Role of Tilapia *(Oreochromis andersonii)* in Integrated Farming Systems in Zambia

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Abstract

The potential for development of aquaculture as an industry in Zambia has been found to be appreciable because of the favorable climate, soil, water supply, availability of land and the spontaneous interest generated in the private sector. The old system of cultivating several species of tilapia together in the same pond has been changed to monospecies culture and *Oreochromis andersonii* has been shown to yield good growth and production rates. A broodstock (Kafue strain) of the species was introduced into the Chilanga Fish Farm and separate ponds for the production of fry, fingerlings and market-size fish have been maintained.

Among the various systems of aquaculture tried during the past three years in three farms established by the project in different regions of the country, integrated fish farming using fish-cum-pig and fish-cum-duck combinations has given very good production results. Modest averages worked out for the fish-cum-pig system are between 4 and 6 t/ha/year and for the fish-cum-Peking duck system between 3.5 and 4.5 t/ha/year. The paper describes details of the integrated farming technology with special reference to the role of *O. andersonii*, pond management practices and related economic considerations.

Introduction

The importance of aquaculture development as a component of integrated rural development in the Republic of Zambia has only been fully recognized in recent years (Gopalakrishnan 1986a). Based on the successful results obtained by the FAO/UNDP Pilot Fish Culture Development Project in Zambia, it has been established that when fish farming is integrated with other types of agricultural production, including animal husbandry, the benefits accruing to the rural community as a result of full utilization of land and water resources, by-products and residues could be significant and attractive (Gopalakrishnan 1986b). The major gains anticipated for the community from development of integrated fish farming are food self-sufficiency for the family, increased income from the fish produced, diversification of income sources, availability of comparatively less expensive stock feed and manure in the rural sector itself and increased agricultural production by using pond humus as fertilizer. Integrated fish farming can be practised in different parts of the country as a primary occupation supplemented by other crops, as a secondary undertaking or as a side-line activity, depending on the resources available. The soil, water and other environmental conditions prevalent in Zambia have been found to be good for the development of aquaculture as an industry.

For rational and scientific development of integrated fish farming in Zambia, the right species of fish had to be chosen. All evidence available indicated that members of the tilapia group should be the first priority, taking into consideration their high culture potential in southern Africa and consumer preference. Field trials conducted during 1980-1982 clearly indicated that *Oreochromis andersonii* was the best candidate. Compared with other local tilapia, the growth potential of this species under semi-intensive culture conditions and its resistance to handling and cold temperatures had been shown to be high. A monoculture production system based on *O. andersonii* was demonstrated to be appropriate for economically viable fish farming.

Tilapia is well represented in Zambia by *Tilapia sparrmanii* and *T. rendalli.* The more common species in the *Oreochromis* group cultivated in Zambia are *Oreochromis andersonii, O. macrochir* and *O. mossambicus.*

Of these, *O. andersonii* (three-spotted bream; local name 'njinji' - Fig. 1) occurs naturally in the lagoons of the Upper Zambezi and Kafue river systems of Zambia. The male of the species is bigger than the female and develops specific maroon red coloration on the top of the head during the breeding season. The breeding habits of the species observed in different areas of the country are similar to typical characteristics of the group. From the experimental trials conducted in Chilanga it has been observed that spawning of the species starts in October and ends by April/May (Cayron-Thomas 1985).

Although earlier reports describe *O. andersonii* as a bottom feeder, observations made in Chilanga indicate that the species feeds at all levels. In trials using supplementary feeding and integrated farming systems, this species showed much better growth and survival rates than other tilapias. The average number of fry/fingerlings obtained per female

