Investigations into the Effects of Volume of Water Flow, Quality of Feed and Type of Feeding on the Production of the Aischgrund Common Carp, *Cyprinus carpio* in Circular Concrete Ponds Under High Stocking Density Rates

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Abstract

High density production studies in circular concrete ponds were conducted with the Dinkelsbühl Aischgrund variety of the common carp, *Cyprinus carpio*, at the Lowveld Fisheries Research Station at Marble Hall. Fish pelleted feeds with different protein content were applied either by hand or by demand feeders to ponds with different volumes of water flow, and the effect of both methods determined on fish growth. The results clearly showed the value of high protein content pelleted feed in fish production when used in concrete ponds. In addition, a slight increase in water flow from 1 to 3 *l*/s through the ponds, resulted in a major improvement on the production capacity of this type of pond.

Introduction

The culture of the common carp, *Cyprinus carpio* L., has been practised in Germany, Hungary and Poland for centuries (Huet, 1970; Bardach, Ryther and McLarney, 1972) and in Palestine (now Israel) since 1932 (Hornell, 1935). In Israel, freshwater fish culture with *C. carpio* (initially as the only species used) developed over a period of about thirty years into a major industry with pond fish produced in 1976 already exceeding 13 000 tons per annum (Schoonbee, 1979).

It was only since the early nineteen fifties that the Transvaal Division of Nature Conservation for the first time started to investigate the possibilities of freshwater fish farming in the Transvaal (Kruger, 1975). At first, the freshwater tilapia *Sarotherodon mossambicus* (= *Tilapia mossambica* Peters), indigenous to the Transvaal, was investigated in pond fish production experiments by Lombard (1956, 1963, 1965a, 1966a) and Van der Waal (1970). In October 1959 a breeding stock of the Dinkelsbühl variety of the Aischgrund common carp (*C. carpio*) was imported from Germany and acclimatized at the Lowveld Fisheries Research Station at Marble Hall for farming purposes (Lombard, 1961). Production studies with the common carp commenced at Marble Hall in 1961, initially under low stocking density conditions with maize rice as the supplementary feed (Lombard, 1961, 1965b; Van der Waal, 1975). In recent years, high stocking density production of the common carp could be effected through the use of high protein pelleted feed (Kruger, 1978). Even though good results were obtained, the volume of water and pond space used to produce a certain tonnage of fish were relatively high, compared to conditions in

