Observations on fish growth in polyculture during late summer and autumn in fish ponds at the Umtata Dam Fish Research Centre, Transkei
Part III: The use of chicken manure with and without pelleted fish feed

J.F. PRINSLOO
Department of Zoology, University of Transkei, Private Bag X5092, Umtata, 5100, Transkei

AND

H.J. SCHOONBEE
Research Unit for Fish Biology, Rand Afrikaans University, P.O. Box 524, Johannesburg, 2000

Abstract

A study was made to determine the effects of chicken manure as fertilizer, with and without pelleted fish feed, on the production capacity of various carp species and the tilapia *Oreochromis mossambicus* in fish ponds in Transkei, during late summer and autumn. Results obtained show that a production of almost 1 t/ha can be obtained within 98 days, even though minimum water temperatures may decrease to as low as 16 °C. By supplementing the chicken manure with pelleted fish feed, a yield of almost 2,5 t/ha can be achieved within 128 days under similar conditions. By using a fish polyculture system which includes the herbivorous Chinese grass and silver carps, in addition to three varieties of common carp, it is possible to avoid anoxic pond conditions as these fish are able to utilize excessive algal growth in the ponds.

Introduction

The poultry industry of South Africa which produces mainly broiler chickens, is a multi-million rand industry which has already made important inroads into the meat market. This industry is now expanding rapidly into the National States.

Although poultry manure is presently incorporated into cattle feed, the disposal of wastes from the poultry already poses a serious problem and in some cases may become a health hazard.

In central Europe and the Far Eastern countries, such as China, Taiwan and Hong Kong, the integration of duck, goose and pigeon production with fish farming largely solves the problem of waste disposal (Lin, 1940; Blume, 1960; Hickling, 1962; Sin, 1979). The recycling of animal wastes, such as poultry constitutes the major fertilizer in the fish culture industry (FAO, 1977, 1978; Edwards, 1980).

In Israel the poultry industry competes fiercely with the pond fish industry for its share in the meat market. Poultry manure in Israel was first used as a component in the food of the small cattle industry in that country, but in recent years poultry manure is used extensively and with success as a fertilizer in fish ponds (Rappaport, *et al.*, 1977; Rappaport and Sarig, 1978; Kerns and Roelofs, 1977; Joseph, 1981; Barash, *et al.*, 1982).

In the present study, dried chicken-droppings were tested as a fertilizer in a fish polyculture system and compared with pig manure (Prinsloo and Schoonbee, 1984a) and cattle manure (Prinsloo and Schoonbee 1984b) where all these animal wastes were used with and without pelleted fish feed in fishpond production experiments over the same period of study. This paper forms the last in a series of three on the use of various manures in a fish polyculture production experiment at the Umtata Dam Fish Research Centre. A detailed description of the fish species included in the study, the prevailing pond conditions, pond management practices followed, the climate of the area where the study was made, as well as the materials and methods employed, is provided in Part I of this series. (Prinsloo and Schoonbee, 1984a).

Collection and Application of Chicken Manure and Pelleted Fish Feed

Dry chicken manure was obtained from a poultry farm in the Butterworth District. The manure was collected in plastic bags and transported to the ponds at the Umtata Dam Fish Research Centre. Moisture content of the manure averaged 15%.

The chicken manure was applied directly to the ponds without being previously mixed with the water as was the practice for some time in Israel (Rappaport *et al.*, 1977). The necessary corrections were made to express the quantities of the chicken manure used as dry mass, as were the cases with pig and cattle manure during the present series of experiments.

Application of chicken manure in ponds was made for five days per week at quantities of 7% of the total estimated biomass of the fish standing crop in the ponds for the first 98 days of the experiment (4 January-11 April 1982, Table 2) and was adjusted during each of the following periods as indicated in Table 2, when mass determinations were made on representative samples of fish collected from each pond. With the decrease in water temperatures, the daily quantities of chicken manure applied were reduced to 3% during period 5 (12 April to 12 May, Table 2). An upward adjustment of the manure to 5% was made for the last period when mean water temperatures dropped to 12,7 °C, in order to determine the possible effects of chicken manure on growth of the individual fish species during cold water conditions.

