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THE FOOD OF THE DAMSELFLY LARVAE OF A TEMPORARY TROPICAL POND (ZYGOPTERA)

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A study of the food of the damselfly larvae of a temporary tropical pond reveals that the dietary ingredients become more diversified with the size of the larvae. In general, it is difficult to speak of a clear food preference in terms of particle size. The kind of prey captured by the larvae is only partly determined by the size of the larvae and of the prey. The ease in capturing and eating a prey item may result in a preference for smaller prey (chydorid Cladocera) when apparently more attractive bigger prey (midge larvae) are also available.

INTRODUCTION

In the course of a limnological survey of some temporary ponds situated in a tropical savannah environment (region of Lamto, Ivory-Coast), some aspects of the insect fauna of these biotopes were considered. In some, a major fraction of the insect fauna consists of zygopteran larvae, among which *Coenagrionidae* and *Lestidae* are the most abundant (FORGE, 1976). In order to estimate the impact of these larvae on the plankton and benthos communities, I examined their gut contents.

Although it is universally known that dragonfly larvae are predators, remarkably little is known about their diets in natural conditions, and no systematic survey has been carried out to throw light on this question. A temporary tropical environment is extremely suitable for this type of work, since larval development takes place in a short, well-defined time lapse which is synchronous with the production of the prey species.

Warren (cit. CORBET, 1962) studied two Anisoptera and found chironomid larvae to be a major type of prey. CHUTTER (1961) discussed the food of *Pseudagrion salisburyense* as a function of larval size and found a majority of insect larvae (chironomids, psychodids) and some Oligochaeta in the guts. FISCHER (1964) and MACAN (1964) state that damselfly larvae mainly feed on Entomostraca and aquatic larvae of Diptera. DUMONT (1971), in a qualitative survey of a number of small ponds, found a relationship between the richness of the dragonfly fauna and the plankton and benthos. Laboratory work involves data by TENNESSEN & KLOFT (1972), who mention that newly hatched Odonata larvae feed on ciliates and rotifers. JOHNSON (1974), in attempts at raising *Ischnura verticalis*, fed larvae of this species successfully on *Ceriodaphnia reticulata*, a medium-sized cladoceran. HASSAN (1976) carried out feeding experiments with larvae of *Palpopleura lucia* and noticed that, when fed on Cladocera and Copepoda, the total larval development time was shorter than when ostracods or insect larvae were given as food. THOMPSON (1975) used *Ischnura elegans* to obtain an estimate of the attack coefficient and prey handling time, which are two basic parameters of a Holling-type predation equation. Five different larval instars were used, characterized by their head width (which is linearly related to total body length), and five size classes (defined as total body length) of *Daphnia magna* were given for food.

Although, consequently, Entomostraca are widely used in feeding experiments in the laboratory, very little is known about the effect of dragonfly larvae on natural, mixed populations of Cladocera, Copepoda and Ostracoda, which were the groups I was mainly looking for in the gut contents. Other animal groups occurring in the stomacal contents were, however, not neglected and were identified wherever possible (cf. Tab. I).

METHODS

The insect fauna was sampled by pushing a cylinder (section 0.1 m^2) into the pond; the water-volume inside was filtered through a fine net and the animals retained transferred to a container filled with alcohol. Sampling was done at weekly intervals during the inundation periods of the pools (May-December, 1974). Some general features of the pools are given in LAMOOT (1976). The present study is restricted to samples of pond L2 (surface: circa 2000 m^2, maximum depth: 96 cm).

The damselfly larvae, preserved in 70% alcohol, were measured with an ocular micrometer and dissected under a stereo-microscope. Of the digestive tract only the fore-gut was considered, since here prey animals are not damaged and can easily be identified and counted. It was found that, owing to the sequence of sampling, fixation, transportation and sorting, the total length of the animals was most frequently affected (telescopic effects, tortuous bodies, broken-off segments, etc. . . .). Therefore, head-width was selected as a measure of age and size. The relationship of this variable with total body length is linear in *Ischnura* (THOMPSON, 1975) and may perhaps be generalized for all Zygoptera of similar habitus.

In my material, larvae pertaining to several genera and even families occur; the head width classes thus do not correspond to specific developmental stages. In all, I examined about 170 larvae; I tried to have a fairly similar number of specimens in each of the head width classes (minimum 10). Further, the animals studied were taken from samples selected at random from the whole collection made during the inundation period. This precaution was judged necessary, as it is well known that certain plankton species have a mass development over a well-defined but short period of time, and the effect of such blooms on the gut contents could significantly bias the results. Finally, the smallest possible preys (like ciliates) with a thin body-wall, were not detected in the material. However, if present in the diet (which is improbable), they are likely to explode or to become irrecognisable by contraction.

RESULTS

Results are shown in Table I. There is a distinct evolution in the food of the larvae with time. The smallest classes contain relatively many copepodids and small Cladocera; adult cyclopoids become important starting with the 0.8 mm class. Adult calanoids and *Macrothrix* appear in the guts at a head width of 1.2 mm; 2.0 is the threshold for consuming *Diaphanosoma* and *Latonopsis*; insects become attractive beyond the 2.8 mm class. This evolution cannot be described as a drastic change in feeding habits during the growth process; it looks more like a progressive diversification of the diet. A larger larva can capture bigger prey organisms but this does not prevent it from continuing to take little prey items as well. If the preys are described in terms of particle size, the later larval instars gradually take larger particles but remain efficient over most of the range of particles available.