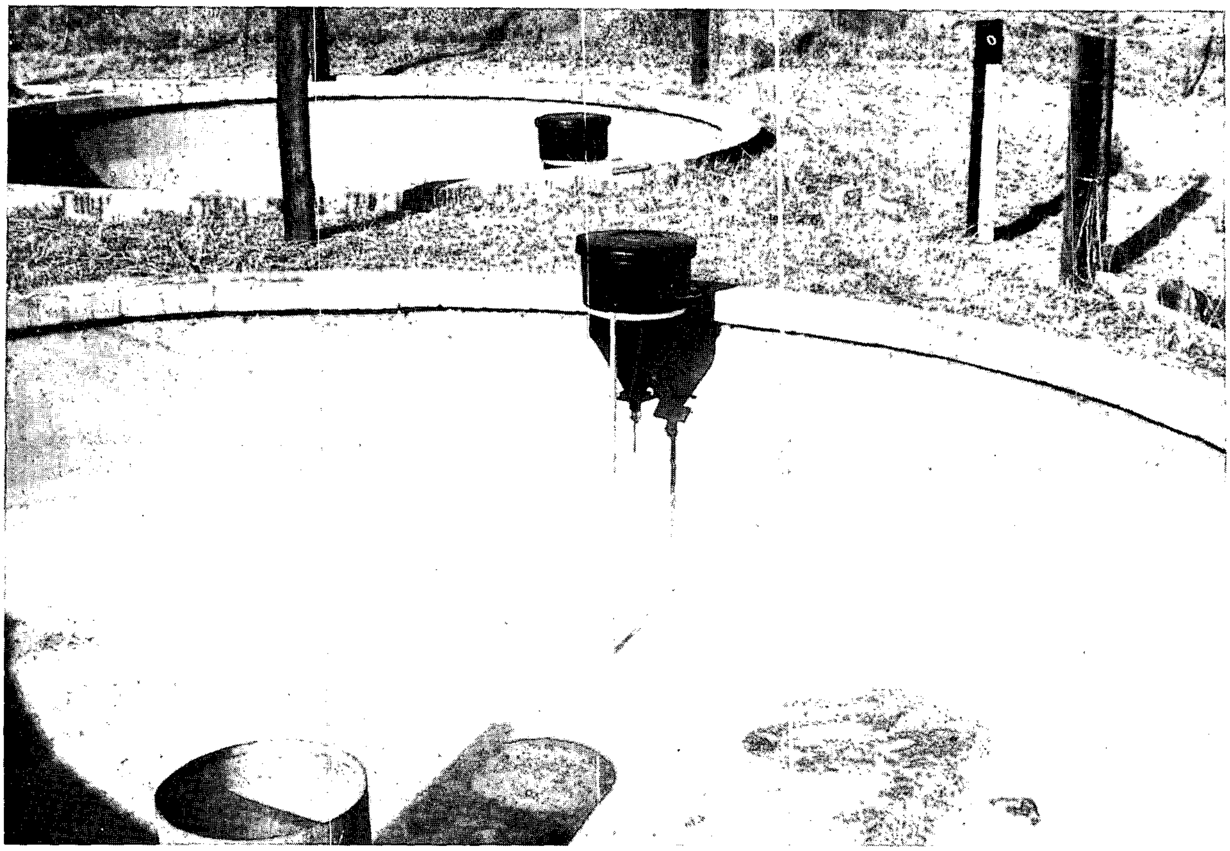

Figure 1
Circular concrete pond with demand feeder installed

countries such as Israel. However, one of the major problems in South Africa is the overall shortage of water for agricultural use, which often results in a competition for water needed in fish production and in agricultural crop production.

The present approach, in which circular ponds are used for fish production and where water is first passed through fish ponds after which it can be used for irrigation, must be seen as a compromise between aquaculture and agriculture with the additional advantage that the same water can be used for both purposes. The more efficient utilization of water in the production of food in a country like South Africa, where the precipitation can be very low at places and where water is a precious commodity, needs serious consideration.

The present series of experiments is primarily aimed at the reuse of potable water and at the actual saving of water in intensive pond fish production. Circular ponds, where water could be supplied in variable volumes, were used for carp production under different stocking densities and with different types of protein pelleted supplementary feeds.

The investigations were carried out during two consecutive summer seasons of 1974—1976. During the first season growth experiments were done with the common carp as the experimental fish in three different concrete ponds, with the same fish densities and volumes of flow through the ponds, but with different protein contents of pelleted fish feeds as well as the methods of feeding. During the second season, the stocking densities were kept the same but the volumes of flow of water differed for each of the three ponds used, in order to determine the possible effects of volume of flow, if any, on the growth performances of the carp. Feeding in all three ponds was done with demand feeders so that unlimited feed was theoretically available in each pond for 24 h/d. This specific study was conducted in the same three ponds that were used in the first investigation, where the quality of feed and the method of feeding was studied.

Description of the Study Area and Ponds Used

The Lowveld Fisheries Research Station at Marble Hall lies within the area of confluence of the Elands and Olifants River Basins, at an altitude of 823 m above sea level. It is situated approximately 200 km N.E. of Pretoria (latitude 25°S, longitude 29°15'E). The climate of Marble Hall is of a subtropical nature. Rainfall occurs during the warmer months of the year, from September to May, with a maximum precipitation between December and February (midsummer).