A procedure of manure application similar to that described for the ponds receiving chicken manure only, was followed in a series of three ponds where chicken manure was supplemented with pelleted fish feed (Table 3). The quantities of manure ap-

plied during days 43-98 were, however, reduced to 3% of the total estimated biomass of fish in each pond. This coincided with the onset of the application of pelleted fish feed, which commenced on day 51. The quantity of manure was further reduced to 2% for days 99-128 and again increased to 5% for the last 32 days of the experiment (days 129-160) for reasons already mentioned. As was the case in the pig and cattle manure experiments, pelleted fish feed was applied for six days per week at quantities of 4% of the estimated biomass of fish in the ponds for a period of 21 days, during 22 February to 14 March, after which the daily quantities applied were reduced to 3% for the rest of the study. Use was made of 45% protein trout pellets which, being mass produced, were not only lower in price than the locally produced carp pellets, but also had better binding properties which made them less water soluble.

Results

Water chemistry of ponds

The results obtained for the water chemistry of the ponds receiving chicken manure only and chicken manure plus pelleted fish feed are summarized in Table 1. A comparison of these findings with results obtained where pig manure (Prinsloo and Schoonbee, 1984a) and cattle manure (Prinsloo and Schoonbee, 1984b) were used in fish polyculture shows, firstly, that the concentration of dissolved oxygen was on the average slightly higher in ponds where chicken manure was applied. Secondly, maximum pH values were the highest in ponds where pig and cattle manure was used. Taken together, the values for dissolved oxygen and pH suggest more algal activities in the chicken manured ponds than in any of the ponds where pig or cattle manure was used. Values for hardness and alkalinity correspond with those of the ponds receiving pig and cattle manure.

Although the concentrations of the nutrients such as nitrate, ammonia and orthophosphate appear to be sufficient to promote algal growth in both pond systems of the present study, none of these parameters showed exceptionally high values, which in turn confirms observations that higher algal activities occurred in these ponds.

Fish production in ponds

Survival rates of fish in both pond systems were disappointing with the biggest loss of fish occurring in ponds receiving chicken manure plus pelleted fish feeds (72% survival). A possible explanation for the mortality rate in these ponds may be predation by the African clawed frog *Xenopus laevis* on the silver carp which were, on average, only 1,9 g each in mass at the time of stocking.

Ponds receiving chicken manure only

The mean total yield in the ponds receiving chicken manure only was almost 1 t after 160 days. Over 62% of the total production had already been attained after 42 days. There was, however, a gradual but sustained increase in the standing crop of the fish in these ponds over the entire study period (Fig. 1). The best production of 16,0 and 13,4 kg $ha^{-1}d^{-1}$, respectively, occurred during the first two periods (42 days). The progressive deterioration of the MCR (manure conversion ratio) coincided with the overall decrease in water temperatures. It was only during the first 2 periods (42 days), when exceptionally good MCR values were recorded, that the natural capacity of the ponds still played a role in sustaining the high yields obtained.

Ponds receiving chicken manure and pelleted fish feed

Apart from the differences in stocking densities between the ponds receiving chicken manure only and chicken manure plus fish feed, which affected the production for the two types of treatments, the growth patterns of fish were similar until day 51 when the application of fish pellets commenced in the one group of ponds (Figure 1; Tables 2 and 3). The effects of the application of fish feed can clearly be seen during the period 98 to 128 days (compare Tables 2 and 3), at the time when water temperatures already dropped considerably to well below 20°C. It was only during the extended sixth period of the experiment, when an additional yield of only 7% could be added over the last 32 days, that the effect of the colder water temperatures was felt. (Figure 1).

Individual contribution of the various fish species to the total production in ponds receiving chicken manure only and chicken manure plus pellets

The relative yields obtained for the individual fish species where chicken manure only was used, were similar in tendency to those ponds receiving pig and cattle manure (Prinsloo and Schoonbee, 1984a and b). The three varieties of common carp and silver carp were again the overall best performers (Table 4).

In ponds receiving chicken manure and pelleted fish feed, the three varieties of the common carp contributed almost 90% of the total yield. Compared to the ponds receiving pig and cattle manure plus fish feed (Prinsloo and Schoonbee, 1984a and b), silver carp did not do well when chicken manure plus pellets were used. One possible factor might have been the high losses amongst silver carp (43%) which were largely attributed to predation by *X laevis* during the initial phases of the experiment.

