The evaluation of live feed in the early larval growth of the sharptooth catfish *Clarias gariepinus* (Burchell)

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Abstract

Zooplankton, *Artemia* and a trout fry starter meal used as a dry feed were evaluated as diets in the early larval growth of *Clarias gariepinus* (Burchell) over a twelve-day period, commencing forty-eight hours after hatching. Zooplankton was found to produce the best growth results, being significantly better over most of the growth period than the other two food types. *Artemia* nauplii were next best while dry food yielded the poorest results. Larvae fed on zooplankton and *Artemia* showed survival rates exceeding 96% compared to a 26% survival rate for dry food.

Introduction

The large-scale commercial spawning of fish in captivity places a great demand on available live food at hatcheries for the maintenance of optimal growth of larvae and juveniles prior to their release into nursery and grow-out ponds.

Difficulties in producing sufficient quantities of live food during fish-spawning programs led to the development of various formulae of dry food as possible substitutes during the larval rearing of fish (Appelbaum, 1976; Appelbaum and Dor, 1978; Dabrowski, 1983a; 1984).

In recent years the suitability of various dry-feed formulae has been investigated for the rearing of cyprinid and catfish larvae (Appelbaum, 1977; Bryant and Matty, 1981; Msiska, 1981; Hecht, 1981; 1982; Hecht and Viljoen, 1982; Uys and Hecht, 1985). Experience, however, showed that as a rule formulated compound diets still do not provide optimal growth when used exclusively as fish larval food, especially during the early larval stages of cyprinids and catfish (Hogendoorn, 1980; Dabrowska *et al.*, 1979; Dabrowski, 1984; Prinsloo and Schoonbee, 1986), and that ideally live food still remains the food source of choice in hatcheries.

Climatic conditions in South Africa enable the year-round production of zooplankton, especially during the early summer, which coincides with the warm-water fish spawning season. Outside pond space can be profitably utilised to sustain a sufficient production of zooplankton for a commercial type fish-hatchery operation. Nutrient enrichment of pond water required for initial phytoplankton growth and the subsequent production of zooplankton can be facilitated with the use of animal manures (Prinsloo and Schoonbee, 1986). Where final maturation pond-treated sewage effluent is available, N and P-containing nutrients are already present in sufficient concentrations in the water to sustain a constant production of zooplankton with a minimum of supervision and effort.

In the present study a comparison is made of the growth of sharptooth catfish larvae using zooplankton developed in final maturation pond effluent, and *Artemia* nauplii, as two alternative live foods during the early larval growth phase of this species. A commercial trout fry diet also used in the feeding of larvae of the American catfish, *Ictalurus*, was used as a dry feed substitute. This investigation lasted for a period of 12 d commencing from the second day after hatching, when active larval feeding begins.

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Materials and methods

Induced spawning of fish

Clarias gariepinus spawners used in the local spawning programs at the hatchery of the University of the North were selected from one-year-old reared fish which matured within the first nine months after hatching when spawners obtained an average mass of one kilogram. Spawning techniques followed were according to methods developed to suit local environmental conditions (Schoonbee *et al.*, 1980; Hecht *et al.*, 1982; Polling *et al.*, in press). Fertilised eggs were hatched in Heath Techna trout hatching trays (Polling *et al.*, in press), after which the larvae were transferred to 1 000ℓ holding tanks supplied with a water recirculation system, where fresh water was matured beforehand for a period of three to four days prior to the release of the larvae into the tanks.

Experimental design

Experiments were done in duplicate. Larvae were collected randomly from the same batch of larvae of the same age and similar size and counted into 100ℓ tanks until each tank contained exactly 1 500 larvae at a density of 15 larvae ℓ^{-1} of water. To minimise the possibility of experimental bias towards any specific batch of larvae, the feeding program was determined after a random selection of two tanks with larvae for each of the three feeding programs. Each tank was provided with an Eheim filter with a recirculation capacity of 6ℓ min^{-1}. These filters were cleaned daily during the entire feeding program.

