Growth of the Chinese grass carp *Ctenopharyngodon idella* fed on cabbage wastes and kikuyu grass

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Abstract

Growth of the grass carp *Ctenopharyngodon idella* was evaluated in fish ponds over a period of 75 d using waste cabbage leaves and kikuyu grass as two alternative foods. The silver carp *Hypophthalmichthys molitrix* was included for pond management purposes. A yield of almost 2 t ha^{-1} was obtained, showing that the grass carp in particular can grow well on vegetable waste materials alone.

Introduction

Attempts in the past to establish aquaculture in South Africa were largely aimed at fulfilling the needs of the angling community or the sophisticated market (Safriel and Bruton, 1984). In recent years a number of investigations were conducted on fish polyculture in Transkei using animal wastes to supplement pelleted fish feed, thereby reducing fish production costs (Prinsloo and Schoonbee, 1984a to c; 1985). Lately, investigations were carried out on the integration of fish and vegetable production (Prinsloo and Schoonbee, 1986) and a duck-fish-vegetable integrated system (Prinsloo and Schoonbee, 1987).

During the latter investigations the need to use the weed-eating grass carp *Ctenopharyngodon idella* (Val.) as the major component in a polyculture system became evident, especially in view of the considerable amounts of unutilised vegetable wastes which are available at some of the irrigation schemes in Transkei.

In the present study the growth of the grass carp was evaluated over a period of 75 d during the summer of 1985 to 1986 using cabbage leaves and kikuyu grass as alternative foods. In this particular system one other species was also included for pond management purposes, namely the phytoplankton and detritus feeding silver carp *Hypophthalmichthys molitrix* (Val.) (Woynarovich, 1975; Hepher and Pruginin, 1981).

Materials and methods

Experimental ponds

Three 200 m^2 earthern ponds were used in the present investigation at the Umtata Dam Fish Research Centre. (Prinsloo and Schoonbee, 1984a). These ponds were filled with piped water from the Umhlahlane River, approximately 50 km from the research station, and the water was gravity-fed to the various fish ponds. The mean depth of the ponds, when full, is 0,75 m. Individual ponds used in the experiment were subdivided by means of 35% shade cloth material into equal halves so that fish used for both feeding programmes were subjected to identical water quality conditions. The experiments were done in triplicate. Water lost through evaporation and seepage was regularly replenished.

Fish used in the experiment

The fish used in the experiments were spawned and reared to stocking size at the Umtata Dam Fish Research Centre according to procedures described by Schoonbee and Prinsloo (1984).

In each case the stocking densities for the grass and silver carps were 5 000 and 2 500 fish ha^{-1} respectively. The initial mean individual mass of the grass carp used in the experiment at the time of stocking was 262,6 g (cabbage leaves) and 235,9 g (kikuyu grass). On average the silver carp weighed 196,6 g (cabbage leaves) and 227,8 g (kikuyu grass) at the start of the experiment.

Application of food

Cabbage leaves were obtained from a local vegetable farmer. Fresh outer leaves which are normally discarded during harvesting of cabbage were utilised. Immediately before application each day, the required quantities of leaves needed for the experiments were chopped into small pieces using a garden shredder. Fresh kikuyu grass was obtained from the fish pond area. During cropping the grass was cut into pieces varying from 5 to 20 cm in length. Application of food was made once daily between 09h00 and 10h00 and in wet mass quantities equivalent to 30% of the total estimated biomass of the grass carp for each group of fish. Adjustment to the quantities of food, based on regular existing crop estimates of fish, was made every fortnight. During such estimates a minimum of 50% of all the fish in each experimental pond was accurately weighed to the nearest gram. Halfway through the experiment, on day 34, an adjustment was made in the dosage quantities of the cabbage leaves in order to equate the dry mass instead of wet mass, of the cabbage leaves with that of the kikuyu grass which has a higher fiber and lower moisture content than that of cabbage leaves (Table 1). Based on the difference in moisture content between the cabbage leaves and kikuyu grass, a substantial upward adjustment of cabbage leaf quantities was made. During the last fortnight of the experiment not all kikuyu grass material was utilised by the fish and excess material had to be removed every morning prior to the application of fresh material.