As was the case for *O mossambicus* in the experiments where pig and cattle manure plus fish pellets were used, this species did not compare well in terms of yield with the varieties of the common carp, a situation which partly may be ascribed to the relatively low water temperatures which prevailed during the last 60 days of the experiment.

Discussion

Attempts to incorporate poultry manure in the diet of fish have been made by authors such as Shiloh and Viola (1973) and Kerns and Roelofs (1977). Both groups came to the conclusion that the direct introduction of poultry waste in the diet of fish, poses problems which outweigh the advantages it may have had for fish growth. Rappaport *et al.*, (1977) and Rappaport and Sarig (1978) contributed much towards promoting the use of chicken manure as a fertilizer in fish ponds in Israel. The use of dry chicken droppings is preferred to liquidised chicken manure. Joseph (1981) also showed with his experiments at Ginosar, Israel, that by using poultry manure at 20-50 kg/ha (dry mass), in addition to pelleted fish feed, a saving of 0,5 on the feed conversion ratio (FCR) was possible, which amounts to a saving of more than 350 US dollars per ha during the active growing season. Barash *et al.*, (1982) proved that the integration of ducks in fish polyculture where the common carp, silver and grass carps as well as tilapia were used, can be successful. By feeding the ducks alone on a platform suspended over a pond, a daily gain in fish biomass of

TABLE 1
SUMMARY OF PHYSICAL AND CHEMICAL CONDITIONS IN FISH PONDS RECEIVING POULTRY MANURE ONLY AND POULTRY MANURE AND PELLETED FISH FEED

Analysis	N	$\bar{X}$	Range Min.	Range Max.	Sx	CV
Ponds receiving chicken manure only						
Dissolved oxygen % saturation	55	43,0	18,5	80,0	13,24	30,82
pH	62		6,56	8,95		
Conductivity $\mu S/m$	60	207,	110	310	41,27	19,96
Alkalinity as $CaCO_3$ mg/ℓ	58	34,3	12	65	13,03	38,00
Total hardness as $CaCO_3$ mg/ℓ	52	37,2	15	65	12,78	34,41
Nitrate (NO_3) mg/ℓ	50	0,180	0,016	0,290	0,08	44,05
Ammonia (NH_4) mg/ℓ	50	0,180	0,112	0,753	0,08	44,05
Orthophosphate (PO_4) mg/ℓ	55	0,434	0,038	0,790	1,05	41,33
Ponds receiving chicken manure and pellets						
Dissolved oxygen % saturation	55	44,6	21,0	85,0	10,34	23,15
pH	60		6,34	9,54		
Conductivity $\mu S/m$	60	189,	140	258	33,65	17,81
Alkalinity as $CaCO_3$ mg/ℓ	58	25,7	12,5	55,0	8,56	33,36
Total hardness as $CaCO_3$ mg/ℓ	52	28,6	15,0	47,5	8,95	31,30
Nitrate (NO_3) mg/ℓ	50	0,120	0,021	0,172	0,05	41,12
Ammonia (NH_4) mg/ℓ	58	0,350	0,073	0,677	0,13	38,53
Orthophosphate (PO_4) mg/ℓ	55	0,260	0,105	0,501	0,09	33,37

