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FISH-CUM-DUCK INTEGRATED FARMING- A CASE STUDY

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Integrated farming system plays vital role in judicious utilization of small water holdings in rural sector for enhancing animal protein production. Considering the potential of duck excreta as manurial input in fish culture, a grow-out trial was carried out in a 0.1 ha earthen pond at the fish farm of the Central Institute of Freshwater Aquaculture, Bhubaneswar, India during 2006-2007 to evaluate the productivity from fish-duck integrated system. The pond was stocked with five carp species *viz.*, rohu, mrigal, grass carp, silver carp and common carp @7500 fingerlings/ha (4.7±1.0 to 10.8±0.4 g). One-day-old layer ducklings (100 nos Khaki Campbell) were reared on the pond embankment in a two-storied shed (6 m length x 3 m width x 0.8 m height). Ducks were provided with commercial starter feed @ 22-50 g/bird/d for initial four weeks and subsequently, 50% commercial feed was replaced with duckweed *viz.*, *Lemna* and *Spirodela*, fed twice daily. The excreta and leftover duck feed from shed were directly washed to pond as manurial input. The water, soil and excreta were analyzed periodically. The survival levels of different species were rohu 97.3%, mrigal 96.8%, grass carp 63.15%, silver carp 47.36% and common carp 99%. The net fish biomass production recorded after one year of culture period was 4174.5 kg/ha. The stocked common carp also found to be self bred resulting 198 additional fish of smaller size (46.85 kg). After 240 days culture period, female ducks started laying eggs (592). There was a declining growth trend observed after 318 days. In addition, 106.4 kg duck meat (85 nos. duck, av. wt. 1.25 kg) was produced. The study reaffirmed the higher production potential of carp polyculture with duck excreta without any supplementary feed.

INTRODUCTION

Integrated fish farming is a diversified coordinated farming practice that emphasizes maximum utilization of available resources without wastage. Fish as the major target product along with other produce are used as source of feed, fertilizer or protein for human consumption (Chen, 1989; Abdou *et al.*, 2000). Fish-duck farming is an economically viable system suitable for small water holdings in rural areas. This type of systems is well established in India (Chand *et al.*, 2006; Kalita, 2006), in Bangladesh (Latif *et al.*, 1993; Mohammad *et al.*, 1993; Khanum *et al.*, 2005), in China (Fang *et al.*, 1986; Yang *et al.*, 1992), in Hungary (Kiss and Pekar, 1994), in Egypt (Soliman *et al.*, 2000), in Germany (Woynarovich, 1979, 1980) and in Philippines (Cruz and Shehadeh, 1980). The relevance

of fish-duck system resulted integrated soil-water fertility management (ISWFM) with *in situ* fertilization, excreta and left-over feed utilization in fish pond (Wolhforth, 1978; Gabrial *et al.,* 2007). Although, the high manurial value of nutrient (N, P, K) in duck excreta has been well documented, a perusal of available literature indicate paucity of information on the estimation of fish production, duck meat, eggs and cost-benefit from these types of culture in Indian context.

MATERIAL AND METHODS

The study was carried out at the Central Institute of Freshwater Aquaculture, Bhubaneswar (Lat. 20°11'06"-20°11'45"N; Long. 85°50'52"-85°51'35" E), India during January-December, 2007 in a 0.1 ha earthen pond. The pond was stocked with rohu (*Labeo rohita*), mrigal (*Cirrihinus mrigala*), grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*) and common carp (*Cyprinus carpio*) with species ratio 50:30:5:5:10 and stocking density of 7,500/ha fingerlings (4.7±1.0 to 10.8±0.4 g) for polyculture.

One-day-old layer ducklings (55±1.8 g), Khaki Campbell (*Anas platyrhycos*), were raised @1000/ha in an inbuilt two storied house (6 m length x 3 m width x 0.8 m height) for brooding. During the initial twenty five days, small ducks were kept on a straw bed litter specially prepared for maintaining hygienic and healthy environment. Three brooders (30" L x 30" W x 18" H each) were used for providing recommended temperature to the ducklings during growing period. Drinkers and feeder were provided throughout the culture period to give sufficient water and uniform distribution of feed to all the ducks. Medicated water with antibiotics, electoral powder, vitamin, liver activator, calcium was given during initial four weeks. The ducklings were fed with commercial starter feed twice daily, prepared with locally available by-products viz., rice bran, wheat bran, broken rice, maize, soybean, mustard oilcake, medicated feed additives & minerals. Commercial starter feed was offered as supplementary feeding @22-50 g/bird/d in feed basket for first four weeks. Further, 50% commercial feed was replaced by duckweed *Lemna* and *Spirodela* as feed for duck during the rest of raising period (Table 2). After 25 days of brooding, the ducks were allowed to roam, swim and feed with natural food organisms from pond periphery water in addition to commercial feed and aquatic weed. Every morning the ducks were released to water (4-5 hrs daily), while during night they were kept in the duck sheds. The duck excreta containing undigested spillover & leftover feed on the shed were washed to pond as manure.

