Comparison of the early larval growth rates of the Chinese grass carp *Ctenopharyngodon idella* and the Chinese silver carp *Hypophthalmichthys molitrix* using live and artificial feed

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Abstract

Live and artificial foods were tested for their relative growth potential for larvae of the Chinese silver carp and grass carp during the first ten to fourteen days after commencement of the active feeding stage. The live food was obtained from predominantly rotifer cultures developed in a combination of earthen and concrete ponds fertilized with poultry manure and inorganic fertilizer. Dry food consisted of a commercial larval fish food formula. Results obtained showed that live food yielded the best growth results for both fish species. However, when frozen, live food was inferior to dry food.

Introduction

With the development of large-scale induced spawning programmes for selected fish species used in aquaculture, the need also arose to produce readily available live and balanced artificial diets required for the rapid growth and intensive rearing of larvae and juveniles in captivity prior to their release into nursery ponds (Huisman, 1979; Matlak and Matlak, 1976; Appelbaum and Dor, 1978; Watanabe, 1979; Woynarovich and Horváth, 1980; Bryant and Matty, 1981; Msiska, 1981; Hecht and Viljoen, 1982; Rothbard, 1982; Geiger, 1983 a,b; Hofsten *et al.*, 1983; Watanabe *et al.*, 1983; Dabrowski, 1984; Lubzens *et al.*, 1984).

The suitability of various dry feeds for the larval rearing of cyprinids and catfish was investigated by research workers such as Appelbaum (1976, 1977), Appelbaum and Dor (1978) and locally by Hecht and Viljoen (1982) and Uys and Hecht (1985). Both live and artificial diets were investigated in Transkei for the large-scale rearing of cyprinid larvae including the Chinese grass carp and silver carp which were spawned artificially in Transkei (Schoonbee and Prinsloo, 1984) at the Umtata Dam Fish Research Station.

In this paper a comparison is made of the relative growths obtained for larvae of the silver carp and grass carp during the first ten to fourteen days after active larval feeding commences, using live food and a formulated artificial diet.

Materials and methods

Six two-hundred litre glass tanks were used, filled to a capacity of 150 litre with previously acclimated water of the same origin as the water used for filling fish ponds at the Umtata Dam Fish Research Centre. The tanks were provided with gravel filters through which the water was recirculated. The experiments were conducted in a temperature-controlled room at water temperatures fluctuating between 26°C and 28°C and with day-night simulated conditions.

Fish larvae spawned at the hatchery of the Umtata Dam Fish Research Station (Schoonbee and Prinsloo, 1984) were collected four days after hatching at a time when active larval feeding commenced. Larvae were transferred to the experimental tanks at exact densities of 500 specimens per tank, i.e. 3 to 4 larvae per litre of water. During counting, fish larvae were carefully scooped up with a small plastic container thus avoiding direct handling of the larvae and any possible injuries. Some larvae were individually weighed and their initial mean biomass (1,3 mg for grass carp and 1,0 mg for silver carp larvae) determined.

Live food used in the experiments was obtained from predominantly rotifer cultures developed in a combination of earthen and concrete pond systems. For the initial development of the phytoplankton blooms, previously dried earthen ponds, filled with water, were fertilized with inorganic ammonium sulphate at a concentration of 100 kg ha^{-1} and supplemented with poultry manure at a quantity of 600 to 700 kg ha^{-1}. Depending on prevailing water temperatures, sufficient phytoplankton, consisting mainly of *Pediastrum*, *Eudorina*, *Euglena* and *Peridinium* species developed within a period of four to six days. This phytoplankton-rich green water was then gravity fed into concrete ponds where the water was further enriched with poultry manure kept in bags to avoid undue release of manure particles into the culture water. A predominantly rotifer culture, consisting almost exclusively of *Keratella* species developed naturally within five to twelve days from the commencement of the culture system described above. The rotifers were first filtered through a 180 μm nylon mesh sieve (to eliminate any copepods present in the culture) into a 63 μm sieve where much of the rotifer material was collected. Most of the algal cells passed through this sieve. The phytoplankton cultures which developed in the earthen ponds, were used to sustain high densities of phytoplankton in the concrete ponds, where the rotifer cultures were kept. It was found that a productive rotifer culture could be maintained in this way for periods of more than fourteen days. Only the development of copepods feeding on the rotifers necessitated the replacement of existing rotifer culture systems with fresh ones.