Water chemistry

Physical and chemical analyses were done on water samples collected between 06h00 and 08h00 fortnightly using standard laboratory equipment (Prinsloo and Schoonbee, 1984a), according to international procedures for the examination of water and

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Received 17 April 1986.

TABLE 1
MOISTURE, CRUDE FIBRE, PROTEIN AND ASH CONTENT WITH AN INDICATION OF THE ENERGY VALUES (kJ/g) OF CABBAGE LEAVES AND KIKUYU GRASS USED IN THE GROWTH EXPERIMENTS WITH THE GRASS CARP

Parameter	Cabbage leaves	Kikuyu grass
Moisture content (%)	86,4	73,6
Crude fibre (%)	12,3	20,2
Protein (%)	11,7	8,7
Ash (%)	11,5	11,2
Energy (kJ/g)	12,5	14,5

waste water (APHA, 1980).

Water temperature was recorded on a Thies Hydrothermograph provided with a 7 day recorder.

Results

Water quality conditions in the fish-ponds

In contrast with experiments done by Prinsloo and Schoonbee (1984a to c; 1985; 1986) no inorganic fertilisers were applied in order to avoid unnecessary algal blooms as it was felt that the digestion of the organic material used as food would facilitate the eutrophication processes in the ponds. From the results obtained (Table 2) this assumption was substantiated by the prevailing values for nutrients such as nitrate, ammonia and soluble reactive phosphorus (SRP). In contrast with the findings of Prinsloo and Schoonbee (1984a to c) where agricultural lime was used, the lack of application of agricultural lime during this study resulted in the pH values of the pond water remaining low and never exceeding 7. The accumulation of partly digested and uneaten organic material by the grass carp also clearly affected oxygen concentrations in the ponds which fluctuated between 1,4 and 5,8 mg ℓ^{-1}.

Fish production results

A summary of production results of fish receiving kikuyu grass and cabbage leaves is set out in Tables 3 and 4 and in Figure 1. Values obtained for total fish standing crop showed very little difference in production between fish receiving the two kinds of diets but with a slightly better yield where cabbage leaves were used as food (Tables 3 and 4). This is also substantiated by fish standing crop increments for the two diets over the study period in both the grass and silver carps (Figure 1). When growth results are compared between grass and silver carp (Figure 1), it is also clear that the grass carp benefited the most from both diets and that the silver carp contributed little towards the total eventual yield of approximately 2 t ha^{-1} achieved in both feeding trials over the 75 d growth period.

An analysis of the total dry and wet mass of plant material used (Tables 3 and 4) emphasises the considerable difference in moisture content between the cabbage leaves and kikuyu grass – a condition which was not fully appreciated at the outset of the experiment but which was rectified later as indicated. For instance 30,8 kg of wet cabbage leaf material is required to produce 1 kg of fish in contrast with 23,7 kg kikuyu grass. It is important to point out however, that cabbage leaves contained an appreciably higher protein content per equivalent dry mass than the grass (Table 1) even though it has a comparatively lower energy and crude fibre content.

Discussion

Although a considerable amount of information exists on the utilisation of aquatic weeds by the grass carp in a number of countries (Edwards and Hine, 1974; Sinha and Gupta, 1975; Stott, 1977; Sutton, 1977, Shelton *et al.*, 1981) very little quantitative data is available on the feed conversion and growth performance of grass carp using vegetable wastes as food.

