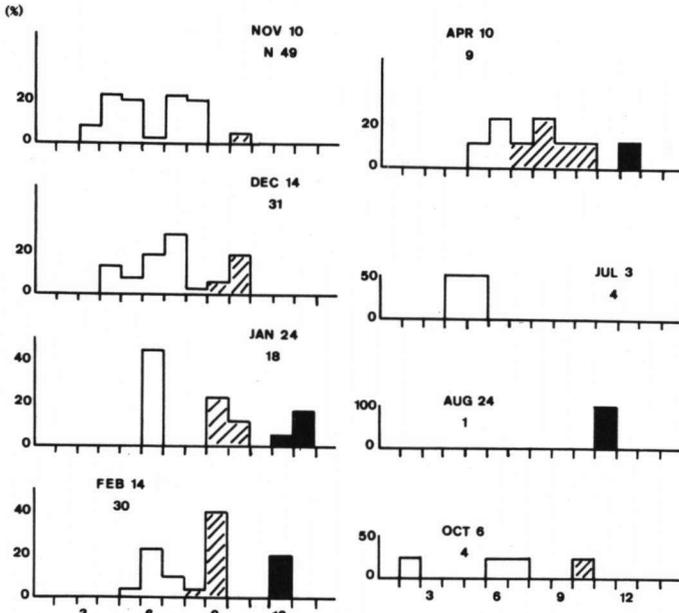


Fig. 6. *C. lindeni*: seasonal change of head-width frequency at site B. — Details as in Figure 5.

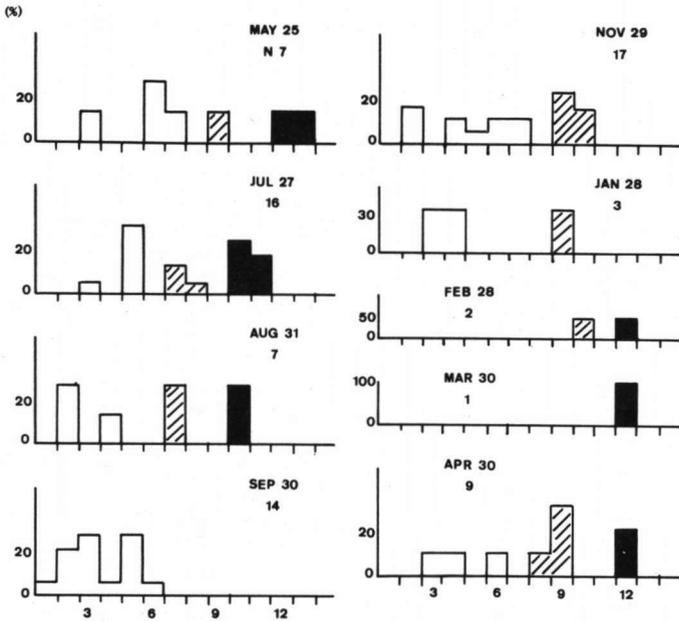


Fig. 7. *C. lindeni*: seasonal change of head-width frequency at site C. — Details as in Figure 5.

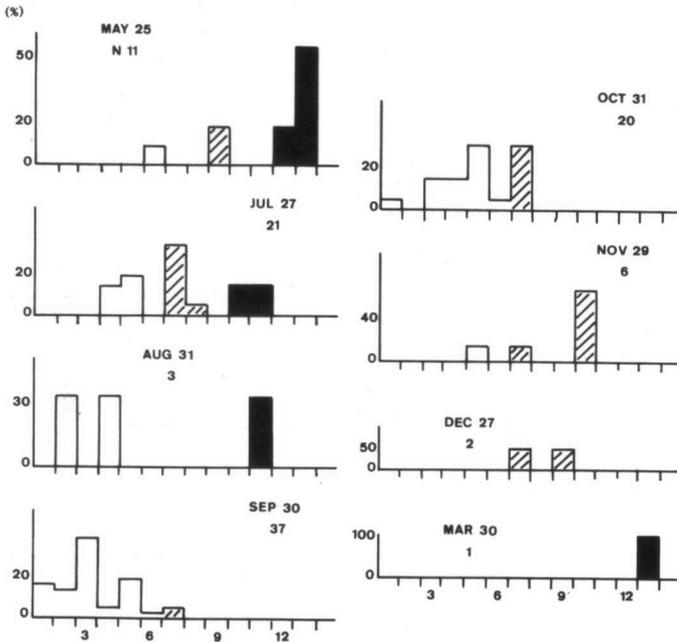


Fig. 8. *C. lindeni*: seasonal change of head-width frequency at site D. — Details as in Figure 5.

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