Observations on the Suitability of Various Dry Feeds for the Commercial Rearing of Carp, *Cyprinus carpio* Larvae in South Africa

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Abstract

The suitability of blood and carcass meal, fishmeal and Torula yeast *(Candida utilis)* combinations was tested as an initial feed for *Cyprinus carpio* larvae during a ten day feeding trial. Growth rates and condition factors obtained with these feeds were compared with Ewos C_{10} "Larvstart" (a new feed for carp larvae). Results obtained showed that larvae could be reared as successfully and considerably cheaper with the various feed combinations than with "Larvstart".

The induced spawning of *C. carpio*, larval rearing techniques, larval mortality and the effect of the feeds on water quality are discussed. Preliminary recommendations for the rearing of carp larvae in southern Africa are made.

Introduction

The Aishgrund carp, *Cyprinus carpio* L., is one of the most commonly used species in intensive fish husbandry in most parts of the world. Intensive research on the rearing of carp larvae (immediately after hatching) for an initial period, before transfer to ponds, has been carried out in Europe and Israel (Imam, 1972; Appelbaum, 1976 & 1977; Kainz, 1974 & 1976; Mires, 1976; Lukowicz, 1977 and Appelbaum and Dor, 1978).

Appelbaum (1977) and Appelbaum and Dor (1978) clearly showed that carp larvae can be reared as successfully with dry feed, if not more so than with live food such as plankton. In Sweden a dry feed (Ewos C_{10} "Larvstart") has recently (1979) been specifically developed for carp larvae as an alternative to the larvae of the brine shrimp, *Artemia salina*, generally used there to rear carp larvae.

Except for some minor trials at Marble Hall Fisheries Station in the Transvaal (Schoonbee, 1981) no such studies on carp larvae have thus far been undertaken in South Africa. The only study conducted on larval feeding in South Africa was by Hecht (1981) who reared *Clarias gariepinus* larvae on an experimental basis. The first aim of this study was to obtain some information, using dry feeds (specifically locally manufactured products), on the successful nursing of carp larvae under local conditions. The second aim was to compare the growth rate when using these products with the growth rate when "Larvstart" is used, with a view to

- cutting the cost of primary nursing of fish larvae;
- avoiding the dependence on imported fish feeds; and
- testing the suitability of the locally available products as a fish food.

For the purpose of the experiment larvae were obtained by artificially inducing adult fishes to spawn by hormonal treatment. The induced spawning techniques employed are briefly referred to below.

Selection of Spawners and Induced Spawning

Adult fishes were obtained from the Chuniespoort Dam near Pietersburg. Aishgrund carp were introduced into this dam from Marble Hall in 1977. Three fishes of each sex, which were judged to be sufficiently mature, were transported back to the laboratory. The fishes were kept in plastic tanks maintained at 870 ℓ capacity, with a continuous flow of 600 ℓ/h of untreated dam water. The males were kept together in one tank whereas the females were kept in separate tanks. All tanks were covered with 27 mm netting material to prevent the fishes from jumping out.

Six hours prior to hormonal treatment the fish were disinfected in 25 mg 40% formalin per litre of water for a two hour period. Schoonbee *et al.* (1978) emphasized the necessity of such treatment prior to hormonal treatment and spawning.

To induce spawning the female fishes were injected with a combination of Human Chorionic Gonadotrophin (HCG) (sold under the tradename of Pregnyl) and common carp pituitary gland extract (PGE). HCG is known for its follicle stimulating hormone characteristics and PGE for its luteinizing hormone characteristics. The glands were prepared for injecting by homogenizing them in 1,5 mℓ of a 0,9% sterile physiological saline solution. As a final injection all females received 5 IU Oxytocin per kg spawner. Males were injected with two similar doses of PGE as the females at the same time as the females received this treatment. Dosage volumes in all cases did not exceed 2 mℓ.

Female 1, which received an initial dose of 400 IU HCG followed 12 h later by two dosages of PGE (0,3 gland per kg and 1 gland per kg, 6 h apart) and a single dose of Oxytocin (5 h after the last PGE injection), was stripped of 1 100 mℓ of eggs (approximately 935 000 eggs according to Woynarovich, 1964) 9 h after the final injection. The milt of one male was discharged over the eggs.