Water used in the fish ponds was obtained by canal from the Loskop Dam Irrigation Scheme, approximately 90 km from the Research Station. Water is first collected in a storage pond from where a canal takes it to the circular ponds. As mentioned before, the construction of the ponds is of concrete, each with a 16,1 m^3 holding capacity. From the canal, water is piped to the ponds where the flow to each one can be manipulated by means of a valve. The water enters the ponds at a height of 600 mm above the water overflow level so that some form of oxygenation is effected through the fall of the water into the pond. The angle of entry of the piped water into the pond causes a clockwise rotation of the pondwater of approximately 0,1 m/s. This allows for the accumulation of wastes along the centre of the pond assisted by a gentle slope in the pond floor towards the centre and the pond outflow. Waste material in the ponds is siphoned off through the outlets by the use of a double walled pipe system with the outer pipe, which surrounds the inner outlet pipe, extending above the water surface and being open at the bottom. A circular, non-corrosive sieve of 3 mm mesh size was placed around the outlet system so that fish could not escape with the water.

Experimental Procedures

Experiments during the first season

Each of the experimental ponds was stocked with 1 000 Aischgrund carp fingerlings with a mean mass of 13,9 g, giving a fish density of 62/m^3 of pond water. Two types of feed were used namely standard trout pellets containing 42% protein, which were administered in ponds 1 and 2, and in pond 3, a 25% protein pellet specifically developed as feed for the common carp. The fish were fed by hand in all three ponds until the 40th day, when a demand feeder of the ball and pendulum type (Fig. 1) was installed in pond 2. During the period of hand feeding the 25% adjustment of feed:fish ratio was determined by the biweekly sampling of each pond of a 10% sample of the original stocking density of fish.

In the pond with the demand feeder (pond 2, Table 1), the carp soon acquired the technique of operating the feeder and hand feeding was discontinued for this pond. The volume of flow to all the ponds was 1 ℓ/s, giving a retention period of 4,5 h for the water in the ponds. In order to prevent birds and other predators from removing fish from the ponds they were enclosed by wire mesh soon after the experiment started. The duration of the experiment was 137 d. Results on the fish:feed ratio and calculated feed production cost for each type of treatment in this experiment are summarized in Table 2.

TABLE 1
PRODUCTION DATA FOR THE COMMON CARP IN CIRCULAR CONCRETE PONDS, DURING WHICH DIFFERENT TYPES OF FEED AND METHODS OF FEED APPLICATION WERE INVESTIGATED

Pond no.	Stocking data				Cropping data					Production	
	Date	No. of fish	Total Mass (kg)	Unit Mass (g)	Date	No. of fish	Loss %	Total Mass (kg)	Individual Mass (g)	Total (kg)	Unit (g)
1	2/1/74	1 000	13,9	13,9	20/5/74	923	7,7	124,9	135	112,1	121
2	2/1/74	1 000	13,9	13,9	20/5/74	958	4,2	194,5	203	181,5	189
3	2/1/74	1 000	13,9	13,9	20/5/74	857	14,3	67,9	79	56,3	65

TABLE 2
TYPES OF FEED, METHODS OF FEED APPLICATION AS WELL AS FEED QUANTITIES USED FOR EACH TYPE OF APPLICATION, FEED CONVERSION INDEX AND CALCULATED COSTS IN THE PRODUCTION OF COMMON CARP IN CIRCULAR CONCRETE PONDS DURING A PRODUCTION PERIOD OF 137 DAYS: JANUARY — MAY, 1974

Pond no.	Feed			Fish:Feed ratio	Production costs per kilogram fish
	Type	Applied	Used (kg)		
1	42% protein trout pellets*	Hand feeding	368,16	1:3,3	69c
2	42% protein trout pellets*	Demand feeder	305,81	1:1,7	35c
3	25% protein special carp pellets**	Hand feeding	277,56	1:5,0	89c

* @ R21,00/100 kg.
** @ R18,00/100 kg.