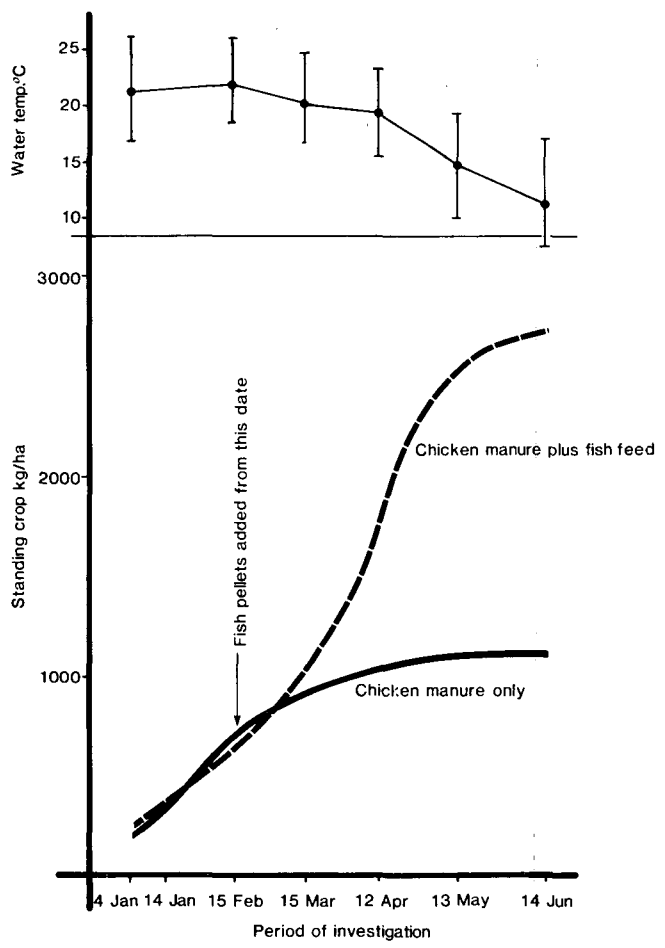

Figure 1A
Standing crop in kg/ha in ponds receiving chicken manure with and without pelleted fish feed

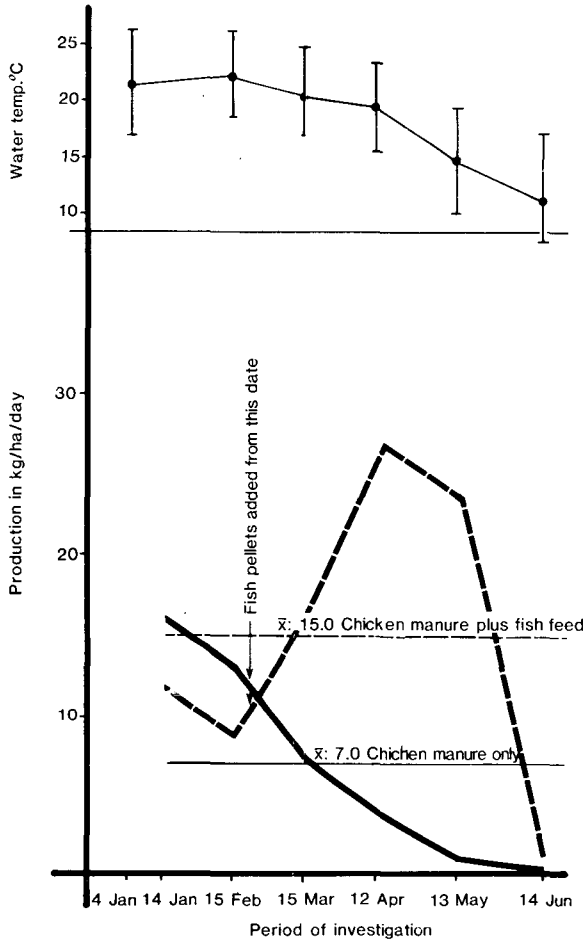

Figure 1B
Production in kg ha^{-1} d^{-1} in ponds receiving chicken manure with and without pelleted fish feed

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TABLE 2
RESULTS OBTAINED ON THE COMBINED MEAN GROWTH AND PRODUCTION OF THREE VARIETIES OF COMMON CARP, AND CHINESE BLACK, GRASS AND SILVER CARPS IN POLYCULTURE IN PONDS RECEIVING CHICKEN MANURE ONLY, DURING THE PERIOD JANUARY TO JUNE, 1982 (160 DAYS)