For fertilization to occur, eggs and milt were gently mixed with a plastic cake spoon for 5 min. The eggs were then divided into two equal portions and washed for 90 min in a 20 g/ℓ solution of full-cream powdered milk to rid the eggs of their adhesiveness. During the rinsing process the milk was decanted and replaced every 5 min. This method was found to be as effective as the method described by Woynarovich (1964). After the rinsing process was completed the eggs were transferred into two 32,25 ℓ hatching funnels (Fig. 1). Table 1 shows the conditions

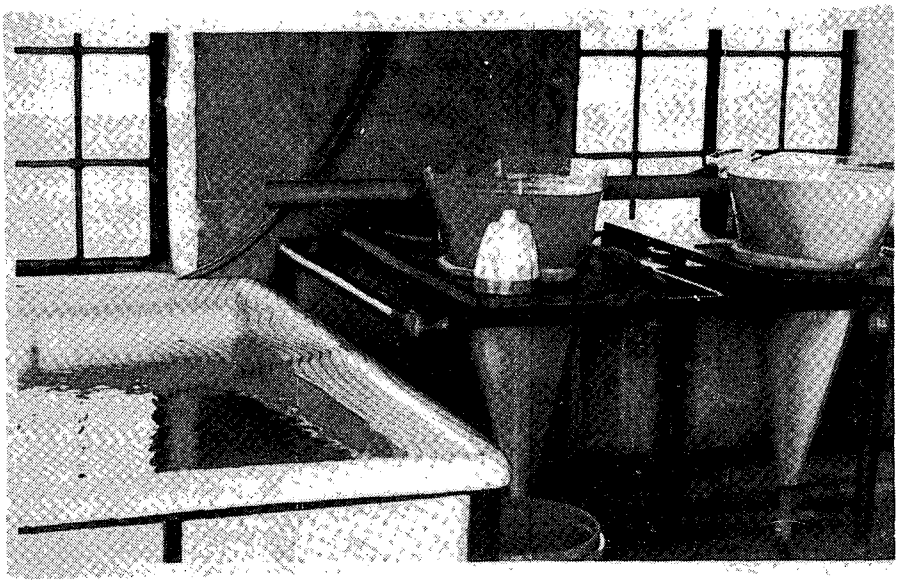

Figure 1
The 32,25 ℓ hatching funnels used for incubating the eggs and the run-off system into the 1 000 ℓ plastic bins

TABLE 1
WATER CONDITIONS AND FLOW RATE THROUGH HATCHING FUNNELS DURING EGG INCUBATION

Temperature °C	20,7 ± 0,99
O_2 % saturation	71,2 ± 0,21
pH	Constant at 8,8
Conductivity mS/m	89 ± 1,41
Water flow rate ℓ/min	3,75 ± 0,35

of the water under which the eggs were incubated in the funnels.

During the incubation period the eggs were treated with Malachite Green to prevent mould formation on dead eggs. The Malachite Green was administered by injecting a concentrated solution of this compound into the funnel supply hose. The solution was instantaneously diluted and then moved through the eggs. This treatment was repeated every 10 h.

The larvae started to hatch 78 h after fertilization. Hatching success was determined to be in the region of 65 %. The larvae were transferred directly by means of a run-off system from the funnels into a 1 000 ℓ plastic tank (Fig. 1). Apart from the water flowing into the tank from the funnels an additional volume of 400 ℓ/h flowed through the system.

Rearing of the Larvae

The aim of rearing larvae under controlled conditions before stocking them into earthern ponds is to obtain strong and healthy larvae which would be better able to survive the natural conditions (which include predators and diseases) in the fish ponds. According to Appelbaum (1980) primary nursing of carp larvae significantly reduces larval mortality after transfer to ponds and is, therefore, of the utmost importance in any commercial fish farming venture. Mires (1976) reports mortalities of carp larvae to be as high as 70 - 100% if transferred into ponds virtually directly after hatching.

Considering that primary nursing of larvae influences final production figures, it was considered to be of the utmost importance to initiate such studies in South Africa, especially in view of the ever increasing demand for animal protein and the growing interest shown for fish farming in southern Africa by the private sector, Universities and Nature Conservation Divisions.