Growth trials were either done in duplicate (grass carp) or in triplicate (silver carp). The two sets of feeding trials were conducted over a period of 10 days for the silver carp and 14 days in the case of the grass carp.

Excess quantities of live and dry food in equivalent dry mass ratios were applied, comprising at least 19% of the total estimated wet biomass of the fish larvae at any given time. The dry feed used in the present experiment consisted of a commercially prepared feed formula marketed as Ewos C10 Larvstart (Appelbaum 1977; Appelbaum and Dor, 1978; Hecht and Viljoen,

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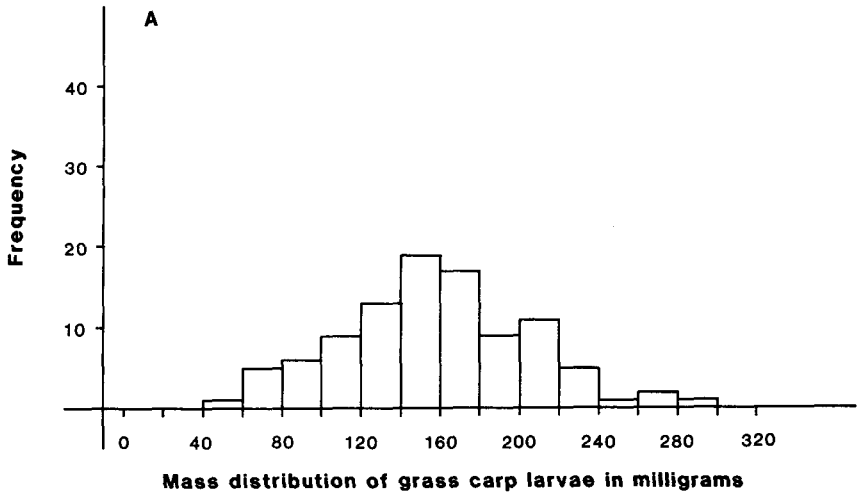

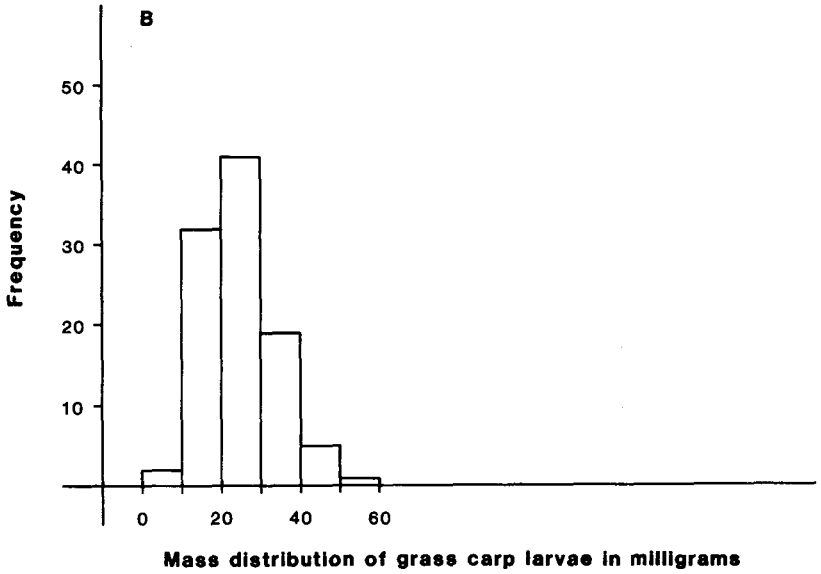

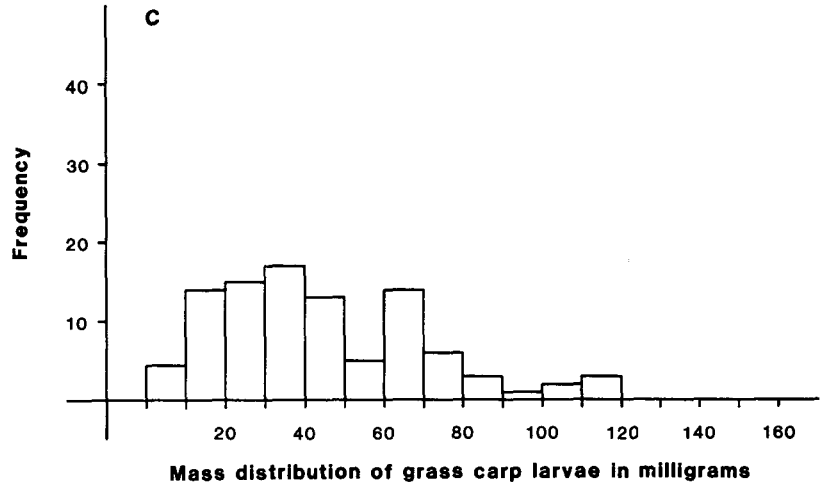

Figure 1
Mass frequency diagram of larvae of the Chinese grass carp fed on live (A), frozen (B) and artificial dry feed (C) over a period of fourteen days (N – 100).

