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SHORT COMMUNICATIONS

FOOD AND TIME RESOURCE PARTITIONING IN TWO COEXISTING *LESTES* SPECIES (ZYGOPTERA: LESTIDAE)

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Two coexisting populations of *Lestes virens* (Charp.) and *L. barbarus* (Fab.) at a temporary pond were studied in 1979 and 1980 to investigate a possible partitioning of time and food resources. Results show that larval diets are affected by larval size in both species. Since the life cycles of the two species are displaced, it is concluded that such displacement facilitates coexistence by reducing food competition.

INTRODUCTION

Although many studies have been carried out to describe lestid autecology, little information exists on the ecological relationships among coexisting species in natural conditions. This paper reports on investigations into resource partitioning between two coexisting *Lestes* species, i.e. *L. virens* (Charp.) and *L. barbarus* (Fab.).

The fact that the two species are morphologically very similar, live in a small pond which contains water for only a short period, where no other Zygoptera exist and where there are fewer predators than in permanent habitats, would imply a remarkable overlap of respective niches. The fact that the two *Lestes* populations are abundant and well-established is, therefore, to be ascribed to mechanisms that make coexistence possible. On the basis of works by BENKE & BENKE (1975), JOHANNSSON (1978) and JOHNSON & CROWLEY (1980), these mechanisms are thought to consist of spatial, temporal and/or food resource partitioning.

On account of the study pond's small dimensions and environmental homogenity, spatial separation may be excluded a priori. Field observations supported our decision to make such an exclusion. Hence, time and food resources only are examined here.

MATERIAL AND METHODS

Observations were made and specimens taken from temporary autumnal pond (sensu WIGGINS et al., 1980) approx. 50 m above sea level, within a well-preserved natural oak wood on the Presidential Estate at Castel Porziano near Rome, Italy. Water is generally present between December and June. In January the basin reaches a maximum diameter of about 40 m and a maximal depth of 1 m. Emerging vegetation is mostly *Juncus effusus* and *J. articulatus* along with *Polygonum hydropiper, Alisma plantago* and *Carex* sp. The pond and its dwellers have already been monitored for a number of years during the course of other ecological and faunistic studies in the area (e.g. CONSIGLIO, ARGANO & BOITANI, 1974; UTZERI, FALCHETTI & CONSIGLIO, 1977).

Collections were taken using a 0.25 mm mesh-size hand net. Seven samples were taken at fortnight intervals from March to June in 1979, and nine for the same period in 1980. Larvae were isolated into separate containers in the field and then taken to the laboratory where they were numbered, identified, measured and grouped into five head-width classes: I=0.25-1.25; II=1.26-2.25; III=2.26-3.25; IV=3.26-4.25; V=4.26-5.25 (all ranges are in mm). Larvae were then kept in isolation, fasted for four days and then returned to the pond. The fecal pellets produced were fixed in 80% alcohol, mounted on microscope slides and then examined at 400 X magnification.

Fecal pellet analysis results were studied by the "occurrence method" (HYSLOP, 1980). Food overlap was evaluated using Pianka's Overlap Index (PIANKA, 1974).

OBSERVATIONS

In 1979, 224 *L. barbarus* and 44 *L. virens* larvae were collected. Totals for 1980 were 170 and 213 larvae, respectively.

LIFE CYCLES

The 1979 and 1980 growth patterns for the two species are shown in Figures 1 and 2. *L. barbarus* developed earlier than *L. virens* in both years, its youngest