Water samples were collected from the pond at quarterly interval to measure important parameters. Water temperature, transparency, dissolved oxygen and pH were measured *in situ*, while the total alkalinity, total hardness, ammonia-nitrogen, nitrate-nitrogen, nitrite-nitrogen and phosphate-phosphorus were analysed in the laboratory

following APHA (2005). Sediment samples collected before stocking, during culture and after final harvesting were analyzed for pH, electrical conductivity, organic carbon (Walkley and Black, 1934), available phosphorus, available nitrogen and total nitrogen (Kjedahl method) as per standard methods (APHA, 2005).

The fish stocked were not given any supplementary feed and the pond was not fertilized except the split duck feed and manure falling directly into the pond. Because of the difficulties involved in estimating feed utilization by duck, the amount of feed consumed in terms of commercial and duckweed (dry wt.) is considered as feed consumed for calculation of feed conversion ratio.

FCR= Dry wt. of feed/net biomass gain (duck)
Net biomass gain for fish = Final fish biomass-Initial biomass stocked
SGR (%/ d^{-1}) = ln (final wt) - ln (initial wt.)/no. of experimental days x 100
Net fish yield (kg/d) = $\frac{\text{Standing crop at harvest- standing crop at stock}}{\text{No. of days culture}}$

RESULTS AND DISCUSSION

The pond water and soil parameters (Table 1) showed a fluctuation in pH and dissolved oxygen without any particular trend. The semi-confined ducks were grown gradually in shelter and stirring pond water daily during daytime (4-5 hrs). This helped in promoting internal nutrient recycling in interstitial water into water column and increase pond fertilization (Costa-Pierce and Pullin, 1989). Relevant water nutrients variables included significant increase in ammonia, nitrate, nitrite and phosphorus with time period. This may be due to nutrient release through leaching and breakdown of soluble organic molecules (Amir Ullah, 1989; Nath and Lanan, 1992). The recorded parameters were within the optimum ranges for fingerling rearing in outdoor system (Biswas *et al.*, 2006; Jena *et al.*, 2007). Daily application of duck manuring enhanced the soluble N & P (Milstein *et al.*, 1995) and increase productivity of the pond considerably. Wet manure produced from duck excreta and urines supplied soluble N and P for algal utilization and provided substrate for zooplankton production (Wohalfarth and Schroeder, 1979).

Pond sediments are an integral part of the pond ecosystem (Boyd and Bowman, 1997). The physico-chemical analysis of the soil was neutral to alkaline in reaction (6.92-7.86) and electrical conductivity increased from 0.110 to 0.485 milli mhos/cm. Organic carbon, available nitrogen, available phosphorus and total nitrogen showed increasing trend (Table 1), indicating the important role that the pond sediments play in cycling of nutrients in fertilized pond (Avnimelech and Lacher, 1979; Boyd, 1995).

The excreta contain 68.36-85.76 % moisture. Dry manure contains about 0.52% organic C, 0.74 mg/100 g phosphorus and 0.9 mg/100 g available nitrogen when ducks were fed with only commercial starter feed (initial four weeks). The duckweed and commercial combined feed fed manure contained 0.64% organic C, 0.87 mg/100 g phosphorus, 1.12 mg/100 g available nitrogen, and 1.85% total nitrogen with 72.36-88.62% moisture. The optimal manuring rate and frequency were determined by undesirable changes in water quality (MacLean *et al.,* 1994). Manure of each duck contributed net fish yield of 4.9 kg/yr.

Table 1. Variations in water and sediment parameters in carp-duck farming pond

Water Quality	Dec, 06	Jan, 07	Apr, 07	Jul, 07	Oct, 07	Dec, 07
Water temperature (^{0}C)	19.9	21.4	28.6	26.0	24.2	20.3
pH	7.5	7.8	8.0	7.6	8.2	8.2
Dissolved oxygen (mg/l)	3.6	4.2	5.4	4.8	5.2	4.4
Transparency (cm)	54	46	38	44	24	24
Total alkalinity (mg/l)	160	176	120	144	156	172
Total hardness (mg/l)	132	146	138	102	114	126
Ammonia nitrogen (mg/l)	0.46	0.42	0.56	0.32	0.42	0.50
Nitrite-nitrogen (mg/l)	0.084	0.078	0.096	0.038	0.068	0.080
Nitrate-nitrogen (mg/l)	0.56	0.64	0.72	0.48	0.52	0.62
Phosphate phosphorus(mg/l)	0.76	0.84	0.96	0.42	0.58	0.70

Soil Parameters	Dec, 06	Apr, 07	Aug, 07	Dec, 07
pH	6.92	6.97	7.69	7.86
Conductivity, m mho	0.110	0.219	0.253	0.485
Organic carbon (%)	0.56	0.64	0.76	0.92
Available nitrogen, mg/100 g d.w	0.46	0.62	0.72	0.76
Available phosphorus, mg/100 g d.w	0.34	0.45	0.67	0.82
Total nitrogen (%)	0.62	0.92	1.06	1.24
C/N ratio	0.90	0.69	0.71	0.74