1982). Supply of dry feed was continuous for periods of 12 hours per day by means of a clock-driven conveyor belt system. During the first three days, the particle size of the Ewos feed used was 150 μm for both chinese carp larvae. From day four until the termination of the experiment, the dry feed particle size was 200 μm. Filtered live food, mainly rotifers, was applied twice daily to the larvae in the tanks. In addition, frozen material of the rotifer cultures was also tested as food for the grass carp larvae.

The larval holding tanks were cleaned regularly once a day using a rubber-tipped scraper and a suction tube for the removal of waste material. In this process approximately 10% of the volume of the water in each tank was drawn off and replaced daily with clean, fresh, acclimated water. Water samples were collected every third day from each tank and analysed for pH, dissolved oxygen, conductivity, ammonia, nitrite and nitrate. (APHA, 1980).

Ten larvae were removed at three-day intervals from each tank and transferred to a nylon mesh sieve where the excess water was drained from the larvae. By applying filter paper to the underside of the sieve, most of the excess water could be removed without physical damage to the larvae. These larvae were individually weighed on an electronic balance accurate to one tenth of a milligram. At the end of each trial, fifty larvae from each individual tank were weighed according to the procedure described. The number of surviving larvae in each system was established at the end of each trial.

Results

According to information on the water chemistry of the tanks (Table 1), water quality did not deteriorate in any of the feeding systems. There was a decline in pH to below 7. Concentrations of dissolved oxygen in the water remained high throughout the investigations, seldom falling below 7 mg/ℓ. Values for electrical conductivity reflect the relatively low concentrations of dissolved solids in the water which originate from the headwater region of a river, approximately 50 km from the research station. None of the parameters ammonia, nitrite or nitrate reflected any serious accumulation or breakdown of organic wastes in any of the systems.

TABLE 1
MEAN VALUES OF SELECTED PHYSICAL AND CHEMICAL CONDITIONS OF WATER IN TANKS USED FOR GROWTH EXPERIMENTS OF GRASS AND SILVER CARP LARVAE BASED ON A SERIES OF FIVE SETS OF ANALYSIS EACH ACCORDING TO APHA (1980)

Analysis	$\bar{x}$	Min	Max	Sx	CV
Tanks receiving live food					
Dissolved oxygen mg ℓ^{-1}	7,2	6,9	7,6	0,356	4,9
pH	6,18	5,55	6,72	0,544	8,8
Conductivity μS cm^{-1}	48,0	28,0	79,0	23,172	49,6
Ammonia (NH_4) mg ℓ^{-1}	0,197	0,045	0,441	0,164	84,5
Nitrite (NO_2) mg ℓ^{-1}	1,156	0,089	0,272	0,072	48,3
Nitrate (NO_3) mg ℓ^{-1}	0,268	0,189	0,374	0,081	29,4
Tanks receiving frozen food					
Dissolved oxygen mg ℓ^{-1}	7,4	7,1	7,8	0,316	4,3
pH	6,30	5,44	6,69	0,523	8,5
Conductivity μS cm^{-1}	46,0	30,0	72,0	18,221	38,8
Ammonia (NH_4) mg ℓ^{-1}	0,098	0,023	0,199	0,063	54,0
Nitrite (NO_2) mg ℓ^{-1}	0,122	0,082	0,175	0,045	35,8
Nitrate (NO_3) mg ℓ^{-1}	0,265	0,202	0,378	0,070	25,6
Tanks receiving dry feed					
Dissolved oxygen mg ℓ^{-1}	7,6	7,2	8,0	0,369	4,9
pH	6,60	5,61	7,12	0,688	10,5
Conductivity μS cm^{-1}	53,0	25,0	100,0	34,248	66,8
Ammonia (NH_4) mg ℓ^{-1}	0,112	0,005	0,233	0,084	88,8
Nitrite (NO_2) mg ℓ^{-1}	0,199	0,069	0,564	0,203	88,3
Nitrate (NO_3) mg ℓ^{-1}	0,228	0,149	0,414	0,109	47,7

Results obtained on the growth trials of both the grass and the silver carp larvae (Tables 2 and 3) showed that the best survival rates occurred where live food was used. Poorest survival (69%) occurred amongst the grass carp larvae receiving frozen food in contrast with 87% survival (live food) and 78% survival (dry food). In the case of the silver carp larvae, the survival of larvae fed on both live and dry food was inferior to that of the grass carp.