Material and Methods

Water systems and stocking densities

For the purpose of the experiment a total of 573 000 larvae were used. Six 115 ℓ glass aquaria maintained at a capacity of 70 ℓ were stocked at a density of 250 larvae per litre of water (i.e. 17 500 larvae per tank). An undergravel filter system was used in all tanks (Fig. 2). During the ten day tenure of the experiment 50% of the water was replaced in each tank every second day with untreated dam water. In addition two of the plastic tanks used in the spawning experiment could be maintained at a continuous flow of 600 ℓ/h. One of these tanks was stocked at a density of 250 larvae per ℓ (i.e. 180 000 larvae), whilst the other was stocked at a density of 400 larvae per ℓ (i.e. 288 000 larvae). This part of the experiment was aimed at determining the effects of higher stocking densities on larval growth. Table 2 shows the water conditions during the feeding trials.

The larvae, the food and feeding methods

At the onset of feeding the larvae were between 69 and 78 h old. The larvae were measured on millimetre graph paper with a stereo microscope at 25 x magnification. Prior to weighing the larvae, 40 specimens were dried on filter paper and their total mass determined to the fifth decimal. Care was taken at all

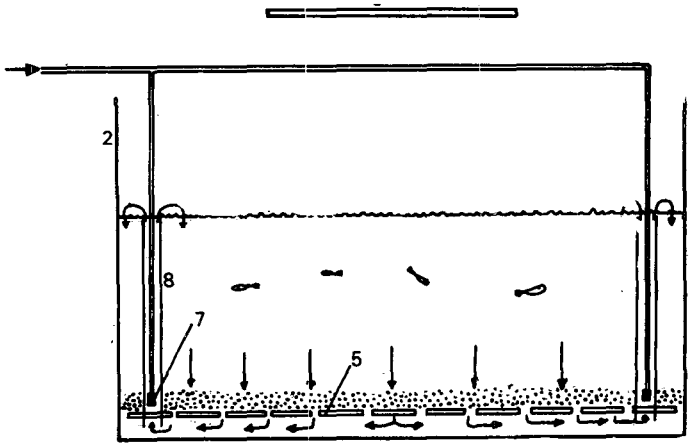

Figure 2
Schematic outlay of a 115 ℓ glass aquarium with an undergravel filter system as used for the rearing of the larvae: 1 — Air supply; 2 — Aquarium; 3 — Water level; 4 — Gravel bed; 5 — Perforated hard plastic sheet; 6 — Neon tube; 7 — Air stone; 8 — Water lift tube

TABLE 2
WATER CONDITIONS RECORDED IN THE OPEN AND CLOSED WATER SYSTEMS DURING THE TEN DAY FEEDING PERIOD

	Closed System	Open System
Temperature °C	20,9 ± 0,48	21,7 ± 0,99
O_2 % saturation	98 ± 1,5	92 ± 1,8
pH	8,2	8,8
Conductivity mS/m	89	89

TABLE 3
THE QUANTITY AND PARTICLE SIZE OF FOOD FED TO 17,500 LARVAE PER DAY

Day	Quantity (g)	Approximate Particle Size (μm)	Ewos C_{10} "Larvstart" Size Groups
1	5,6	150	00
2	7,0	150	00
3	8,4	150	00
4	9,8	150 — 200	00 + 0
5	11,2	200	0
6	11,2	200	0
7	12,6	200	0
8	14,0	200	0
9	15,4	200 — 350	0 + 1
10	15,4	350	1

times that the drying times were of equal duration. Similarly for the length determinations a sample of 40 larvae were used each time. During the ten day tenure of the experiment the larvae were measured for length and weighed on four different occasions at approximately the same time of day.

The larvae were fed for 18 h per day with a 6 h interval (02h00 — 08h00) during which they received no food. This interval was incorporated as various workers have found the growth of fish larvae to be significantly faster with such an interval (Appelbaum *et al.*, 1980). Matlak and Matlak (1976) observed an increased feeding activity of carp larvae in nursery ponds during the day. The feeding tanks were therefore kept under 24 h neon illumination (Appelbaum and Dor, 1978).