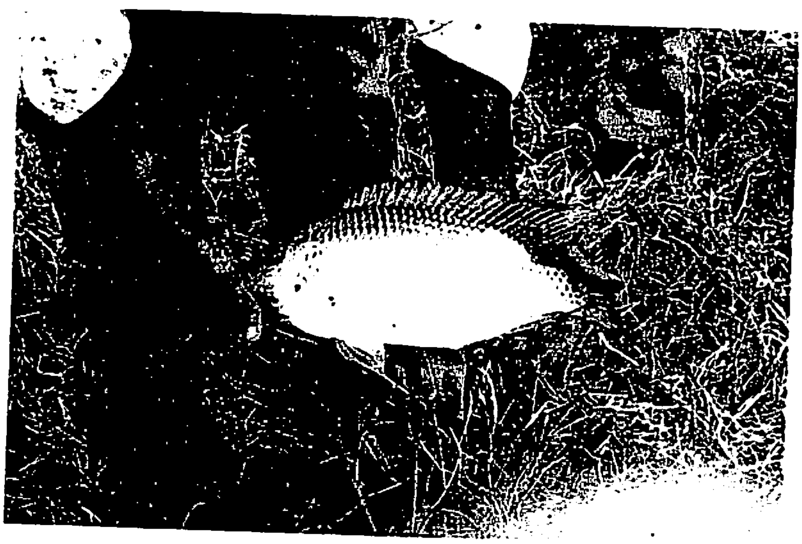

Fig. 1. *Oreochromis andersonii.*

under pond culture conditions has so far reached a maximum of 634. Under these circumstances the old system of cultivating several species of tilapia together in the same pond was changed to monoculture of *O. andersonii.*

O. andersonii in Integrated Farming Systems

Breeding of O. andersonii *in integrated farming systems*

The *O. andersonii* fingerlings used for integrated farming were obtained from a natural stock introduced into the Chilanga Fish Farm from the Chanyanya lagoon in the Kafue River system. The broodfish were originally stocked at a density of 3,000/ha in two ratios; either 4 or 5 females to 1 male. The ratio has now been standardized to 5 females to 1 male (Cayron-Thomas 1986). During the first set of trials, 20% of the broodstock were lost. This loss was reduced to less than 10% during subsequent years by rigorous management measures, especially prevention of predation by otters. It has been shown also that the loss of broodstock can be minimized by draining in pond in mid-season followed by selection and restocking. A summary of the fry/fingerling production results obtained is given in Table 1.

Simultaneously with the breeding trials, a system of maintaining nursery, rearing and production ponds was developed. The breeding system in earthen ponds has been developed as an integrated farming exercise with 'Peking' ducks. In the duck breeding activities, which were undertaken simultaneously in the same pond, 190 birds (150 females and 40 males) were generally used. The females were changed every two years and the males every year. They were fed with layers' mash and maize (7:3) at 200 g/duck/day.

Integrated farming - O. andersonii *and pigs*

Pig weaners of the crossbreed between Landrace and Large White were purchased from commercial farms. The weight of the weaners ranged between 22 and 28 kg. Pigsties built on stilts over water and on the dikes were used for the trials (Fig. 2) with manure brushed or washed into the pond. At the end of each growing cycle, the pigs were sold as baconers or heavy hogs. Commercial pig feed available locally was used and was generally given dry in feeding troughs fixed to the floor of the pigsty, at the following rates:

Ave. wt. of pig (kg)	25	30	40	50	60	70-100
Feed/pig/day (kg)	1.2	1.4	1.9	2.3	2.6	2.8

The average feed : pig conversion ratio obtained was 4.4:1. A summary of *O. andersonii* production rates obtained from the different trials made during 1982-1986 is presented in Table 2. These observations indicate that under normal conditions and with adoption of proper management practices, *O. andersonii* produc-

Table 1. Production of *O. andersonii* seed in integrated farming systems of the Chilanga Experimental Fish Farm.

Season	No./female broodstock	No. harvested	No./ha
1983-84	188	77,800	389,000
1984-85	380	129,320	646,000
1985-86	684	286,671	1,433,400

Fig. 2. Integrated fish farming system with pigsty built on stilts. *O. andersonii* production rate reached 9.8 t/ha/year in this pond.

Table 2. *O. andersonii* production trials (1982-1986) in integrated systems with pigs.