TABLE 2
THE AVERAGE GROWTH OF LARVAE OF THE CHINESE GRASS CARP FED ON LIVE, FROZEN AND ARTIFICIAL DRY FOOD OVER A PERIOD OF 15 DAYS

No. of Days	Food type								
	Live Food			Frozen Food			Ewos Larvstart		
	Average mass in mg	SD	CV	Average mass in mg	SD	CV	Average mass in mg	SD	CV
0	1,3	0,4	31,4	1,3	0,4	31,4	1,3	0,4	36,4
3	5,6	0,8	14,9	1,9	0,3	18,6	2,7	0,7	28,8
6	17,4	6,6	38,0	6,0	1,4	22,5	7,3	1,9	25,5
9	57,2	7,4	13,0	10,6	1,9	18,1	11,9	5,5	46,5
12	101,6	27,0	26,5	15,7	4,3	27,6	16,6	9,1	54,4
15	157,9	46,9	29,7	25,4	8,2	32,4	26,5	26,5	59,0
	Survival: 87,4%			Survival: 66,6%			Survival: 78,0%		

When comparing the growth performance of the larvae receiving the different feed types (Tables 2 and 3; Figures 1 to 4), it is obvious that live food was the best and performed better than the dry feed in both the grass and silver carps. In the grass carp, the mean individual mass of the larvae after 15 days reached 157,9 mg (live food) compared to 26,5 mg (dry food) whereas in the silver carp the mean individual mass of the larvae after ten days was 103,0 mg (live food) compared to 27,5 mg (dry food). Poorest results were obtained where frozen food was used. (Table 2).

TABLE 3
THE AVERAGE GROWTH OF LARVAE OF THE CHINESE SILVER CARP FED ON LIVE AND ARTIFICIAL DRY FOOD OVER A PERIOD OF 10 DAYS

No. of Days	Food Type: Live food			Ewos larvstart		
	Average mass in mg	SD	CV	Average mass in mg	SD	CV
0	1,00	—	—	1,00	—	—
3	7,40	1,8	24,3	3,00	1,1	36,7
7	46,1	9,9	21,5	11,5	5,0	43,5
10	103,0	19,8	19,2	27,5	20,0	72,7
	Survival: 75,8%			Survival: 68,2%		