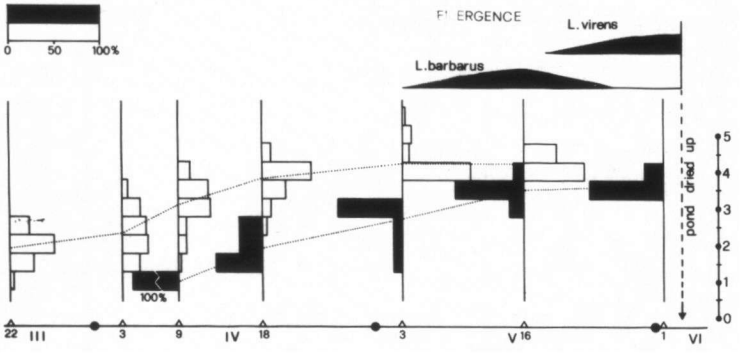

Fig. 1. Growth of *Lestes virens* and *L. barbarus* in 1979. Dark histograms: *L. virens;* — white histograms: *L. barbarus.* (Dashed line: mean larval sizes in each sample; — Abscissa: relative frequencies per sample; — Ordinate: head width in mm; — Emergence: semi-quantitative description).

larvae appearing in February (quantitative data not available for Feb. 1979). Egg--hatching presumably occurred in January; no *Lestes* larvae were detected in the pond in December (21/XII). Larval development in *L. barbarus* lasted approximately three months in both years, from February to May. Emergence occurred in May, lasted about one month, and was not affected by pond dry-up.

The youngest larvae of *L. virens* appeared for the first time in early April, about two months later than those of *L. barbarus*. In the studied population of this species, larval development lasted about two months (from April to June) in 1979, and about three months (from April to July) in 1980. In both years, emergence began in mid-May, ending in early June in 1979, and in early July in 1980. Larval development and emergence in *L. virens*, therefore, appear to be affected by pond water regime.

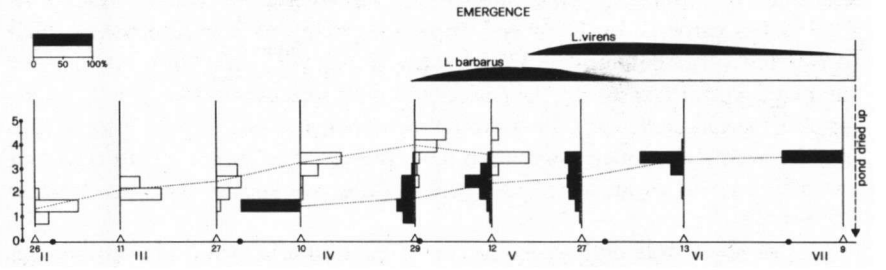

Fig. 2. Growth of *Lestes virens* and *L. barbarus* in 1980. Explanation as in Figure 1.

The coexistence period between the two *Lestes* species lasted about 40 days in both years. Each species spent more than half of its larval life with no direct competitors; this being the result of a life cycle displacement of about two months at the time of egg hatching. Displacement does, however, drop to about 20 days at the time of emergence. Larval sizes of coexisting *L. barbarus* and *L. virens* differed, but less so with time, as may be seen in Figures 1 and 2.

DIETS

Fecal pellet analysis is available for 1979 only. Of all larvae collected, only 173 *L. barbarus* and 38 *L. virens* individuals were found to have deposited fecal pellets. For both species, the most frequent preys were: Cladocera, Copepoda, Rotifera, Chironomidae and Ostracoda. Few remains of Acarina or unidentified insects were found in four pellets only. Isopoda, Heteroptera, Coleoptera and Culicidae, although abundant in the pond, did not appear to have been preyed upon. Lestidae larval remains were found in two pellets only. In both cases, the predator was *L. barbarus*, and at least the first event was cannibalistic as it occurred in a sample when *L. barbarus* alone was present in the pond.

Table I

Prey items in fecal pellets of *L. barbarus* and *L. virens* larvae. (Overlap values by Pianka's index)

Sampling dates	22/III	3/IV	9/IV	18/IV		3/V		16/V		1/VI	All dates	
Species	*L.b.*	*L.b.*	*L.b.*	*L.b.*	*L.v.*	*L.b.*	*L.v.*	*L.b.*	*L.v.*	*L.v.*	*L.b.*	*L.v.*
Total number of pellets examined	19	50	21	43	8	29	11	11	17	2	173	38
No. of pellets containing items of:												
Cladocera	13	44	21	43	7	28	11	8	16	2	157	36
Copepoda	16	44	21	38	5	27	10	5	11	2	151	28
Rotifera	1	22	0	1	5	1	0	0	3	0	25	8
Chironomidae	0	24	7	35	5	21	10	3	9	2	90	26
Ostracoda	0	0	0	2	0	9	0	7	9	1	18	10
Overlap values				*0.44*		*0.50*		*0.72*			*0.94*	

