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THE EFFECT OF FOOD ON THE LARVAL DEVELOPMENT OF *PALPOPLEURA LUCIA LUCIA* (DRURY) (ANISOPTERA: *LIBELLULIDAE*)

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The effects of diet, quantity of food, and complete starvation on larval development of *P. l. lucia* were investigated in the laboratory. Groups of larvae were fed on 4 diets: copepods and cladocerans, ostracods, ephemeropteran larvae, and a combination of the 3. These types of food affected the duration of larval development which was 35.4, 46.6, 42.4 and 37.3 days respectively. It did not affect the total length of larvae in each instar. In experiments on the effect of quantity of food on larval development, groups of larvae were supplied with a "standard diet", 1/2, 1/4, and 1/8 of the standard. The resulting larval developmental periods, 40.0, 57.2, 76.4 and 118.5 days respectively, showed that quantity of food has a great effect on duration of development but not on total lengths of each larval instar. Experiments with total starvation, beginning at various instars, showed that development and moulting could occur in the early instars without feeding. However, this ability was lost at VI instar, although larvae could live for considerable periods before dying. The ecological significance of these 3 groups of experiments is discussed.

INTRODUCTION

Field observations (HASSAN, 1974) on the abundant prey of libellulid larvae in Ibadan, Nigeria indicated that the abundance of each type of prey fluctuated seasonally and also varied from pond to pond. This gave an impression that the diet of the odonates may vary from season to season depending on abundance of particular prey types, and analyses of gut contents of larvae (PRITCHARD, 1964; HASSAN, 1974) showed that the prey types eaten varied seasonally.

Studies on the duration of larval development of 3 libellulids in a semi-natural environment (HASSAN, 1974) indicated that scarcity of food may be caused by the abundance of vegetational cover providing hiding places for the prey. This agrees with BENKE's (1972) conclusion that the actual consumption of prey in the field is small compared with their potential consumption. Consequently, laboratory experiments with larvae of *Palpopleura lucia lucia* (Drury) were designed to test the effects of: (a) different kinds of prey, (b) different quantities, and (c) total starvation at specific instars. Since the productivity of tropical waters varies greatly, these laboratory data should contribute to a better understanding of field data.

REARING TECHNIQUE

Eggs of *lucia* were obtained directly from ovipositing females in the field. These eggs were incubated in the laboratory in crystallizing dishes at mean room temperature of 28.9°C. The II instar larvae which hatched were used for all experiments. Each newly hatched larva was isolated in a crystallizing dish and kept at room temperature for rearing and experimentation. Prey fed to the larvae were: copepods (mostly *Thermocyclops* spp.), cladocerans (mostly *Ceriodaphnia* spp.), ephemeropteran larvae (*Baetidae*), and ostracods (*Cypris* sp.). After each moult the cast skin was removed and the length of each new instar was measured from the tip of the labium to the posterior end of the paraprocts. The duration in days between successive moults was recorded for each larva.

THE EFFECT OF DIFFERENT DIETS ON LARVAL DEVELOPMENT

METHOD

Four treatments (A, B, C, D) were set up, each consisting of 10 individuals. Treatment A larvae were fed exclusively on copepods and cladocerans, B only on ostracods, C only on ephemeropteran larvae and D on a combination of the 3. In treatments B, C, D, larval instars II to IV were fed on copepods and cladocerans because these young larvae could not feed on larger ostracods and ephemeropterans. Throughout development, all larvae were supplied with abundant food.

RESULTS

Duration of larval development for the 4 treatments is shown in Table I. Larvae fed entirely on copepods and cladocerans (A) completed their development in 35.4 days, those fed on ostracods (B) in 46.6 days, those on ephemeropterans (C) in 42.4 days, and those on a combination of the 3 diets completed development in 37.3 days. This result, when tested by analysis of variance was significant (variance ratio = 79.53, at 24 and 3 d.f.; F is significant at 1% level).

Table I

The duration of larval development (in days) of *Palpopleura lucia lucia* under various diets

Serial number	Copepoda & Cladocera	Ostracoda	Ephemeroptera	Combination
1	35	46	42	37
2	36	–	43	35
3	36	46	45	36
4	35	–	45	–
5	37	–	–	–
6	36	47	42	37
7	35	47	40	40
8	–	–	–	39
9	35	–	40	–
10	34	47	42	–
Mean ($\bar{x}$)	*35.4*	*46.6*	*42.4*	*37.3*
Standard deviation	± 0.88	± 0.55	± 1.92	± 1.86

A comparison of the treatments using a t-test shows that treatments D and A were significant at 5% level, treatments D and B at 1% level, and treatments D and C were significant at 1% level. This shows that different diets have a significant effect of duration of larval development. However, there were no significant differences in the average total lengths (Tab. II) of each larval instar subjected to the 4 treatments.

Table II

Average body length (in mm) of *Palpopleura lucia lucia* larval instars fed on various diets

Larval instar	Copepoda & Cladocera	Ostracoda	Ephemeroptera	Combination
II	1.20	1.20	1.20	1.20
III	1.54	1.52	1.53	1.50
IV	2.12	2.01	2.06	1.99
V	2.89	2.77	2.87	2.94
VI	3.92	3.73	3.82	3.91
VII	5.09	4.99	4.92	5.19
VIII	6.89	6.51	6.83	6.87
IX	8.81	8.62	8.74	8.90
X	13.41	12.62	13.14	13.28

THE EFFECT OF QUANTITY OF FOOD ON LARVAL DEVELOPMENT

METHOD

Again, 4 treatments (A, B, C, D), each consisting of 10 individuals, were set up. Treatment A larvae were fed on a diet regarded as standard, B larvae on half that amount, C on 1/4, and D on 1/8. For larval instars II-IV the standard food was a constant aupply of 80-120 copepods and cladocerans/1 ml pond water; for instars V and beyond the standard was 4 ephemeropterans per day. The choice of ephemeropteran larvae was good because it could be easily quantified. Food for treatments B, C, D was obtained by direct dilution of pond water containing the copepods and cladocerans.