Period					Estimated values based on initial numbers and biomass for each species			Empirical values based on final numbers and biomass for each species				
No.	Day(s)	Date	Mean and extreme pond temp. for period (°C)	Stocking (s) and final (f) densities of fish/ha	Standing crop in kg/ha	Yield increment in kg/ha	Production in kg $ha^{-1}d^{-1}$	Standing crop in kg/ha	Yield increment in kg/ha	Production in kg $ha^{-1}d^{-1}$	Manure dosage quantities in kg (as dry mass)	MCR (manure conversion ratio)
0	1	4/1		7 700(s)	141,6			141,6				
1	14	4/1-17/1	21,5 17,0-26,1		442,7	301,1	21,5	365,0	223,4	16,0	416,0	1,8
2	42	18/1-14/2	22,6 19,0-26,3		910,9	468,2	16,7	739,8	374,8	13,4	1 466,7	3,9
3	70	15/2-14/3	20,9 17,3-25,1		1 191,8	280,9	10,0	947,3	207,5	7,4	2 193,2	10,5
4	98	15/3-11/4	20,7 16,5-23,8		1 352,6	160,8	5,7	1 062,9	115,6	4,1	2 629,3	22,7
5	128	12/4-12/5	15,6 10,8-19,9		1 397,7	45,1	1,5	1 099,0	36,1	1,2	968,0	26,8
6	160	13/5-13/6	12,7 8,5-18,0	6 067(f)	1 398,1	0,4	0,01	1 101,7	2,7	0,08	1 600,0	592,6

38,5 kg/ha could be obtained without any supplementary feeding to the fish. This system of fish-cum-duck polyculture has, according to available evidence, been in practice for more than sixty years in Hong Kong, (Sin, 1979).

The best yields of fish produced daily in the present study do not compare favourably with the results obtained in Israel (Rappaport *et al.*, 1977; Rappaport and Sarig, 1978; Joseph, 1981). The highest yield using chicken manure alone was 21,5 kg $ha^{-1}d^{-1}$ (Table 2; Figure 1). Where pelleted fish feed was incorporated with chicken manure, the highest daily production rate was 37,7 kg $ha^{-1}d^{-1}$ (Table 3; Figure 1). Several factors in concert may have influenced the present results. With the study being conducted during the second half of the summer growing season and the deliberate extension of the study period into winter (June 1982), declining water temperatures had a decided effect on the daily production figures. This is very well illustrated by the successively declining yields, particularly for the ponds receiving chicken manure only (Table 2). The influence of temperature on yields where pelleted fish feed supplemented the manure, was not so severe (Figure 1), and did not have a decided effect on the actual feed conversion ratio's (FCR), obtained for the consecutive periods (Table 3). In the interpretation of the results of the actual production capacity of the various manures, in this case chicken manure, the sixth extended period and perhaps even the fifth period, where mean water temperatures barely exceed 15 °C, should be ignored if a better perspective is required for the potential of chicken manure as a fertilizer in a fish polyculture system. There is no doubt that much better growth results will be obtained if this kind of production investigation is made during the warmer summer months of mid-October to mid-March.

An analysis of the results also showed that the initial fish production rate in the ponds receiving chicken manure, did not compare well with those for pig or cattle manure. (Prinsloo and Schoonbee, 1984a and b). Despite the fact that the initial dosage rate of chicken manure exceeded 50 kg $ha^{-1}d^{-1}$, and that it was adjusted during each period to constitute approximately 7% of the mass of the fish standing crop at a given time, the production continuously declined over the entire period of investigation (Table 2). Since the mean water temperatures exceeded 20 °C during the first 98 days of the investigation, temperatures should not be a factor in the poor yields obtained when using chicken manure as nutrient. The quality of the chicken manure used, must therefore be questioned.

It has been pointed out in the available literature that the addition of manures to fish ponds may result in the collapse of algal populations, with resultant oxygen depletion and consequent fish mortalities (Schroeder, 1975; Moav, *et al.*, 1977; Sin and Chiu, 1982; Rimon and Shilo, 1982a and b). It is for this reason that aeration systems are installed to avoid conditions of oxygen depletion in heavily manured fish ponds in Israel (Rappaport, *et al.*, 1976; Moav *et al.*, 1977).