Results obtained on the growth of the Chinese grass carp during the present investigation clearly showed that vegetable material can be used with great success as exclusive feed to obtain good yields within one growing season. By stocking fish of approximately 200 g in size, indications are that individual fish can grow well in excess of 1 kg within a normal summer growing season of 180 d in Transkei. The authors' results did however show that the accumulation of partly digested plant material in the ponds may lead to eventual declines in oxygen levels, affecting the daily production figures adversely (Tables 3 and 4). If a longer growth period than the 75 d of the present experiment is anticipated, it would be essential to remove the excess waste material from the ponds through periodic draining and refilling with fresh water. An excellent alternative would be the use of irrigation canals and/or dams at irrigation schemes where the grass carp could be kept in cages in monoculture in much higher densities than was the case in the present experiment.

Tendencies towards anoxic conditions occurred increasingly during the last fortnight of the experiment which could be ascribed to the vast accumulation of organic material in the experimental ponds which may have detrimentally affected the feed conversion ratio of both fish species during the last part of the experi-

TABLE 2
SUMMARY OF PHYSICAL AND CHEMICAL CONDITIONS IN FISH PONDS RECEIVING CABBAGE LEAVES AND KIKUYU BASED ON FORTNIGHTLY ANALYSIS IN 3 EXPERIMENTAL PONDS DURING THE SUMMER PERIOD 7th NOVEMBER 1985 to 20th JANUARY 1986

Analyses	N	$\bar{x}$	Min	Max	Sx	CV
Dissolved oxygen mg ℓ^{-1}	12	3,47	1,40	5,80	1,34	38,62
pH	12		6,39	6,88	0,15	
Conductivity μS m^{-1}	9	116,00	92,00	130,00	11,52	9,93
Alkalinity as $CaCO_3$, mg ℓ^{-1}	12	23,42	14,00	34,00	5,23	22,33
Total hardness as $CaCO_3$, mg ℓ^{-1}	12	30,30	20,00	50,00	9,45	31,18
Nitrate (NO_3), mg ℓ^{-1}	11	0,144	0,092	0,185	0,029	20,13
Ammonia (NH_4), mg ℓ^{-1}	12	0,220	0,087	0,489	0,113	51,36
Soluble Reactive Phosphorus (PO_4), mg ℓ^{-1}	12	0,021	0,010	0,049	0,013	61,90

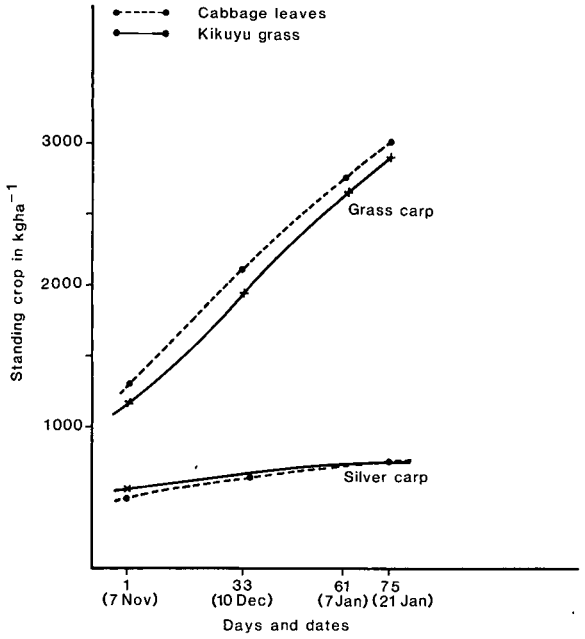

Figure 1
Standing crop of the Chinese grass carp fed on diets of kikuyu grass and cabbage leaves over a summer period of 75 d. Data on Silver carp, included to utilise detritus and phyto-plankton development in ponds, are also given.

ment (Tables 3 and 4). The utilisation of phytoplankton and detritus in the ponds by the silver carp, probably contributed towards the avoidance of total oxygen depletion during the last phase of the investigation, which lasted 75 d.