This is in good agreement with THOMPSON's (1975) work on the *Ischnura-Daphnia* system; the largest instar of *Ischnura* still consumed the five size-classes of *Daphnia* offered, without a distinct size-preference; while the smallest instars did well on the smaller *Daphnia* classes, but could not handle the largest size-classes.

Table I also gives an idea of the relative importance of each group of preys. 86.4% of all food organisms are Crustacea Entomostraca and only 9.9% are insects. Among the Entomostraca, 57.7% are Cladocera, 34.4% are copepods and

Table I

Results of the gut analyses

Prey	Head width classes (mm) ⩽0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	⩾3.4	Total in %
Rotifers	1	1	2	1	3	1	2		1		1	2	4				*2.4*
Nauplii	3	1			1												*0.7*
Copepodites	3	7	10	13	7	10	5	5	2	3	13	1	1	1	3	3	*11.6*
Adult cyclopoids		1	7	8	3	4	6	6	4	9	8	5	5	6	5	8	*11.3*
Adult calanoids			1		1	1	4	3	2	4	5	5	4	6	4	5	*6.0*
Chydoridae	4	3	11	6	5	8	16	15	13	12	20	9	16	14	20	5	*23.7*
Ceriodaphnia		1	5	3	4	2	6	3	3	1	3	5	1	4	1	5	*6.3*
Macrothrix			3		2	5	7	13	5	5	13	2	8	8	2	4	*10.3*
Diaphanosoma			2	4					2	1	7	1	14	9	9	4	*7.1*
Iliocryptus								1		1		1					+
Simocephalus				1			2			1		2	1				+
Latonopsis									1	1		4	1	1	1		*1.2*
Ostracods		1	1	3	1	3	3	1	3	3	4	2	9	6	8	5	*6.8*
Chaoborus larvae								1	2	1				3	2	3	*1.5*
Chironomids							1					3	11	8	9	7	*5.2*
Coleopteran larvae										1							+
Zygopteran larvae														2	1		+
Ephemeropteran larvae					1	1					1		1				+
Insects undet.							1			2	2	1		1	4	1	*1.6*
Mites				1													+
Coleopterans													1				+
Oligochaeta					1		1		2	1		1		1	1		*1.1*
Empty	4		1		3	1	1		2	1		1	1	2	1	4	
Number examined	10	10	14	11	10	10	14	10	10	10	10	11	12	10	11	10	

7.9% are ostracods. Besides these two major groups, I also found some rotifers, one mite and a few Oligochaeta.

The presence of the rotifers in the digestive tract of the damselfly poses a problem. It is difficult to know if these were actually captured or if they were swallowed accidentally. I am personally in favor of the second possibility, since numbers of rotifers in the guts are very low and their densities in the plankton were very high (up to 4.000 ind. l^{-1}).

Rotifers (and Ciliata as well) should, therefore, be considered as outside the normal particle range for the damselfly larvae of the size dealt with here.

Among Cladocera, 47.5% are *Chydoridae*, this is perhaps related to the fact that zygopteran larvae are weed climbers and that the number of contacts with the substrate-dwelling cladocerans must be larger than with representatives of planktonic genera such as *Ceriodaphnia* and *Diaphanosoma*.

Within the insect prey-group, the midges are the most important food item. It is worth noting that they do not become a major prey for the largest larvae included in the study although, at certain moments of the inundation period, midges reached densities of 3.300 ind. m^{-2}. It seems, therefore, that the Zygoptera actually underexploit this food source. However, it may well be that most of these Diptera are somewhat large-sized for the damselfly species occurring in the pools, and that they prefer to exploit the more easily obtainable crustaceans. This is, moreover, a better strategy than overexploiting the Diptera. Indeed, the dragonfly larvae would then risk the reduction of one of their major adult food-sources prematurely, while by eating crustacea they do not interfere with their own later resources. It is probable that, if the crustacean stock would become exhausted, insects would become more important.

The presence of damselfly larvae in the gut of other damselfly larvae proves that they may even feed on their own group. FISHER (1961) reports a density-dependent phenomenon of cannibalism in *Pyrrhosoma nymphula*. In the present case, no evidence was found for cannibalism and, further, it may be a common phenomenon that larger species feed on smaller ones, provided that the size difference is big enough.

Another interesting feature is the low percentage (13%) of empty guts found. MACAN (1964) recorded up to 58.5% animals "without any identifiable remains". This discrepancy may be related to a circadian rhythm in the feeding activity of the larvae (MORI & WADA, 1974; CLOAREC, 1975) to the time of sampling; but most probably had to do with inadequate food-supplies.

CONCLUSIONS

The diet of zygopteran larvae becomes more diversified in the course of their development; bigger larvae take larger prey but also the smaller prey organisms they were consuming before. In the case of pond L2 it seems that the midges are underexploited as a food source by the large damselfly larvae. The dominance of chydorid Cladocera in the diet is thus considered to be related to their ready availability and not necessarily to their being actually preferred over other types of prey.

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