The quantities (according to the Ewos Fishfeed Programme, 1980) and particle sizes of food offered to the larvae are shown in Table 3. The food was supplied to the larvae using automatic feeders (Fig. 3) as well as by hand *ad libitum*.

The following six feed types were fed to the larvae:

Group 1 — Plankton rich sewerage water, obtained from sewerage ponds which consisted primarily of *Daphnia pulex*.
Group 2 — Blood and carcass meal (B & C).
Group 3 — An equal mixture of B & C and Torula yeast *(Candida utilis)*.
Group 4 — An equal mixture of fishmeal and Torula yeast.
Group 5 — Torula yeast (*C. utilis* grown on molasses)
Group 6 — Ewos C_{10} "Larvstart".

Zooplankton was included as a feed type as it constitutes the natural food of carp larvae (Matlak and Matlak, 1976) and would therefore serve as a control food.

Prophylactic treatment of the larvae during the feeding trial consisted of two hourly treatments with 25 ppm "Furanace" prior to the 50% water change every second day.

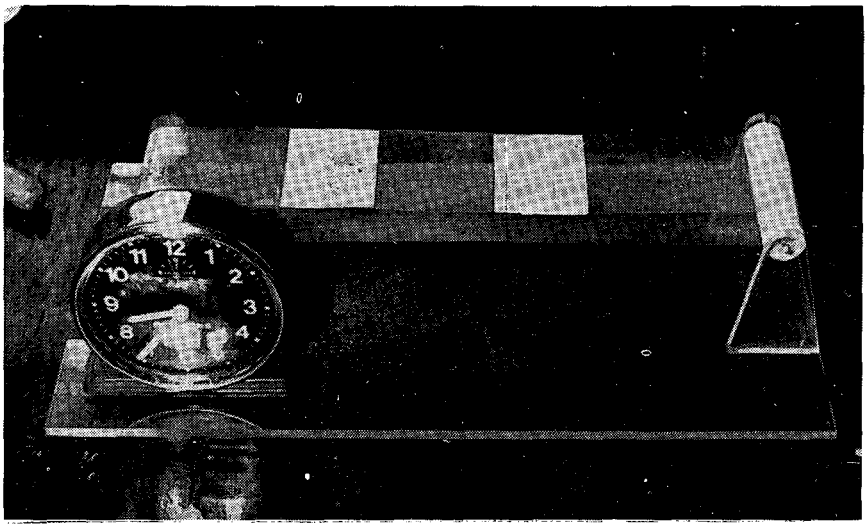

Figure 3
An automatic alarm clock operated feeder

Results and Discussion

General

The experimental conditions stimulating the intake of dry food as described by Appelbaum (1977) were met. These included continuous water turbulence and illumination of the experimental tanks. All dry feeds offered to the larvae sank to the bottom at a slow rate, meeting one of the requirements of a suitable substitute feed for carp larvae (Appelbaum, 1976).

All feeds were readily taken by the larvae from the beginning of food intake. It was observed that the larvae fed mostly in the water column and to a lesser degree from the bottom of the tank. Food was not taken from the water surface. This behaviour can be expected as common carp larvae are initially predacious, feeding mainly on zooplanktonic organisms in midwater and only later become benthic omnivores (Appelbaum, 1976; and Matlak and Matlak, 1976).

Effects of the different feeds on water quality

In all tanks in which the larvae were fed on dry feed the left over food had to be siphoned off every second day to avoid fungal development on the non-ingested food particles.

In the recirculating aquaria the various feeds had the following effects during the ten day tenure of the experiment:

Plankton rich water — water slightly green but clear, no visible fungal formation.

Torula yeast — water clear, slight fungal formation after seven days.

Ewos C_{10} "Larvstart" — water clear, no visible formation of fungus.

Fishmeal and Torula yeast — water clear, slight fungal formation after seven days.

B & C and torula yeast — water became slightly discoloured after two days. Discolouration became more acute after four days. Fungal growth started to appear after two days. Special attention was therefore paid to this tank as far as cleaning and prophylactic treatment was concerned.