The ducks attained 1.2-2.0 kg in size (male 1.5-2.0 kg; female 1.2-1.5 kg) after 240 days of rearing with commercial feed and duckweed (Table 2). Some of the female ducks started laying eggs after 240 days and continued till 304 days on daily basis. Total 592 eggs were collected from 60 female ducks in laying period. The eggs harvested were less compared to other studies (172/bird/yr; Chand *et al., 2006*) may be due to higher male population (1: 2.4) in the lot. Suddenly, due to bad weather (rain & cloudy environment for 5 days), the ducks stopped laying eggs. Declined growth trend was observed after 318 days even though feeding and other activities were normal (Mohapatra and Das Mohapatra, 1991). Duck mortality observed during different stages of culture was in the

brooder house (5%), sudden agro-climatic change (4%), accidental mishap & injury (3%) and disease (3%). The average size of ducks after termination of the study (365±8 days) were male 1.46±0.18 kg (1.0-1.8 kg; n=25, SGR 0.89) & female 1.18±0.23 g (0.8-1.6 kg; n=60, SGR 0.84). Total 106.4 kg duck meat was obtained from the study from 85 ducks.

Table 2. Commercial feed & duckweed used, growth, survival and feed conversion ratio (FCR) of duck during culture period

Month	Types of Commercial feed	Commercial feed kg/d	Types of Duckweed	Total dry duckweed kg/d	Av. wt. of duck g ± S.D	Survival (%)	Total Feed Consumed (dry wt) kg/month	FCR
January, 07	Starter	3.92	-	-	55 ±1.8	100	113.20	62.88
February	Starter	3.37	*Lemna*	6.28	72±5.6	98	105.10	70.75
March	Grower	3.83	*Lemna*	6.83	156±8.4	95	128.15	13.13
April	Grower	6.65	*Spirodela*	8.60	330±10.6	95	211.33	7.71
May	Grower	5.74	*Spirodela*	8.49	550±34.6	90	192.02	10.67
June	Grower	6.22	*Spirodela*	9.48	986±50.8	87	201.96	5.05
July	Grower	3.95	*Spirodela*	10.65	1228±64.2	86	146.92	10.74
August	Grower	3.95	*Spirodela*	9.25	1348±56.8	85	142.62	10.27
September	Layer	3.95	*Spirodela*	9.25	1580±30.7	85	142.62	7.23
October	Layer	3.95	*Spirodela*	9.25	1368±42.7	85	142.62	-
November	Layer	3.95	*Spirodela*	9.25	1220±38.6	85	142.62	-
December	Layer	3.95	*Spirodela*	9.25	1185±46.2	85	142.62	-

The total fish yield was 4174.5 kg/ha with rearing of 1000 ducks/ha. This production is similar to the yield of 4,290 kg/ha/yr obtained in polyculture experiments with supplementary feeding and fertilization (Jhingran and Sharma, 1978). In Vietnam, raising 1,000 to 2,000 ducks/ha on ponds increased the average fish yield to as much as 5000 kg/ha/yr, compared to 1000 kg/ha/yr without ducks (Delmendo, 1980). Fish production of 4000-5000 kg/ha/yr was obtained in duck-fish culture experiments in Thailand, when 625 to 800 ducks/ha were raised over ponds (Gupta, 1985). Observation on individual species revealed that rohu performed 98.4% survival, net yield 0.55 kg/d with maximum contribution (48.47%) to the total yield (Table 3). Although, silver carp grown more than 2.7 kg, the survival was as low as 36% and the net yield was 0.18 kg/d. According to Olah *et al.* (1986) and Green *et al.* (1989), duck manure and spilled over feed directly ingested by filter feeding silver carp, resulting in higher growth.

About, 18 m^2 areas can accommodate 100 ducks and 85% survival with fish yield of over 4000 kg/ha/yr. Sin and Cheng (1979) reported that a shed of 20 m^2 is capable of accommodating about 350 ducks. The dry run space as pond dykes and wet run water

areas provided for each duck in present study was 2.76 and 11.75 m^2, respectively. The 1000/ha ducks raised in the present study produced encouraging fish yield compared to suggestions of 400/ha by other workers (Chand *et al.*, 2006).

Table 3. Stocking and harvesting attributes of fish in polyculture ponds

Fish species	Ratio	Stocking size (g)	Harvested size (g)	Survival (%)	SGR (%/ day)	Gross production (kg/pond)	Contribution to total biomass (%)	Net fish yield (kg/d)
Rohu	50	6.9± 0.1	551.4 ±0.1	98.4	1.20	203.5	48.47	0.55
Mrigal	30	9.4±0.5	454.1±0.4	96.9	1.06	99.0	23.71	0.26
Grass Carp	5	10.8±0.4	366.6±0.8	63.1	0.97	8.8	2.10	0.012
Silver Carp	5	8.6±0.2	2735.7±0.5	36.8	1.58	38.3	9.17	0.18
Common Carp	10	10.4±0.8	245.9±0.5	100.0	0.87	67.8	16.55	0.048

The case study reaffirmed that polyculture, selective harvesting and high density rearing of ducks at 1,000/ha is advantageous for maintenance of adequate natural fish food organisms in the pond. From the viewpoint of input-output relationship, integrated fish farming with ducks is considered to be one of the best models of integration of fish and livestock.

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