Irrigation schemes suitable for this purpose exist in Transkei where vegetable production, in particular large-scale production of cabbage, is practised. At one such scheme, namely the Ncora irrigation scheme, large-scale cabbage production is undertaken annually. Based on information provided by the management of this irrigation scheme, an estimated total of 20t ha^{-1} of unutilised cabbage leaves are available after harvesting which can be used for grass carp production in irrigation dams or irrigation canals. If these cabbage wastes are converted into potential yields of grass carp at 35:1, an estimated yield of 570 kg of fish is possible for each hectare of otherwise unused cabbage leaves. This does not exclude the availability of other vegetable wastes or even plants such as rye grass which can be grown specifically for grass carp production, or to supplement the cabbage leaves during those periods when quantities of the latter are insufficient.

A very important factor to be considered is whether grass carp is acceptable as a food fish amongst the local population. During the past three years, market testing proved the acceptability of the various carp species as food fish amongst the local population. Grass and other carp produced at the local research station at the Umtata Dam and by a fish farmer in the Ncora area, sold well at competitive prices compared with red meats.

TABLE 3
RESULTS OBTAINED ON THE COMBINED PRODUCTION OF THE CHINESE GRASS AND SILVER CARPS USED IN POLYCULTURE IN PONDS RECEIVING KIKUYU GRASS DURING THE PERIOD NOVEMBER 1985 TO JANUARY 1986 (75 DAYS)

Period	Days	Date	Mean and extreme pond temp. for period (°C)	Stocking (s) and final (f) densities (fish ha^{-1})	Standing crop (kg ha^{-1})	Yield increment (kg ha^{-1})	Production in (kg $ha^{-1}d^{-1}$)	Kikuyu grass quantities (as dry mass) in (kg ha^{-1})	FCR (Feed conversion ratio)
0	1	7.11.85		17 500 (s)	1 749,0				
1	33	7.11-9.12	20,6 15,6-23,4	6 900**	2 765,5**	1 016,5	30,8	3 360,5	3,3
2	61	10.12-6.1	22,2 21,1-23,5	6 900**	3 588,9**	823,4	29,5	5 590,5	6,8
3	75	7.1-20.1	22,1 20,7-23,5	6 900 (f)	3 702,5	113,6	8,1	3 275,0	28,8
TOTAL						1 953,5		12 226,0*	x̄:6,3***

*Wet mass equivalent: 46 349 kg ha^{-1}
**Estimates. Based on final empirical results obtained
***Mean FCR over entire period

TABLE 4
RESULTS OBTAINED ON THE COMBINED MEAN PRODUCTION OF THE CHINESE GRASS AND SILVER CARPS USED IN POLYCULTURE IN PONDS RECEIVING CABBAGE LEAVES DURING THE PERIOD NOVEMBER 1985 TO JANUARY 1986 (75 DAYS)

Period	Days	Date	Mean and range pond temp. for period (°C)	Stocking (s) and final (f) densities (fish ha^{-1})	Standing crop (kg ha^{-1})	Yield increment (kg ha^{-1})	Production in (kg $ha^{-1}d^{-1}$)	Cabbage leave quantities (as dry mass ha^{-1})	FCR (Feed conversion ratio)
0	1	7/11		7 500 (s)	1 804,5				
1	33	7/11-9/12	20,6 15,6-23,4	7 400**	2 768,6**	964,1	29,2	1 811,1	1,9
2	61	10/12-6/1	22,2 21,1-23,5	7 400**	3 622,4**	853,8	30,5	4 283,5	5,0
3	75	7/1-20/1	22,1 20,7-23,5	7 400 (f)	3 800,2	177,8	12,7	2 339,0	13,2
TOTAL						1 995,7		8 433,6*	x̄:4,2***

*Wet mass equivalent: 62 011 kg ha^{-1}
**Estimates. Based on final empirical results obtained
***Mean conversion over entire period

There was a substantial demand for freshwater fish.

Acknowledgements

The authors wish to express their sincere appreciation for the financial assistance from the Development Bank of Southern Africa, as well as the Department of Agriculture, Transkei Government, for the facilities and equipment provided by University of Transkei and the Rand Afrikaans University, for the technical assistance of Mrs. P. Rajadevan and Mrs. M. Prinsloo as well as pond workers at the Research Station for their help with the sampling program.

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