Live zooplankton consisting mainly of the rotifer *Brachionus* spp. and two species of the cladoceran *Moina* were obtained daily from six specially constructed 12 500ℓ plastic ponds which received final sewage maturation effluent water. In addition, quantities of approximately 5kg dry chicken manure were introduced into each pond every week in nylon bags of 2 to 3mm mesh. This facilitated leaching of N and P-containing nutrients from the bags into the ponds but prevented the release of manure particles. Development of zooplankton took place in the inoculated

phytoplankton-rich water within four days after putting the system into operation. Ponds were drained periodically and refilled with fresh phytoplankton inoculated water. Zooplankton were collected three times per day, i.e. during the early morning hours (07h00), at midday (12h00), and during the afternoons (16h00). On arrival at the laboratory the zooplankton were aerated until use. The plankton were first filtered through a 0,8mm mesh nylon sieve where the larger macro-invertebrates were screened from the zooplankton. This was followed by the rinsing of the zooplankton in a 65 μ nylon sieve with fresh clean water in which the zooplankton were retained for the feeding of the larvae.

Culture of *Artemia* nauplii

The culture of *Artemia* nauplii took place in conical flasks, each containing 20ℓ of water to which 150g of coarse salt had been added. Twenty gram *Artemia* cysts were used at a time. Continuous aeration was provided and water temperature was maintained at 24 to 28°C. Hatching of nauplii took place from 24h onwards and nauplii were usually drawn off after 36h. Nauplii were then continuously harvested over a period of three days. Fresh cultures were made on a rotational basis, depending on the quantities required as food. In this experiment the simultaneous use of three conical *Artemia* culture jars was found to be sufficient.

Dry feed used consisted of pulverised trout starter pellets (48% protein) passed through a 125 μ (initial) and 255 μ (final) mesh sieve.

Application and quantities of food

In the case of all food types being tested (i.e. the zooplankton, *Artemia,* and commercial trout starter pellets), the daily quantities of live and artificial food supplied to the tanks comprised a minimum of 20% (expressed as dry mass) of the total daily estimated wet mass of the fish larvae at the time of supply.

Zooplankton and *Artemia* were supplied three times per day during the first 6 d after which supplies were intoduced six times daily for the rest of the period. This step was necessary to spread the supply of food and to prevent the overloading of the tanks at feeding times during the latter part of the experiment, which clearly affected the oxygen levels in the various tanks. Dry feed was supplied by means of a clock-driven conveyor belt system with a daily supply period of approximately 16h. This procedure was followed to prevent the undue accumulation of dry food particles on the bottom of the tanks, which affected the survival of larvae.

Cleaning of tanks and replacement of water

In addition to the use of an Eheim filter, all tanks were cleaned daily using a suction tube to collect accumulated faeces and excess food. This was done during the early morning hours before the commencement of the following feeding program. Oxygen levels in the water were used as an indication for the replacement of water in the tanks. During the first three days when the larvae were relatively small, and the quantities of the food applied comparatively low, only 10% of the volume of the water in each tank was replaced daily with fresh acclimated water. Thereafter 50% of the water was replaced daily for the rest of the investigation.

Chemical analysis of water

Daily analyses took place during early morning (7 to 8h00) for water temperature (°C), pH, dissolved oxygen ($mg\ell^{-1}$) conductivity (μScm^{-1}), ammonia ($mg\ell^{-1}$) and orthophosphate ($mg\ell^{-1}$). Analyses were carried out according to Apha (1980).