RESULTS

For the 4 treatments, the total duration of larval development is shown in Table III. Average duration of larval development increased as the amount of food supplied decreased: on the standard diet, development was complete in 40.0 days, on 1/2 that amount in 57.2, on 1/4 in 74.6, and on 1/8 in 118.5 days. This result was significant when tested by analysis of variance (variance ratio = 800.27 at 28 and 3 d.f.; F is significant at 1% level). A comparison of the treatments using t-test shows that all were significant at the 1% level. These

Table III

The effect of quantity of food on the duration of larval development (in days) of *Palpopleura lucia lucia*

Serial number	Copepoda & Cladocera	Ostracoda	Ephemeroptera	Combination
1	–	58	–	117
2	36	55	–	124
3	39	58	72	–
4	–	58	–	115
5	43	58	80	118
6	42	58	74	124
7	40	61	78	116
8	–	58	73	122
9	41	54	71	112
10	39	54	74	–
Mean ($\bar{x}$)	*40.0*	*57.2*	*74.6*	*118.5*
Standard deviation	± 2.31	± 2.20	± 3.26	± 4.41

Table IV

The effect of quantity of food on average body length (in mm) of *Palpopleura lucia lucia* larval instars

Larval instar	Standard	1/2 Standard	1/4 Standard	1/8 Standard
II	1.20	1.22	1.20	1.20
III	1.50	1.54	1.55	1.50
IV	1.99	2.02	1.96	2.03
V	2.96	2.70	2.76	2.69
VI	4.05	3.67	3.69	3.70
VII	5.26	4.68	4.69	4.76
VIII	6.90	6.50	6.59	6.12
IX	8.81	8.73	8.64	8.25
X	13.34	12.85	12.33	12.30

results show that the quantity of food has a profound effect on larval development. However, there were no significant differences in the average total lengths (Tab. IV) of each larval instar subjected to the 4 treatments.

EFFECT OF STARVATION ON LARVAL DEVELOPMENT

METHOD

Ten treatments were set up, each with 5 individuals. The treatments were as follows: 1 (the control) – adequately fed throughout, 2 – starved from II instar, 3 through 10 – starved from instars III through X. Larvae for each treatment were well fed prior to the instar in which starvation began. Duration of larval development, interval between moults and, when applicable, the ages of the larvae at the instar when they died were recorded.

RESULTS

These are summarized in Table V. Larval instars II through V developed and moulted without feeding. Larvae starved in instars II and III averaged 2 moults, whereas those starved in instars IV and V moulted once before dying. No larva in which starvation began at instar VI or later moulted. However, these lived for fairly long periods before dying. The instars and the average number of days lived after starvation began were: VI – 6 (5-8), VII – 7 (6-8), VIII – 9 (7-11), IX – 12 (11-14), X (final) – 25 (23-28).

Table V

Effect of starvation, commencing at definite instars, on the development of the larval instars of *Palpopleura lucia lucia*

Instar at which starvation was started	Attainment of subsequent instar in days									Age in days at the instar at which death occurred
	III	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*Adult*	
II	4*	6*	+							3
III		5*	7*	+						1
IV			6*	+						2
V				4*	+					4
VI					+					6
VII						+				7
VIII							+			9
IX								+		12
X								+		25
Control (fed throughout)	*3*	*4*	*3*	*3*	*3*	*3*	*4*	*5*	*18*	*46* (Larval developmental duration)

* moults during starvation
\+ instar at which death occurred

DISCUSSION

PRITCHARD (1964) and HASSAN (1974) show that survival of larvae in nature is guaranteed by a wide variety of prey, and the laboratory results of the present study confirm this. Except for larvae fed exclusively on copepods and cladocerans, those supplied with a combination of the 3 food types developed most rapidly. Somewhat similarly, FISCHER (1961) (as quoted by CORBET, 1962) found that *Lestes* sp., fed exclusively on their own species as prey, grew slightly less rapidly than those fed on a more varied diet.

When prey populations decline to critically low levels, the survival of the larvae seems guaranteed because of their ability to withstand partial or total starvation for considerable periods (Tabs. III, V). This may be significant in oligotrophic waters. PRITCHARD (1964) noted that one *Aeshna interrupta lineata* Walker larva lived for 59 days without food. AGUESSE & TESTARD (1972) stated that the ability of larvae to withstand starvation is an important adaptation to the food available in their biotope. The laboratory results of the present study seem to confirm this conclusion.

The availability of food also affects rate of larval development (AGUESSE & TESTARD, 1972). In a semi-natural enclosure, vegetation provided hiding places for prey (HASSAN, 1974). This probably accounts for the much longer larval duration (58 days) of *lucia* in nature than in the laboratory (39.8 days in this study). The former figure is probably close to what happens in eutrophic waters, while development in oligotrophic waters might be very prolonged, probably beyond the highest average obtained in this study – 118.5 days. This definitely will affect the overall larval and adult populations.

The ability of the early instars to moult without food (Tab. V) has some survival value. This allows the larvae to grow and thus enhances their ability to feed later upon a wider variety of prey. This is in keeping with CORBET's (1962) conclusion that animals which await the arrival of their prey should be capable of withstanding long periods without food.

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