Table I compares *L. barbarus* and *L. virens* larval diets independently of larval size. The two extreme right columns give diets as ascertained from analyses of all fecal pellets gathered in the seven samples. Overlapping is seen to be very high (0.94). The other columns in Table I also present data from three of the four samplings performed during the period that both species coexisted (the *L. virens* larvae collected on 9 April, 1979 produced no pellets). The three overlap values may be seen to be much lower than 0.94; they tend to increase with time and the difference in mean larval size between the two species tends to decrease (cf. Fig. 1)

The diets of differently-sized larvae of each species were also compared. However, comparison was not possible for each sample owing, in some cases, to the low number of differently-sized larvae. It was therefore decided to pool data from all seven samples. Results are shown in Table II. Food overlap values indicate that larvae of both species belonging to size classes II and III have very similar diets, whereas larger larvae have more varied diets. Moreover, the diets of

Table II

Prey items in fecal pellets of *Lestes virens* and *L. barbarus* larvae during all samplings. (Overlap values by Pianka's index; cf. text for class definition)

Species	*Lestes virens*			*L. barbarus*			
Size class of larvae	II	III	IV	II	III	IV	V
Total Number of pellets examined	9	13	16	31	51	80	11
No. of pellets containing items of:							
Cladocera	9	13	14	21	48	78	10
Copepoda	5	9	14	26	47	73	5
Rotifera	4	3	1	9	14	2	0
Chironomidae	5	10	11	7	25	50	8
Ostracoda	0	0	10	0	0	16	2
Overlap values	*0.93*	*0.58*		*0.95*	*0.50*	*0.71*	

same-sized larvae in both species are very similar, as shown by respective size-class overlap values (II size class: 0_{bv}=0.90; III size class: 0_{bv}=0.96; IV size class: 0_{bv}=0.90).

These results show that there is considerable similarity in food preferences of the two species but that differences in food choices exist according to body size.

CONCLUSIONS

Both *L. barbarus* and *L. virens* populations are numerous in the study pond where they seem to coexist with no spatial separation. However, inter-species temporal separation and resultant life cycle displacement are reported.

Fecal pellet analysis shows that both species have very similar diets during the larval stage. Detailed examination of prey consumption shows that, during the coexistence period, *L. virens* and *L. barbarus* larvae have considerably different diets when mean larval sizes between species are very different. Furthermore, diet differences diminish when larval sizes are more similar. The positive correlation between predator and prey sizes among Odonata larvae has previously been observed by CHUTTER (1961) and by THOMPSON (1978).

Thus, it may be concluded that life cycle displacement produces size differences between coexisting *Lestes* larval populations. Such size separation gives rise to a food-resource partitioning that probably facilitates coexistence by reducing food competition. A similar coexistence pattern has been hypothesized by JOHNSON & CROWLEY (1980) in a study of an Odonata association in the USA, and supported by CARCHINI & NICOLAI (1983) in a paper on a coenagrionid association living at Castèl Porziano.

In comparing 1979 and 1980 data, it may be observed that *L. barbarus* shows the same growth pattern and the same abundance in both years, whereas *L. virens* was probably decimated in 1979 by the drying up of the pond at the beginning of June, and only completed its emergence in 1980. Thus the delay in growth of *L. virens* involves risks that seem to be compensated for by reduced food competition with *L. barbarus*.

Lastly, as noted by FISCHER (1961, 1967) in studies of *Lestes dryas* and *L. sponsa*, the feeding patterns of *L. barbarus* include some cannibalistic events, but these seem to be of negligible importance. It is however interesting to note that *L. virens* does not show cannibalism, even if the early drying up of the pond in 1979 probably caused an overcrowding of the larval population that could, foreseeably, have accentuated such intraspecific predation.

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