Collection, weighing and measurement of the larvae

Twenty larvae were collected at random from each tank once per day, 2 to 3h after feeding. These larvae were immediately killed in 5% formalin. Measurement (total length) took place under a stereo microscope provided with a measuring grid, accurate to 0,1mm. Thereafter excess moisture was removed from each specimen before weighing, using blotting paper. Mass determinations were done on a Mettler model AE 160 balance weighing accurately to 0,1mg. In the determination of the daily estimated quantities of food to be supplied to each tank, the larvae removed as well as the observed mortalities were first accounted for. On the last day of the feeding trials (day 12) all remaining larvae were sacrificed, preserved in 5% formalin and individually weighed. In this way an accurate assessment could be made of the actual survival of the larvae in each tank and for each type of treatment, respectively.

TABLE 1
PHYSICAL AND CHEMICAL CONDITIONS IN *CLARIAS GARIEPINUS* LARVAL-REARING TANKS RECEIVING ZOOPLANKTON, *ARTEMIA* AND TROUT FRY MEAL AS FOOD

DETERMINAND	TANKS RECEIVING ZOOPLANKTON		TANKS RECEIVING ARTEMIA		TANKS RECEIVING DRY FOOD	
	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE
Temperature °C	27,0	26,8 - 27,2	26,8	26,0 - 28,1	27,5	26,8 - 28,1
pH		7,34 - 7,60		7,33 - 7,59		7,29 - 7,60
Conductivity (μScm^{-1})	74,1	59,4 -103,7	73,9	59,6 -103,6	74,1	61,6 -108,6
Oxygen ($mg\ell^{-1}$)	6,12	4,30 - 7,94	6,88	5,90 - 7,94	7,09	6,35 - 7,94
Ammonia ($mg\ell^{-1}$)	0,570	0,100- 1,130	0,560	0,060- 1,310	0,310	0,010- 1,020
Nitrite ($mg\ell^{-1}$)	0,842	0,089- 1,632	0,586	0,089- 1,422	0,488	0,660- 0,091
Nitrate ($mg\ell^{-1}$)	5,7	1,8 - 8,5	3,9	7,5 - 1,4	3,6	4,7 - 1,8
Orthophosphate ($mg\ell^{-1}$)	0,651	0,255- 1,087	0,500	0,242- 0,726	0,395	0,259- 0,628

Statistical evaluation of larval growth results

A BMDP7D one-directional analysis of variance was applied in the comparison of growth results obtained for the larvae for each of the three types of feeding programs. Pairwise comparisons of all pairs of means were made, using amongst others, the T-test with Bonferroni levels of significance. The levels of significance in possible differences in growth performance were evaluated between larvae receiving the three food types.

Results

Water chemistry of larval rearing tanks (Table 1)

Water temperatures in the tank systems fluctuated within 1°C and were similar for the three treatments. Values for pH showed a slight increase with time in all three treatments. The water remained alkaline in all cases throughout the period of investigation. One of the parameters that was clearly affected by the addition of the food was the dissolved oxygen concentrations in the tanks which consistently declined in all three treatments as the addition of food increased with the growth of the larvae. The tanks receiving zooplankton were the most affected with a lowest oxygen concentration of 4,30 $mg\ell^{-1}$ recorded. Values for dissolved oxygen however would have been much lower, were it not for the daily cleaning of the tanks and replacement of a portion of the water in each with fresh, acclimated water.

The negative affects of live food on the water quality in the larval rearing tanks can clearly be seen from values recorded for ammonia, nitrite, nitrate and orthophosphate, where the highest values for these parameters occurred. Again, values for these parameters would have been much higher and perhaps even more detrimental to the larvae were it not for the daily, partial replacement of water in all tanks during cleaning operations.

Growth results

Growth of the larvae receiving the three different kinds of food and the statistical evaluation of the results are summarised in Tables 2 and 3 and Fig. 1, respectively.

Differences in growth performance between the three food treatments already became apparent form day 1, with larvae receiving zooplankton performing the best, followed closely by those fed on *Artemia*, with growth of larvae where dry feed was used clearly inferior to that of the other two food types. This finding is also supported by T-tests applied between the means obtained for larval mass of the different treatments (compare Tables 2 and 3). Even though the relative larval growths for the different treatments remained significantly or highly significantly different between all three diets over virtually the entire growth period, larvae receiving *Artemia* appeared to improve in growth with time and tended to narrow the gap in mean mass with those receiving zooplankton towards the last phase of the experimental period.