Experiment during the second season

This experiment, which lasted 163 d, differed from the first in that the volume of water to the ponds was regulated to be 1, 2 and 3 ℓ/s, respectively. As in the experiments of the first season, each pond was originally stocked with 1 000 Aischgrund carp but in this case, the mean mass per fish was 95 g. The stocking density in all three groups was 62/m^3. Since the experiment of the second season commenced during the onset of spring and thus during the early spawning season of the carp in the Marble Hall area, there were no fingerlings available at that stage of sizes similar to that of the 13,9 g per fish of the first season. Fingerlings from the previous season had, therefore, to be used in this trial. The fish had an average mass of 95 g and this was an advantage in that they were strong enough to better survive possible attacks of parasites. Due to an unforeseen blockage of piped water to the ponds early in September, cropping of the fish had to be done in all three ponds and results analysed, after which the experiment was continued with new fish. The experiment was terminated in February, 1976 (Table 2). The necessary calculations on feed conversion ratio, individual and total mass gains for the fish in each pond were then made. Results of this experiment are presented in Tables 3 and 4. The respective growth curves of the fish during the second season, from ponds 1, 2 and 3 are presented in Fig. 2. The data used to construct the growth curves was based on 20% of the total population sampled fortnightly.

TABLE 3
PRODUCTION DATA ON THE AISCHGRUND COMMON CARP IN CIRCULAR CONCRETE PONDS RECEIVING DIFFERENT RATES OF WATER FLOW DURING THE SEASON: SEPTEMBER, 1975 — FEBRUARY, 1976

Data	Concrete ponds used in experiment					
	Pond 1		Pond 2		Pond 3	
Volume of water flow (ℓ/s)	1		2		3	
Date at time of stocking*	3/09/75	7/10/75	3/09/75	7/10/75	3/09/75	7/10/75
No. of fish used	1 000	885	1 000	885	1 000	885
Individual mass (g)	95	143	95	141	95	155
Total mass (kg)	95	126,1	95	124,8	95	137,2
Date at time of cropping	1/10/75	19/02/76	1/10/75	9/02/76	1/10/75	19/01/76
No. of fish	997	811	998	822	979	813
% Mortality	0,3	8,3	0,2	7,1	2,1	8,1
Individual mass (g)	127	343	174	504	168	672
Total mass (kg)	126,6	278,2	173,7	413,9	164,0	546,3
Individual gain (g)	68	200	115	363	109	517
Total gain (kg)	67,6	152	114,7	289,1	105,0	407,1
Individual growth rate (g/d)	2,4	1,5	4,1	2,7	3,9	3,8

*Different sets of results for each pond relates to production prior to mass mortality due to blockage of water pipe feeding ponds and again after restocking with fish

TABLE 4
PRODUCTION FIGURES AND CALCULATED COSTS FOR CARP RAISED IN CIRCULAR CONCRETE PONDS RECEIVING DIFFERENT RATES OF WATER FLOW

Pond no.	Water supply (ℓ/s)	Period (days)	Mortalities %	Production (kg)	Feed*		
					Consumed (kg)	Fish:Feed ratio	Production cost per kg fish
1	1	163	8,3	118,7	377	1:3,2	63c
2	2	163	7,3	403,8	693	1:1,7	34c
3	3	163	10,5	514,1	714	1:1,4	28c

*Standard trout pellets (35 percent protein) @ R19,90/100 kg.