In the present study, the possible problem of oxygen depletion following algal blooms was taken into consideration in the selection and numbers of the species of herbivorous fish stocked

TABLE 3

RESULTS OBTAINED ON THE COMBINED MEAN GROWTH AND PRODUCTION OF THREE VARIETIES OF COMMON CARP, AND CHINESE BLACK, GRASS AND SILVER CARPS AND *O MOSSAMBICUS* IN POLYCULTURE IN PONDS RECEIVING CHICKEN MANURE AND PELLETED FISH FEED DURING THE PERIOD JANUARY TO JUNE, 1982 (160 DAYS)

Period					Estimated values based on initial numbers and biomass for each species			Empirical values based on final numbers and biomass for each species						
No.	Day(s)	Date	Mean and extreme pond temp. for period (°C)	Stocking (s) and final (f) densities of fish/ha	Standing crop in kg/ha	Yield increment in kg/ha	Production in kg ha^{-1} d^{-1}	Standing crop in kg/ha	Yield increment in kg/ha	Production in kg ha^{-1} d^{-1}	Manure dosage quantities in kg (as dry mass)	Fish pellets in kg	MCR* (manure conversion ratio)	FCR* (food convertion ratio)
0	1	4/1		9 400(s)	222,1			222,1						
1	14	4/1-17/1	21,5 17,0-26,1		550,1	328,0	23,4	389,9	167,8	120,0	416,0		2,5	
2	42	18/1-14/2	22,6 19,2-26,3		895,9	345,8	12,4	639,0	249,1	8,9	1 466,7		5,9	
3	70	15/2-14/3	20,9 17,3-25,1		1 565,7	579,8	20,7	1 122,3	483,3	17,3	1 186,7	667,5 as from 22/2	2,5	1,4
4	98	15/3-11/4	20,7 16,5-23,8		2 622,4	1 056,7	37,7	1 874,9	752,6	26,9	1 102,9	2 098,3	1,5	2,8
5	128	12/4-12/5	15,6 10,8-19,9		3 580,3	957,9	31,9	2 582,9	708,0	23,6	1 232,0	2 182,5	1,7	3,1
6	160	13/5-13/6	12,7 8,5-18,0	6 722(f)	3 794,7	214,4	- 6,7	2 737,8	44,6	1,4	1 636,0	2 646,7	36,7	59,5

*Calculated as if manure or feed contributed exclusively to conversion ratio

TABLE 4

INDIVIDUAL CONTRIBUTION OF THE VARIOUS FISH SPECIES TO THE TOTAL PRODUCTION IN THE TWO SETS OF THREE PONDS EACH RECEIVING CHICKEN MANURE ONLY AND CHICKEN MANURE AND FISH PELLETS RESPECTIVELY

Fish Species	Stocking density and initial biomass per ha			Final density and biomass per ha		Fish yield in kg/ha	Percentage of total yield
	Numbers	Biomass (kg)	%	Numbers	Biomass (kg)		
Ponds receiving chicken manure only							
Aischgrund carp	1 600	21,8	15,4	1 333	277,3	205,5	21,4
Dor 70 carp	1 600	46,5	32,8	1 450	292,1	245,6	25,6
Aischgrund x Dor 70 carp	1 600	51,8	36,6	1 275	262,1	210,3	21,9
Black carp	600	14,2	10,0	525	41,1	26,9	2,8
Grass carp	600	4,1	2,9	242	40,6	36,5	3,8
Silver carp	1 700	3,2	2,3	1 242	238,6	235,4	24,5
TOTAL	7 700	141,6		6 067	1 101,8	960,2	100,0
Ponds receiving chicken manure and pellets							
Aischgrund carp	1 600	17,3	7,8	1 558	798,2	790,9	31,3
Dor 70 carp	1 600	48,3	21,7	983	694,5	646,2	25,6
Aischgrund x Dor 70 carp	1 600	55,4	24,9	1 058	845,8	790,4	31,3
Black carp	600	12,0	5,4	583	113,0	101,0	4,0
Grass carp	600	3,9	1,8	358	71,8	67,9	2,7
Silver carp	1 700	3,1	1,4	975	80,3	77,2	3,1
O. mossambicus	1 700	82,1	37,0	1 207	134,0	51,9	2,0
TOTAL	9 400	222,1	100,0	6 722	2 737,6	2 525,5	100,0

in the ponds. This also applied to the pond systems where pig and cattle manure was used. Largely for this reason, no problems with oxygen depletion were experienced even though isolated low values for dissolved oxygen were recorded (Table 1).

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