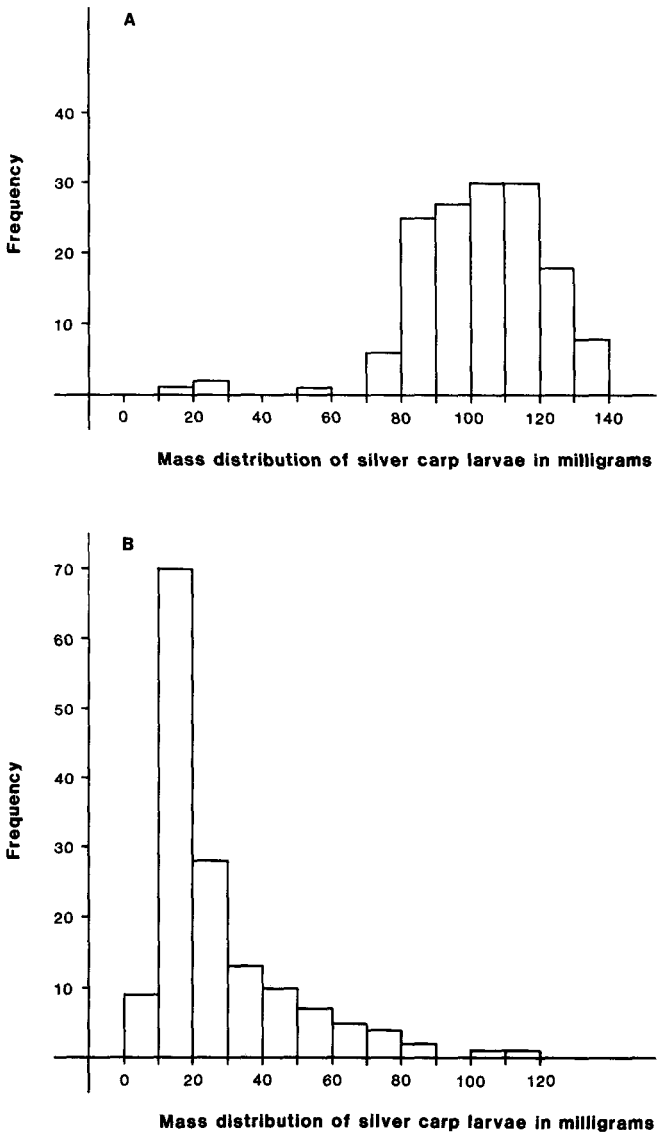

Figure 2
Mass frequency diagram of larvae of the Chinese silver carp fed on live (A) and artificial dry feed (B) over a period of ten days (N – 150).

Discussion

Although it has been emphasized by a number of research workers (Appelbaum, 1976; 1977; Hecht and Viljoen 1982; Uys and Hecht, 1985) that balanced dry food must be available for large-scale fish larval rearing and although attempts have been made to develop such formulae, the majority of research workers dealing with larval rearing of fish concluded almost unanimously that live food alone, or in combination with artificial diets, is important for superior growth and survival during early larval development (Anwand *et al.*, 1976; Bryant and Matty, 1981; De Silva and Weerakoon, 1981; Msiska, 1981; Rabelahatra, 1982; Geiger, 1983 a,b; Watanabe *et al.*, 1983; Dabrowski, 1984; Dabrowski and Bardega, 1984). By using a combination of live food and artificial food, some research workers (De Silva and Weerakoon, 1981; Lubzens *et al.*, 1984) obtained superior growth rates. Lubzens *et al.* (1984) indicated further that an oversupply of the rotifer *Brachionus plicatilis* could reduce the growth rate of carp larvae. Msiska (1981) observed the importance of live food during the first period of growth of catfish larvae whilst Bryant and Matty (1981) showed that carp larvae larger than 9,5 mg are better able to utilize artificial diets. The importance of the mouth size of the larvae of carp species in the utilization of food items and consequently food size preferences of larvae, is pointed out by Dabrowski and Bardega (1984) and Dabrowski (1984).

The results obtained by using Ewos C10 Larvstart during the present investigation provided even better results with this artificial diet for the grass and silver carps than was obtained by Hecht and Viljoen (1982) for the common carp. Even so, the results described here showed clearly that live food is superior to this specific formulated fish larval feed.

It must be pointed out, however, that Hecht and Viljoen (1982) made use of extremely high densities of larvae (250 to 400 larvae per litre of water) which may have affected their growth results. The densities of larvae maintained by the present authors, namely 3 to 4 larvae per litre correspond with densities normally maintained when larvae are stocked in outside rearing ponds. Prior preparation of such ponds for the development of rotifers ensures a survival rate of fish juveniles which usually exceeds 40 to 60%. This practice of pond rearing of larvae after an initial 10 to 14 day rearing period in the hatchery, yielded not only the best results in the eventual larval survival and growth, but also facilitated successive induced breeding programmes of the