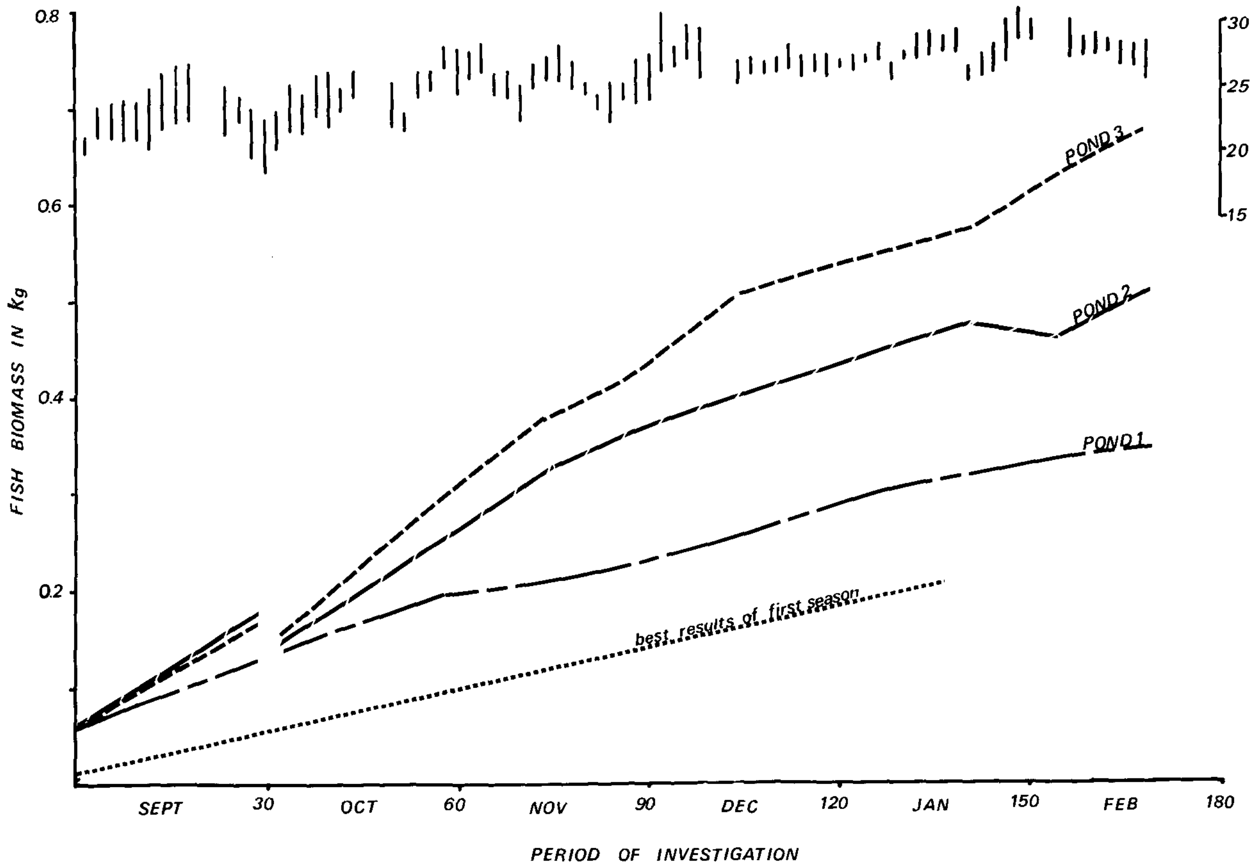

Figure 2
Water temperatures and mean fish biomass for the second season's experiments in circular concrete ponds 1, 2 and 3 over a period of 163 days compared to the best results obtained for the first season (pond 2)

Water chemistry of ponds

Water samples from the storage dam outlet and from each pond used in the second series of experiments were collected monthly for water quality analysis. Chemical analyses were performed using the Hach Direct Reading Engineers Laboratory (Model DR-EL/2), and were all based on the APHA Standard Methods (1971) test procedures. Dissolved oxygen (DO) concentrations were analyzed according to the Alsterberg modification of the Winkler titration method (APHA, 1971). Long term temperature fluctuations were recorded on a thermograph installed in an adjacent earthen pond.

Results

Possible effects on feed and feeding, growth, survival and feed conversion of carp

It can be seen from Table 1 that the percentage loss of fish in ponds 1 and 2 was reasonably low with some of the fish being lost due to routine handling procedures. In contrast, pond 3 clearly showed a marked increase in percentage loss of fish above those of ponds 1 and 2 (14,3%, Table 1). Based on the observations of the actual condition of the fish, it was concluded that the 25% protein carp pellets used here did in fact not compensate for the actual loss of natural food normally present in earthen ponds. The mortality rate in pond 3 may therefore, partly be due to some form of starvation. The dead fish from this pond were usually found to be small and very lean, pointing towards a typical undernourished condition. Investigations for parasites and other diseases did not reveal these as major reasons for the high mortality of fish encountered in pond 3.