TABLE 2
MEAN, MAXIMUM AND MINIMUM DAILY MASS (g) of *C. GARIEPINUS* LARVAE FROM THE SECOND TO THE 13TH DAY AFTER HATCHING (12 DAYS), FED ON ZOOPLANKTON, *ARTEMIA* AND A COMMERCIAL TROUT STARTER MEAL

	ZOOPLANKTON					ARTEMIA					DRY FEED				
DAY	$\bar{x}$	Max	Min	SD	SE	$\bar{x}$	Max	Min	SD	SE	$\bar{x}$	Max	Min	SD	SE
0	* 2,89	3,60	2,40			* 2,89	3,60	2,40			* 2,89	3,60	2,40		
1	5,14	8,3	3,8	1,24	0,28	3,26	5,1	1,4	1,07	0,24	2,30	3,2	1,7	0,37	0,08
2	6,79	10,1	2,3	2,20	0,49	3,83	5,8	1,3	1,07	0,24	2,94	4,4	1,9	0,64	0,14
3	11,76	16,6	6,7	2,73	0,61	5,35	9,5	1,6	1,92	0,43	3,84	5,6	2,6	0,79	0,18
4	15,83	30,3	9,6	4,58	1,02	8,10	14,8	3,5	2,70	0,60	4,47	7,7	2,4	1,32	0,30
5	26,18	35,9	15,8	5,85	1,31	13,51	30,6	4,4	5,54	1,24	5,46	7,9	3,1	1,45	0,32
6	27,01	32,6	18,9	4,64	1,04	18,25	26,9	8,7	5,61	1,25	4,73	9,9	2,8	1,72	0,38
7	34,14	52,10	16,50	4,64	2,08	28,81	49,60	14,5	10,75	2,40	4,26	6,6	2,8	0,98	0,22
8	43,48	63,3	27,0	8,92	1,99	34,25	51,7	19,0	10,91	2,44	5,96	13,2	2,5	2,53	0,57
9	57,70	97,2	33,3	16,26	3,64	40,32	63,3	21,3	10,87	2,43	6,65	15,0	4,1	3,01	0,67
10	67,17	105,6	29,6	18,98	4,24	50,87	104,7	19,8	17,98	4,02	7,20	16,3	2,3	3,49	0,78
11	105,04	187,7	59,9	29,61	6,62	63,11	115,5	33,8	21,39	4,78	7,20	16,9	4,8	2,90	0,65