B & C — Using this feed, fungal growth was more acute than with B & C and Torula yeast. On day two the water was already as discoloured as on day four for the last mentioned feed combination. From day four onwards heavy mortalities occurred daily and on day eight all the larvae in this group were dead.

In the "open system" plastic tanks, in which the larvae were fed with B & C, fishmeal and Torula yeast, there was no sign of fungal formation or water discolouration. These ideal conditions were probably due to the water flow of 600 ℓ/h.

Mortality

Table 4 shows the accumulative daily percentage mortality for each feeding programme. Mortalities in the two open system trials were not determined but were regarded to be negligible after removal of the larvae from these tanks after ten days.

From the data presented in Table 4, it can be concluded that the mortalities in all feeding programmes, except in Groups 2 and 3 were negligible and can be considered acceptable. As mentioned in the previous section these were also the two groups in which fungal growth was most prolific. It appeared that if the larvae come in contact with the mould on food particles they are infected and resultingly die. However, the larvae grew well in both length and mass on blood and carcass meal. This particular feed as well as all other feeds will therefore be sterilized during the next primary nursing trials, which should eliminate the deleterious effect that the feeds presently have on water quality.

Growth of the larvae

The mean total length and mass of the larvae prior to first food intake were 6,26 ± 0,25 mm and 1,17 ± 0,27 mg respectively. Both length and mass were determined as Appelbaum (1977) found carp larvae to increase in length even when receiving no

TABLE 4
THE ACCUMULATIVE DAILY PERCENTAGE MORTALITIES OF LARVAE IN THE VARIOUS FEED GROUPS

Groups	1	2	3	4	5	6
Day	Plankton	B & C Meal	B & C Meal and yeast	Fishmeal and yeast	Yeast	Ewos C_{10} "Larvstart"
1	0,02	0	0	0,03	0	0,05
2	0,08	0,50	0,30	0,10	0	0,06
3	0,08	2,25	0,30	0,10	0,02	0,06
4	0,08	10,85	0,62	0,10	0,14	0,06
5	0,12	36,87	1,14	0,10	0,14	0,06
6	0,12	83,94	1,14	0,17	0,14	0,06
7	0,13	97,71	1,20	0,18	0,16	0,07
8	0,14	100	1,20	0,26	0,16	0,18
9	0,18		1,20	0,26	0,18	0,18
10	0,18		1,51	0,29	0,18	0,18
Total Actual Mortalities	32	17,500	264	50	32	31

food, and therefore stated that mass is a more reliable parameter on which to base conclusions. As the aim of the entire exercise of primary nursing is to rear larvae which are better equipped to withstand natural pond conditions than larvae introduced into ponds directly after hatching, it was decided that the condition factor (CF = 100 Mass/L^3) would be the best parameter upon which to judge the "fitness" of the larvae before stocking them into ponds. Other workers (Kainz, 1976 and Appelbaum, 1977) have also used the condition factor as a parameter to judge the "fitness" of carp larvae. Due to different weighing procedures the condition factor values could not be compared.

Figs. 4 and 5 show the growth of the larvae in length and mass and Fig. 6 shows the CF increment over the ten day period. From graph 6 in Figs. 4 and 5 the Ewos "Larvstart" feed appears to be the most suitable feed, throughout the ten day rearing period. However, it is felt that these results are somewhat misleading. The condition of the larvae as shown in Fig. 6 suggests that either Ewos "Larvstart" (graph 6) or blood and carcass meal (graph 1) can be fed to the larvae from day 0 (start of feeding) up to day 5 (Phase 1). With both these feeds the larvae attain a mean condition factor value of 0,60. During this period plankton is the third alternative. Table 5 shows the composition of the various feeds.

From day 6 to 8 the only two groups showing an increase in their condition are the Torula yeast and fishmeal and yeast groups (graphs 4 and 5 — Fig. 6). All other groups show a decrease in their condition during this period (Phase 2). From day 8 onwards (Phase 3) the fishmeal and yeast appears to be the best feed combination.

The present results of growth in length compare favourably with the results of similar experiments conducted both in ponds and under controlled conditions by other workers (see Table 6).