As mentioned, the demand feeder installed in pond 2 was regularly filled while the fish in ponds 1 and 3 were fed daily by hand in two equal portions during the early morning and late afternoon. In comparing the growth performances of fish in ponds 1 and 2, which both received a 42% protein enriched pellet (Table 2), a direct comparison of the effectivity of hand feeding and continuous feeding through a demand feeder can be made. In the case of pond 1 (hand feeding) where 20% more of the same type of feed was used than in the pond with the demand feeder, the loss of fish was 7,7% as against 4,2%. In both cases, therefore, the mortality rate was not high but in this experiment it was clearly the fish fed by the demand feeder which showed the lowest total loss of fish at the end of the experiment. If the individual and total mass gains of the fish are, however, taken into consideration (Table 1), then the real difference in growth performance of the fish in pond 2 (demand feeder) can actually be appreciated. In this pond the quantity of feed administered was not only much lower than that of pond 1, but the total and individual mass gains during the period of investigation were 62% and 50% respectively higher than those of pond 1 (Table 1). Of considerable importance, however, was the feed conversion ratio for fish in these ponds (Table 2), which in the case of pond 1 is 3,3 as against 1,7 for pond 2. Costwise, this virtually implies a 50% saving in production costs by applying the same type of feed with the aid of a demand feeder as against hand feeding.

It has already been mentioned that the special 25% protein carp pellet used in pond 3 did not appear to be suitable for use in concrete ponds. The figures on mortality, total and unit mass gains shown in Tables 1 and 3 all substantiate this assumption. Apart from the higher loss of fish in this pond during the period of the experiment, the total mass gain for fish was 50% less than that of pond 1 and almost 70% lower than that of pond 2, where the demand feeder was employed. A further reason why this type of pellet is not recommended for use in concrete ponds can also be seen in the feed conversion ratio which is 5,0 and therefore, for the feed alone, fish produced would cost 89 c/kg.

The effect of different volumes of flow on survival, growth and feed conversion

Mass mortalities caused by the blockage of the pipeline to the three ponds resulted in the termination of this experiment (Table 3) which was otherwise reasonably successful with a minimal loss of fish in ponds 1 and 2 (0,3 and 0,2% respectively). The loss of fish at that stage in pond 3 was 2,1%. In the case of this pond the mortalities amongst the fish were mainly caused by the gillrot fungus *Branchiomyces* c.f. *sanguines,* which was promptly treated by bathing the infected fish in a 1 mg/ℓ Furanace solution, whilst the pond was thoroughly scrubbed with commercial Germotol disinfectant.

A comparison of the fish production in ponds 1, 2 and 3 for the first stocking experiment, which lasted for 28 days, showed the total mass gain of fish in pond 1 to be already well behind those of ponds 2 and 3 (Table 3). The relatively small difference in total mass gain in ponds 2 and 3 at the end of the first 28 days can, however, be taken as an indication of the effects of volume of flow on the production capacity of fish in the 2 and 3 ℓ/s volume of flow ponds, as the critical biomass point had certainly not yet been reached (Fig. 2).

A study of the figures obtained for the second set of fish stocked in the three ponds on 7 October 1975 again showed up the poorer mass gain of fish stocked in pond 1. It also clearly points towards the pronounced effects of volume of flow on production in ponds 2 and 3, with pond 3 (which received 3 l of water per second) clearly being superior in production for all three ponds (Table 3). This difference in mass gain between the period 7 October 1975 and 19 February, 1976 is clearly illustrated in Figure 2.

A comparison of the results for ponds 1, 2 and 3 with respect to production, feed conversion ratio and relative feed cost (Table 4), again confirms the importance of volume of flow on fish growth. Feed conversion ratios of 3,2 (pond 1), 1,7 (pond 2), and 1,4 (pond 3) were obtained, which, in the latter case yielded an extremely efficient feed conversion value with costs at the time of the experiment calculated to be less than 30 c/kg for fish produced, as compared to 34 c/kg for pond 2 and 63 c/kg for pond 3.

The results of this specific experiment, although still of a preliminary nature, underlines the importance of volume of water flow in fish production where concrete ponds are employed.

Water chemistry of fish ponds

It was only possible to do monthly physical and chemical analyses on water samples from the circular ponds during the second season's experiments (Table 5). Water temperatures (Fig. 2) were monitored with a continuous recorder at nearby earthen ponds. It was, however, found that the temperatures in the concrete ponds were generally slightly lower.