* Values obtained from pool of larvae sampled

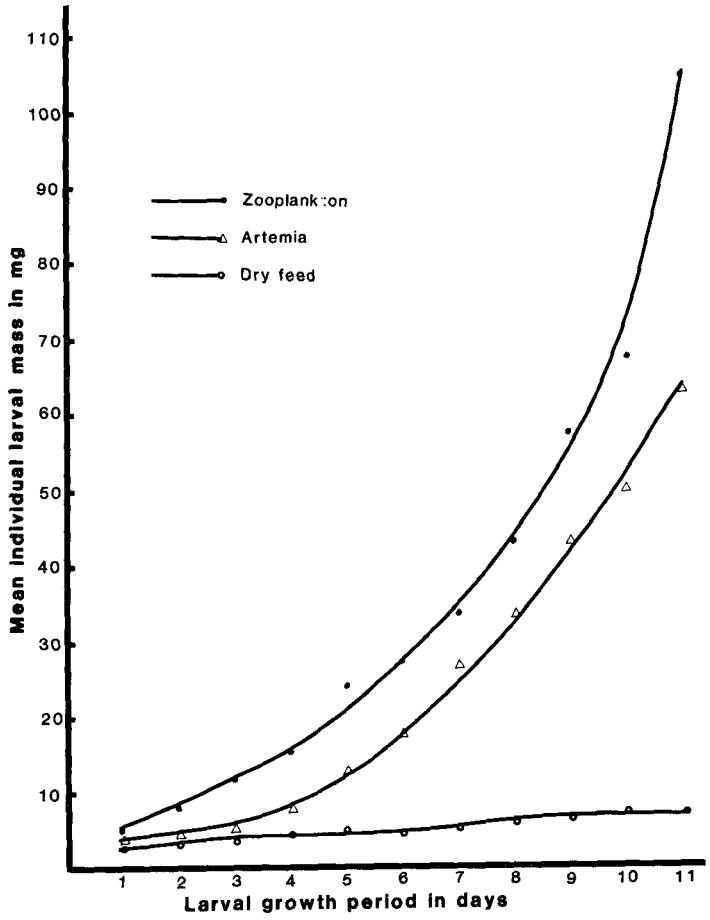

Figure 1
Comparison of early larval growth of ***Clarias gariepinus*** *fed on zooplankton,* ***Artemia*** *nauplii and a formulated dry feed. Lines handfitted.*

TABLE 3
STATISTICAL EVALUATION OF RELATIVE GROWTHS OF *C. GARIEPINUS* LARVAE FED ON DIETS OF LIVE ZOOPLANKTON, LIVE *ARTEMIA* NAUPLII AND A FORMULATED DRY FEED (TROUT STARTER MASH) OVER A PERIOD OF ELEVEN DAYS, COMMENCING TWO DAYS AFTER HATCHING

	ZOOPLANKTON AND ARTEMIA			ZOOPLANKTON AND DRY FEED			ARTEMIA AND DRY FEED		
DAY	t-VALUE	DF	P-VALUE	t-VALUE	DF	P-VALUE	t-VALUE	DF	P-VALUE
1	5,14	37,25	<0,001	9,84	22,35	<0,001	3,78	23,43	<0,01
2	5,42	27,52	<0,001	7,53	22,18	<0,001	3,19	31,01	<0,01
3	8,59	34,13	<0,001	12,48	22,19	<0,001	3,26	25,29	<0,01
4	6,50	30,76	<0,001	10,66	22,15	<0,001	5,41	27,65	<0,001
5	7,03	37,89	<0,001	15,37	21,32	<0,001	6,29	21,59	<0,001
6	5,38	36,73	<0,001	20,12	24,09	<0,001	10,32	22,53	<0,001
7	1,68	37,25		14,27	19,42	<0,001	10,17	19,32	<0,001
8	2,19	35,99	<0,05	19,18	36,02	<0,001	13,70	31,70	<0,001
9	3,98	33,17	<0,01	13,81	20,30	<0,001	13,35	24,89	<0,001
10	2,79	37,89	<0,05	13,90	20,28	<0,001	10,66	20,43	<0,001
11	5,13	34,59	<0,001	14,70	19,36	<0,001	11,58	19,70	<0,001

Survival of the larvae receiving the two types of live food was exceptionally high, exceeding 96% in both cases (Table 1). This is in contrast with high mortalities experienced with the larvae receiving dry food, where the eventual survival of larvae recorded was 29,2%.

Discussion

From the literature it is clear that live food remains an extremely important diet in the rearing of larvae of a number of fish species (Bryant and Matty, 1980; Hogendoorn, 1980; Msiska, 1981; Stenson, 1982). The importance of the rotifer *Brachionus plicatilis* for the mass propagation of fish in Japan is reviewed by Watanabe *et al.* (1983). Lubzens *et al.* (1984) stressed the value of the rotifer *Brachionus plicatilis* for the growth of *Cyprinus carpio* larvae where it is used in combination with artificial food. Matlak and Matlak, (1976) indicated that rotifers are an impotant food item of carp larvae during the first three weeks in nursery ponds, being the third most common food item after Crustacea and chironomidae. Zooplankton as larval food for fish is reviewed by authors such as Watanabe (1979), Green and Merrick (1980), Kilambi and Zdinak (1982), Geigher (1983 a, b) and Dabrowski (1984). The nutritional value of *Artemia* for carp, *Cyprinus carpio* larvae was evaluated by Bryant and Matty (1981) and Vanhaecke and Sorgeloos (1983). A variety of dry foods was used for the rearing of *C. carpio* larvae (Appelbaum and Dor, 1978; Hecht and Viljoen, 1982; Viola and Arieli, 1982).