Pond area (ha)	No. pigs (total)	Stocking rate (no./ha)	Growth period (days)	Net prod. rate (kg/ha/ year)1	Harvest rate (kg/ha/ year)2
17	20	27,900	173	7,220	8,640
17	20	36,900	196	6,380	7,340
17	20	43,500	134	9,840	11,970
17	16	21,500	152	5,070*	6,290*
17	16	25,400	53	9,880	19,320
17	12	35,600	252	3,380*	4,300*
17	15	32,200	284	4,540	4,730*
17	15	23,100	185	4,420	6,200*
16	25	25,500	87	2,390	10,830
16	12	25,600	225	3,340*	3,390*
16	14	28,700	212	2,680*	3,630*
16	14	38,000	133	4,910	8,420
32	20	43,000	204	3,490	5,950

*Results vitiated by poaching/drought.
1Based on final wt. less stocked wt.
2Based on gross wt. of fish harvested. Harvest rate is taken into consideration by farmers for determining economic indicators.

tion rates can average between 4 and 6 t/ha/year in the integrated farming system with pigs. It was determined that the ideal number of pigs to be grown is between 80 and 100/ha, except during the cold season when it would be advisable to reduce the manuring rate, and hence the pigs, to the minimum level.

Integrated farming - O. andersonii *and ducks*

Preliminary trials of integrated fish farming with ducks were conducted using *T. rendalli* and the locally available 'Muscovy' ducks. The production results were not satisfactory, caused by a combination of factors. These trials indicated that 'Muscovy' ducks are not suitable for semi-intensive integrated fish farming as they do not stay in the water for long enough periods, thus producing insufficient manuring. Therefore, 225-day-old 'Peking' ducklings were procured from Hungary and the progeny derived from them fully acclimatized to local conditions. The duck breeding program has yielded successful results and approximately 20,000 ducklings have been produced so far.

The ducklings are transferred to fishponds when 3 weeks old and stocked at 300-500/ha, according to availability, the higher density having been found to produce the maximum tilapia production.

All further trials were conducted using 'Peking' ducks and *O. andersonii.* Two types of duck houses were tried out successfully. In the first system, the houses were built on stilts above the water surface with the floor made of wire mesh (Fig. 3). In the second system, the house was built either on dikes or nearby land area. The manure accumulated in the shed during the night was either washed down into the nearest ponds or collected and transported according to requirements in other ponds.

When 3-5 weeks old, the ducks were generally fed with a 1:1 mixture of broiler finisher and whole maize at 0.20 kg/duck/day. When the ducks were 6-9 weeks old, this was increased to 0.25 kg/duck/day. The results obtained so far indicate that in integrated systems with *O. andersonii* and 'Peking' ducks, fish production rates between 3.5 and 4.5 t/ha/year can be obtained with proper management practices (Table 3).

Economics of Integrated Farming Using *O. andersonii*

A study of economics of tilapia farming in Zambia indicates that integrated farming with *O. andersonii* and pigs or 'Peking' ducks could be an attractive financial proposal (L'Heureux 1985; Gopalakrishnan 1986a). The potential rates of return for a standard 5-ha fish farm are presented in Table 4. These estimates were based on rather high construction costs quoted by an engineering company, mainly because other reasonable estimates were not available at that time. Further observations, however, have shown that pond construction costs will be much lower than those used in the

Fig. 3. Duck house built over water in integrated duck-fish culture.

computations. Profit and loss accounts based on current costs have been estimated as shown in Table 5.

Conclusions

The scope and potential for development of integrated fish farming in different regions of the world have been demonstrated through several studies (Pullin and Shehadeh 1980; Hopkins and Cruz 1982). It is also known that even empirical methods of cultivating fish along with other animals have been successfully practised for many years (FAO 1983). However, it is only in recent years that such systems have been considered for adaptation in the African region. Members of the tilapia group are certainly

Table 3. *O. andersonii* production trials in integrated systems with ducks.

Pond area (ha)	No./ha	Growth period (days)	Net. Proc. rate (kg/ha/year)[1]	Harvest rate (kg/ha/year)[2]
0.16	30,000	185	3,730	4,610
0.16	43,000	139	7,040	9,097
0.16	19,400	240	6,160	7,740
0.49	38,000	170	2,130*	2,260*
0.27	17,000	341	3,350	3,600
0.25	25,000	176	3,150	4,940
0.25	25,000	188	1,690*	4,090*

*Results vitiated due to poaching/drought.
[1]Based on final wt. less stocked wt.
[2]Based on gross wt. of fish harvested.