As can be seen from Fig. 2 the water temperatures largely fluctuated between 17 and 30°C with most of the temperatures above 20°C. A general increase in temperatures occurred between September, 1975 and February, 1976, with most temperatures in December, January and February above 25°C. The relatively high water temperatures during this period of the investigation were ideal for the growth of the common carp and for warm water fish in general.

TABLE 5
VALUES OBTAINED ON WATER QUALITY OF CANAL WATER AND CIRCULAR CONCRETE PONDS STOCKED WITH HIGH DENSITIES OF COMMON CARP UNDER DIFFERENT VOLUMES OF WATER FLOW DURING THE 1976—1977 PRODUCTION STUDIES

Analysis sample	Water flow ℓ/s	pH	DO	DO %	Expressed in mg/ℓ: Total Alkalinity ($CaCO_3$)	Total Hardness ($CaCO_3$)	NH_3-N	NO_3-N	NO_2-N	PO_4
Canal			10,7	135	48	67	0,15	1,80	0,003	0,227
		6,4–9,8	9,5–13,0	119–165	45–50	60–71	0–0,6	1,0–2,3	0–0,006	0,14–0,30
Pond 1	1		4,7	57	48	66	0,54	1,59	0,005	0,529
		6,4–10,0	1,0–11,0	13–129	24–60	52–72	0–1,0	0,9–2,5	0,001–0,013	0,16–1,44
Pond 2	2		5,2	64	48	69	0,70	1,64	0,011	0,602
		6,3–9,2	2,0–11,0	26–129	40–60	65–78	0–1,6	0,9–2,9	0,002–0,053	0,16–1,65
Pond 3	3		6,5	80	50	66	0,53	1,70	0,015	0,396
		6,6–9,0	4,0–11,0	52–129	50–55	65–70	0–1,81	0,8–2,2	0,003–0,060	0,12–1,00

Analysis for pH showed the water to fluctuate considerably in both the canal and pond waters from below 7 to as high as 10. It also does not appear that pH is much affected by the different volumes of water flow through the ponds. Values obtained for oxygen clearly showed the effect of the fish in decreasing oxygen concentrations. Where the canal water was constantly supersaturated with oxygen, pond 1 with a flow of 1 ℓ/s had the lowest minimum oxygen saturation value of 13%, followed by that of pond 2 (26%) and pond 3 (52%). The effect of the volume flow and, therefore, the retention of water in the ponds can clearly be seen. Values for total alkalinity and total hardness showed the water to be moderately rich in mineral content.

The effects of metabolic wastes of the fish on the ammonia concentration in the pond water can also be seen if the results for this parameter for the ponds are compared with those of the canal water. There is, however, no specific tendency as judged from the mean values calculated, but maxima for ammonia increased with volume of flow, which can most likely be associated with the increased feeding and metabolic activity of the fish where larger volumes of water and more oxygen were provided. Very little deduction can be made from the values for nitrates, but nitrite concentrations were generally slightly higher in the ponds than in the canal water, which can also be ascribed to the discharge of metabolic wastes by the fish. Similarly, phosphate values were also slightly higher in the ponds compared to values obtained for the canal water.

Discussion

The results of the first season's experiments clearly demonstrated the importance of the protein quality of the pellets when used in concrete ponds, where in contrast to earthen ponds, no natural food items were available to the carp. Where the 25% protein enriched pellet was found to be sufficient for good production results in earthen ponds (Kruger, 1978), a very poor feed conversion of 5,0 resulted in the use of this type of pellet in the concrete ponds. In contrast, the 42% protein trout pellet used in ponds 1 and 2 showed a marked improvement in the feed conversion of the carp. The value of the use of demand feeders, where not only the loss of feed through the breaking up of the pellets is minimized but also where the fish obtained smaller quantities of feed over an extended period daily, is clearly demonstrated by the good feed conversion of 1,7 as compared to 3,3 for hand fed fish. The saving of feed also contributes much to the estimated production costs of 35 c/kg of fish in the case where the demand feeder was used (Table 2).