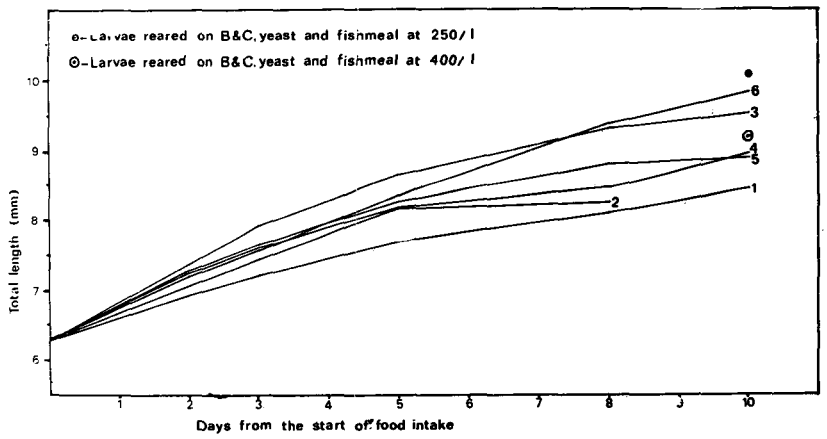

Figure 4
The growth in length of ***Cyprinus carpio*** *larvae reared on different feeds (1 — 6): 1 — Plankton; 2 — Blood and carcass meal (B & C); 3 — B & C and Torula yeast; 4 — Fishmeal and Torula yeast; 5 — Torula yeast (**Candida utilis**); 6 — Ewos C_{10} "Larvstart"*

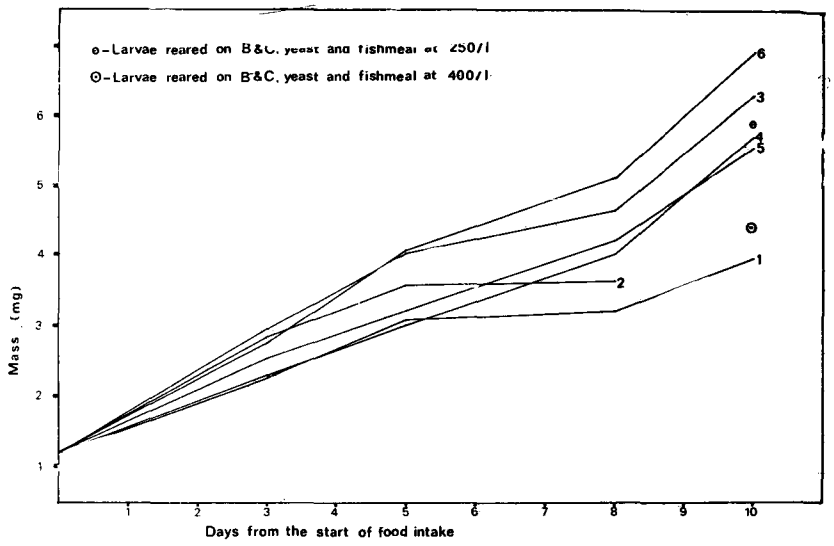

Figure 5
The growth in mass of Cyprinus carpio *larvae reared on different feeds (1—6): 1 — Plankton; 2 — Blood and carcass meal (B & C); 3 — B & C and Torula yeast; 4 — Fishmeal and Torula yeast; 5 — Torula yeast* (Candida utilis)*; 6 — Ewos C_{10} "Larvstart"*