Table 4. Investment costs and rates of return of integrated fish farming in 5-ha farm (costs in Kwacha; 1 US$ = 8.00 Kwacha).

Size of ponds		5,000 m^2	2,500 m^2	1,500 m^2
Base investment costs				
Ponds		280,650	378,845	473,398
Buildings		50,989	50,906	50,590
Broodstock and contingencies		18,000	18,000	18,000
Fish-cum-pig				
Additional investment costs		36,450	36,450	36,450
Working capital		117,400	117,400	117,400
Rate of return:	4 t/ha	23.0%	19.0%	16.3%
	6 t/ha	30.6%	25.4%	21.4%
	8 t/ha	38.1%	31.8%	27.4%
Fish-cum-duck				
Additional investment costs		60,000	60,000	60,000
Working capital		20,000	20,000	20,000
Rate of return:	4 t/ha	24.1%	19.2%	16.0%
	6 t/ha	33.2%	26.8%	22.5%
	8 t/ha	42.3%	34.2%	26.8%

Table 5. Profit and loss statement of integrated fish farming in Zambia (based on a currently operating 5-ha farm): US$1.00 = 8.00 Kwacha.

		Quantity (kg)	Unit price*	Revenue
Fish-cum-pig				
1.	*Annual production and revenue (in Kwacha)*			
	Production sold:			
	Fish (at minimum 4 t/ha)	20,000	7.5	150,000
	Pigs	1,080 x 75	8.5	688,500
	Total			838,500
2.	*Annual operating costs (in Kwacha)*			
	Variable costs:			
	Labor		30,000	
	Weaners (1,080 x 25 kg x K 6.50)		175,500	
	Feed (1,080 x 50 kg x FCR 4.4 x K 1.41/kg)	335,000	335,000	
	Transportation		8,000	
	Supplies		20,000	
	Miscellaneous		20,000	
	Fixed costs:			
	Management		10,000	
	Depreciation		31,200	
	Interest (10%)		72,920	
	Total cost		706,620	
3.	*Investment costs* (in Kwacha)			
	Fixed capital costs		418,000	
	Additional capital costs		72,000	
	Working capital		239,200	
	Total		729,200	
4.	*Key economic indicators*			
	Profit = K 838,500 - 702,620 = K 135,880			
	Rate of return on investment = 18.63%			
Fish-cum-duck				
1.	*Annual production and revenue (in Kwacha)*			
	Production sold:			
	Fish (at minimum 4 t/ha)	20,000	7.5	150,000
	Ducks	9,600 x 2.5	10.0	240,000
	Total			390,000
2.	*Annual operating costs (in Kwacha)*			
	Variable costs:			
	Labor	14,000		
	Broodstock replacement	2,000		
	Feed	157,000		
	Transportation	7,000		
	Supplies	2,000		
	Miscellaneous	15,000		
	Fixed costs:			
	Management	8,000		
	Heating Lamps	4,500		
	Depreciation	31,600		
	Interest (10%)	59,715		
	Total cost	300,815		
3.	*Investment costs (in Kwacha)*			
	Fixed capital costs	418,000		
	Additional capital costs	130,000		
	Working capital	49,150		
	Total	597,150		
4.	*Key economic indicators*			
	Profit = K 390,000 - 300,815 = K 89,185			
	Rate of return on investment = 14.94%			

*Note: Selling price of fish is at Government rate. Commercial rate is 50% more at farm gates.

important candidates for active consideration in this respect and the investigations being conducted in Zambia have demonstrated the technical and economic feasibility of integrated fish farming using *O. andersonii*. While it is necessary to develop the techniques further in order to develop new systems and new species, especially polyculture, the applications made so far are suitable for adoption in different parts of Zambia. Considerable interest, especially from the private sector, has been generated in this country for development of fish farming. It is necessary to develop standardized management plans for ensuring regular supply of high quality tilapia seed and for the implementation of integrated fish farming systems suitable for different countries of the subregion.

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