From the results obtained during the present feeding trials it is obvious that live food, in particular zooplankton, is a most desirable diet for the rearing of the sharptooth catfish *C. gariepinus* larvae. The importance of *Artemia* as live food for *Clarias* larvae (Hogendoorn, 1980; Msiska, 1981) is again confirmed by this investigation. Our findings support investigations previously conducted by authors such as Hogendoorn (1980) and Msiska (1981) who reported unsatisfactory growth in catfish larvae fed on dry diets, which also confirms our previous investigations (Prinsloo and Schoonbee, 1986), where zooplankton as live food was compared with a commercial dry feed for the larval rearing of two Chinese carp species over a period of 10 to 14 d. In the case of the Chinese silver and grass carps, the relative growths of the larvae receiving zooplankton as food clearly outperformed those which received a commercial dry food.

In South Africa dry feeds were specifically developed for the primary nursing of *C. gariepinus* larvae by Uys and Hecht (1985). These authors compared the nutritional value of their dry food formulae against natural live food for an eleven day feeding period where the larvae were fed in excess of 25% of their body mass per day on a dry mass basis, compared to a minimum of 20% in the present experiment. Their larvae were kept at a density of 10 ℓ^{-1}, compared to 15 ℓ^{-1} in the present investigation. According to the results obtained by Uys and Hecht (1985) the larvae receiving dry feed increased from 2,89 mg individual mass to a mean mass of 16,23 mg in eleven days, i.e. an increment of 13,39 mg. Where zooplankton was used by these authors, a mean mass increment of 8,28 mg was obtained over the same period.

When the *C. gariepinus* larval growth results of the present investigation are compared with those obtained by Uys and Hecht (1985), the mean mass increment over eleven days of larvae receiving the trout starter meal was a mere 4,31 mg. This indicates a much better dry feed formula developed by the latter research workers for this fish species even if it is taken into account that the higher density of 15 larvae ℓ^{-1} in the present investigation as against 10 ℓ^{-1} by Uys and Hecht (1985) may have impeded larval growth performance somewhat. The present results obtained when using *Artemia* as food leaves no doubt as to the superiority of this organism in the diet of *C. gariepinus* larvae. A mean individual growth increment of 60,22 mg was achieved in eleven days, outperforming the growth results of the dry feed formulae used by Uys and Hecht (1985) by almost 47 mg (mean individual mass) over the same growth period. Our *C. gariepinus* larval growth results where zooplankton was used as food were even more dramatic, showing a mean mass increment of more than 100mg over the eleven-day growing period which is 4,5 times better than the growth obtained by Uys and Hecht (1985) for their dry feed formulae and 12,3 times better then their zooplankton-fed larvae. Our findings for both *Artemia* and zooplankton are more in line with those of Hogendoorn (1980) and Msiska (1981) who also reported somewhat inferior growth for *Clarias* larvae when using a dry food (trout starter meal) alone. Growth of *C. lazera* (= *C. gariepinus*) using live food, corresponded well with our findings if extrapolated over the first eleven-day larval growing period (Hogendoorn, 1980).

Although our present results strongly support the use of live food in the early larval growth phase of fish such as *C. gariepinus*, it should not detract from the fact that the further development and improvement of balanced dry feed formulae to supplement or even eventually replace live food in fish larval diets must be encouraged.

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