Based on the experience of the first season's experiments on the growth of the carp, demand feeders were installed in all three circular ponds during the second season where the role of volume of flow was investigated in the fish growth experiment of the carp. In the case of this experiment the density of fish per cubic metre of water ranged between 55 and 62. The results obtained in this part of the study showed a marked difference in actual fish growth as well as feed conversion between fish in pond 1 (1 ℓ/s) and ponds 2 and 3 (2 and 3 ℓ/s), respectively, where in both cases exceptionally good feed conversion values were obtained with a best value of 1,1 for fish in pond 3.

To summarize, the present series of experiments showed the value of the use of demand feeders in the production of carp under very high densities. Furthermore, the results obtained showed that extremely favourable feed conversions of as low as 1,4 can be achieved in concrete ponds with a minimum flow of water of 3 ℓ/s. Compared to trout the Aischgrund carp, therefore, proved to be a much more efficient converter of high protein pellets under high densities, but with the added advantage of needing a much lower volume of water flow to obtain these results. By increasing the volume of flow of water to 3 ℓ/s through the circular ponds, the production potential in this type of pond could be increased from a best value of 11,2 kg/m^3 during the first season (pond 2) to 31,8 kg/m^3 (3 ℓ/s, pond 3, season 2). This compares well with earthen ponds where a good production of fish of 5 t/ha amounts to only 0,5 kg/m^3 of water.

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References

BARDACH, J.E., RYTHER, J. & McLARNEY, W.D. (1972) Aquaculture. *The farming and husbandry of freshwater and marine organisms.* J. Wiley, N.Y. 868 pp.

HUET, M. (1970) Textbook of fish culture — breeding and cultivation of fish. *Fishing News* (Books) Ltd., Surrey, England. 436 pp.

HORNELL, J. (1935) *Report on the fisheries of Palestine.* Crown agents for the Colonies, London. 186 pp.

KRUGER, E.J. (1975) *Introduction to carp farming.* Heer Printing Co. (Pty) Ltd., Pretoria. 54 pp.

KRUGER, E.J. (1978) Carp culture at increased stocking rates and with improved feeding. *S. Afr. J. Wildl. Res.* 8 25–27.

LOMBARD, G.L. (1956) *Report on the Lowveld Fisheries Research Station, at Marble Hall, Transvaal. C.C.T.A./C.S.A. 2nd Symposium on African Hydrobiology and Inland Fisheries, Brazzaville 7 pp.*

LOMBARD, G.L. (1961) The first import and production of Aischgrund carps in South Africa. Fauna and Flora 12 2–8.

LOMBARD, G.L. (1963) *Groei en produksie van derde jaar* Tilapia mossambica of Marble Hall. 1962–1963. Departmental Research Report, Transvaal Nature Conservation. 17 pp.

LOMBARD, G.L. (1965a) *Groei en produksie van derde jaar* Tilapia mossambica *op Marble Hall.* 1964–1965. Departmental Research Report, T.N.C. 13 pp.

LOMBARD, G.L. (1965b) *Groei en produksie van voorgestrekte Aischgrund karp by verskillende bemestingskwotas.* 1964–1965. Departmental Research Report T.N.C. 18 pp.

LOMBARD, G.L. (1966a) *The effect of inorganic fertilization of ponds in the production of* Tilapia mossambicus *in Transvaal.* Paper read to the Limnological Society of South Africa, Pietermaritzburg. 6 pp.

SCHOONBEE, H.J. (1979) Tendense in verband met varswatervisboerdery in Israel. *Die Visboer* 24 2–7.

VAN DER WAAL, B.C.W. (1970) *Die produksie van klein* Tilapia mossambica *in damme en bevolkings van gemengde ouderdomsgroepe.* Departmental Research Report, T.N.C. 10 pp.

VAN DER WAAL, B.C.W. (1975) Production and growth of Aischgrund carp at the Lowveld Fisheries Research Station Transvaal. *J. Sth. Afr. Wildl. Mgmt. Ass.* 5(1) 63–67.