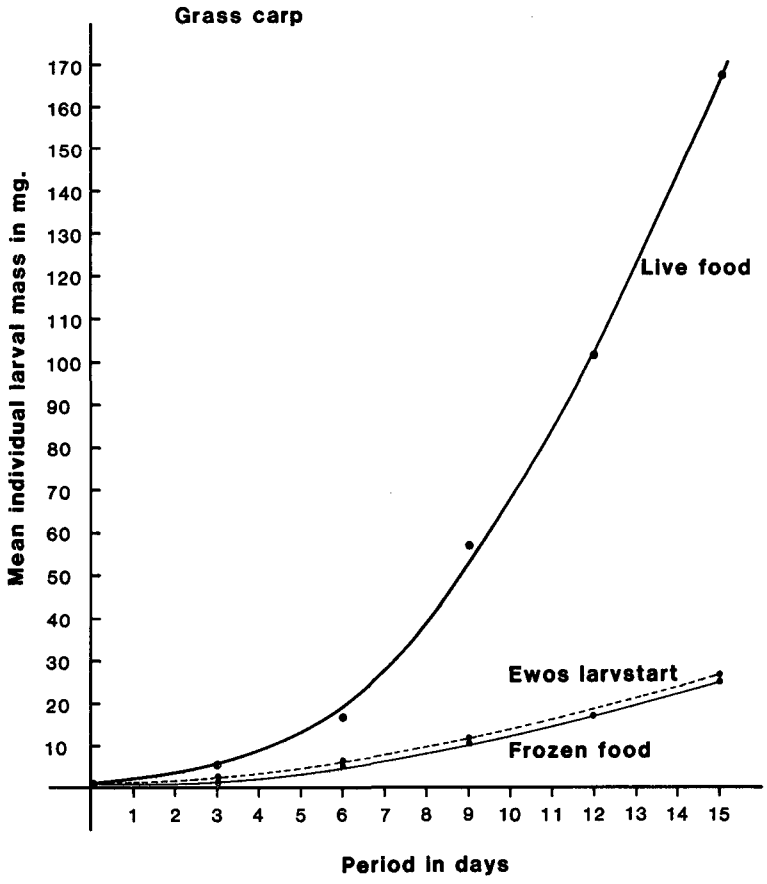

Figure 3
Growth curves of larvae of the Chinese grass carp fed on live, frozen and artificial feed.

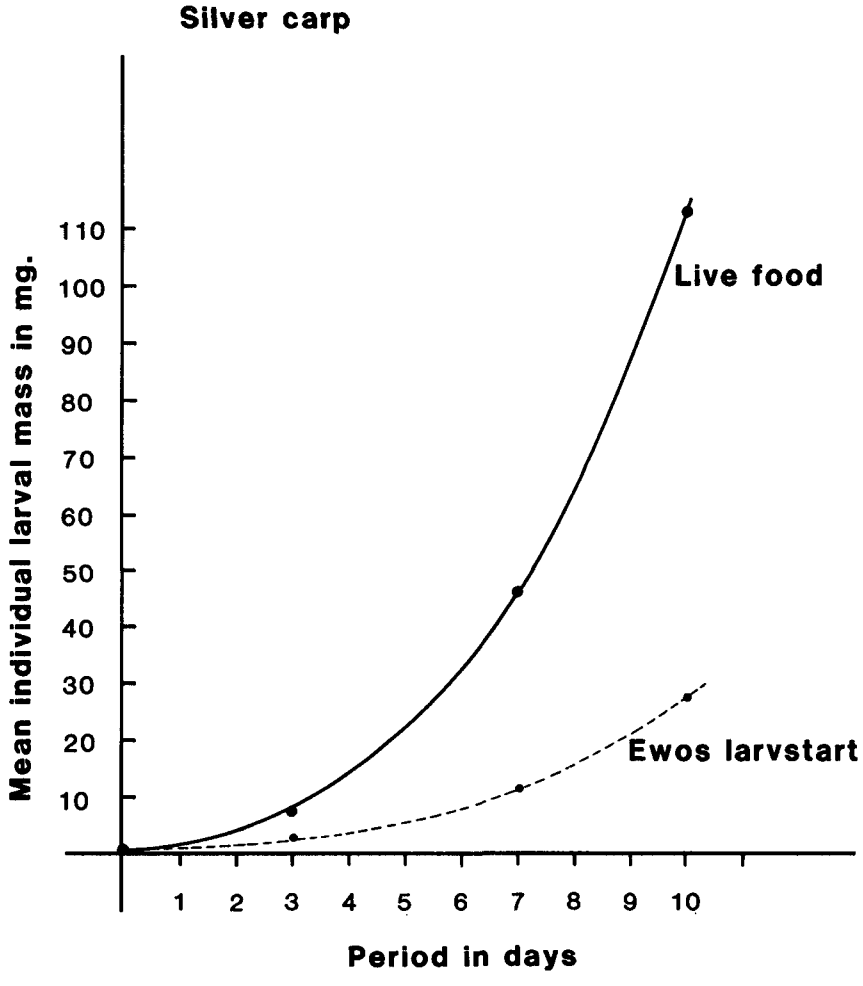

Figure 4
Growth curves of larvae of Chinese silver carp fed on live and artificial feed.

various fish species kept at the Umtata Dam Fish Research Centre.

The present system of larval rearing in Transkei must be regarded as unsophisticated and relatively inexpensive. Natural production of rotifer cultures (*Keratella* spp.) is achieved by using organic and inorganic fertilizers. The relatively expensive and sophisticated maintenance of pure cultures of algae and rotifers is thus not necessary. Furthermore, sufficient live food is produced during the spawning season to rear large numbers of larvae within the limited available laboratory and pond space.

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