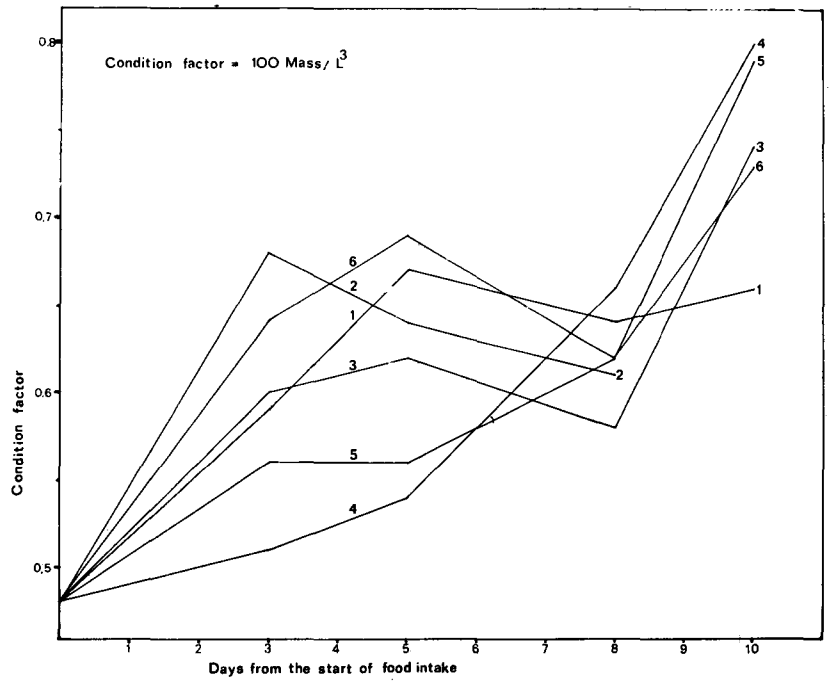

Figure 6
The condition factor increment of Cyprinus carpio *larvae during the 10 day primary nursing trial with different feeds (1—6): 1 — Plankton; 2 — Blood and carcass meal (B & C); 3 — B & C and Torula yeast; 4 — Fishmeal and Torula yeast; 5 — Torula yeast* (Candida utilis)*; 6 — Ewos C_{10} "Larvstart"*

TABLE 5
THE PARTIAL PERCENTAGE COMPOSITION OF THE VARIOUS DRY FEEDS

	Fishmeal	B & C Meal	Yeast	Ewos C_{10}
Moisture	9,8	8,5	7,0	9,0
Protein	70,1	58,5	51,0	58,0
Fat	11,4	18,4	2,5	4,5
Fibre	0,2	0,2	0	0,5
Calcium	3,59	3,42		Vit. & Minerals added
Phosphorus	2,04	1,95	3,7	

TABLE 6
COMPARATIVE GROWTH RATES OF *CYPRINUS CARPIO* LARVAE

Author	Feeding Period (days)	Total Length (mm)
*Saadi, 1965 (Spawning ponds)	12	13,8
*Saadi, 1965 (Nursery ponds)	12	18,4
*Saadi, 1965 (Ponds)	12	10,5
*Schäperclaus, 1967	7–9	6,0–10,0
*Schlaperclaus, 1967	10	13,5
Imam, 1972 (Concrete ponds)	7	9,0
Imam, 1972 (Concrete ponds)	14	22,0
**Woynarovich & Kausch	12	10,0
Appelbaum, 1976 (lab.)	7	9,2
Appelbaum, 1976 (lab.)	12	10,9
Appelbaum, 1977 (lab.)	10	11,4
Appelbaum, 1977 (lab.)	10	11,2
Appelbaum & Dor, 1978 (lab.)	10	10,4
Appelbaum & Dor, 1978 (lab.)	10	9,0
Kainz, 1974 (lab.)	15	12,0–15,0
Kainz, 1976 (lab.)	10	8,5
Mires, 1976 (lab. tanks)	32	14,0
Mires, 1976 (lab. tanks)	24	12,0
Mires, 1976 (lab. tanks)	20	11,5
Present results (x length)	10	9,3
Present results (max. length)	10	9,8

* fide Appelbaum, 1977
**fide Kainz, 1974

From the data of larval growth obtained at different stocking densities in the "open systems" but fed on the same food (i.e. B & C, fishmeal and yeast in equal proportions) and under similar conditions, it follows that the larvae reared at a density of 250 per litre were significantly larger and heavier ($P < 0,01$) after ten days, than the larvae reared at 400 per litre (Figs. 4 and 5). The larvae reared at 400 per litre also had a poorer condition (0,53) than the larvae reared at 250 per litre (0,58). From these results it may possibly be assumed that a density of 400 per litre is above the optimum density at which carp larvae can be reared.

Summary, Questions, Cost Considerations and Preliminary Recommendations

From the present results indications are that products such as blood and carcass meal, fishmeal and Torula yeast can be used with the same degree of success as a first feed for carp larvae as Ewos C_{10} "Larvstart".

A number of questions regarding the primary nursing of carp larvae have arisen as a result of these investigations. These will have to be considered and dealt with in future primary nursing trials.

What are the basic dietary requirements of the larvae during the various stages of their development during the primary nursing period? Apart from determining the optimal feed during the various developmental larval stages, Appelbaum (1980) also stresses the need for experimental work to determine the optimal aquarium/hatchery conditions.

What should the duration of the primary nursing period be? Appelbaum (1977) in this regard mentioned that larvae with a length between 10 and 12 mm are sufficiently "robust" to be stocked into plankton rich ponds and to survive the natural conditions in temperate regions. In warmer and sub-tropical regions he suggests that larvae should be larger than 12 mm before introducing them into nursery ponds. Mires (1976) found mortalities negligible in nursery ponds after the larvae had been raised for up to 32 days under controlled conditions. Conversely he also mentions mortality figures of between 70 and 100% if larvae are stocked into ponds too soon after hatching. Experiments to determine the length of this period for southern African conditions are extremely necessary and will have to receive attention.

As set out in the introduction one of the aims of this investigation was to use locally produced products to eliminate the importation of fish feed and at the same time to reduce the cost of fish fry production.

Tables 7 and 8 are comparative tables of the unit cost of the various feeds and of the cost of rearing larvae respectively. From the figures presented in Tables 7 and 8 it follows that a mean saving of 96% can be achieved when using locally produced products. Such a saving is of considerable importance to commercial hatcheries.

TABLE 7
UNIT COST OF THE VARIOUS FEEDS IN S.A. RAND

Food	Unit cost/25 kg
Blood & carcass meal	R 4,75
Fishmeal	R 11,75
Torula yeast	R 53,13
Ewos C_{10} "Larvstart"	R427,73

TABLE 8
COST OF FRY PRODUCTION IN CENTS

Feed Type	Cost of Feeding 17,500 Larvae for 10 days	% Saving Compared to Ewos C_{10} "Larvstart"
B & C meal	2,1	99,4
B & C meal and yeast	12,7	96,6
Fishmeal and yeast	14,3	96,2
Torula yeast	23,4	93,8
Ewos C_{10} "Larvstart"	376,4	

The following tentative recommendations as regards the commercial rearing of carp larvae (for an initial period of 10 days) under local conditions can be made, based on the findings of the present investigation:

1. Stocking density should not exceed 250 larvae per ℓ of water.

2. Water temperature should be above 21°C (Ewos Fishfeed Programme, 1980 recommends a temperature of 25°C).

3. Food must be sieved into various sizes (see Table 3) during the nursery period. This prevents fouling of food particles which are either too big to be ingested or too small for the larvae to notice.

4. The larvae should be reared in large containers (up to 1 000 ℓ capacity and preferably made of plastic as these are easy to handle and are robust. These tanks should have a through flow water system. For the purpose of aeration the water should be let into the system by way of a shower, at a minimum rate of 350 ℓ/h for a 1 000 ℓ container. A circulation of water should be established with the shower inflow. By this method the water is also kept slightly turbulent, which according to Appelbaum (1977) is one of the requirements for the good intake of food by the larvae.

5. To prevent larvae from being removed by overflow water from such open system tanks it was found best to fix fine mesh curtain gauze across one of the corners from the bottom of the container to the top. A swivel arm pipe can then be inserted into the bottom of the cordoned off triangular area. The swivel arm is then used to regulate the water depth.

6. All food given to the larvae should be sterilized in order to avoid fungal formation as much as possible.

7. From the first day of food intake up to day 5 the larvae should be fed on sterilized blood and carcass meal, whereafter they should gradually be changed over to an equal mixture of fishmeal and Torula yeast up to day 8 and kept on this diet up to day 10.

8. If a good supply of plankton rich water is available it is strongly suggested to add up to 2 ℓ of such "green water" to the tanks per day.

9. To avoid mould formation food remains must be siphoned off the tank substrate every day.

10. The larvae should be treated with 25 ppm "Furanace" every third day for a period of up to two hours.

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