towards a value-added polyculture of stocked and wild fish among new adopters.

A constraint to the wider adoption of *T. pectoralis* farming may be the lack of a hatchery system that could supply juveniles. The logistics of moving large numbers of broodfish to stock growout systems may have deterred the spread of *T. pectoralis* culture. The necessity of grass production and cutting, although providing both spawning substrate and a source of food in extensive systems, may also inhibit intensification. Increased yields of both stocked *T. pectoralis* and wild fish appear to be linked to higher inputs of manure and feed. Water use is far more efficient in modern than in traditional systems. The water required to produce 1 kg of *T. pectoralis* is nearly double in extensive as compared to intensive systems. The potential of the *T. pectoralis* as a candidate for more intensive, waste-fed polyculture appears promising if seed supply constraints can be overcome.

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Stocking of Eggs versus Hatchlings in Rice Fields: A Comparison of Survival and Growth of Common Carp (*Cyprinus carpio*) Fingerlings

Mark Ireland and Golam Faruque

Abstract

The study assesses the relative profitability of stocking eggs versus hatchlings of common carp in the rice-fish system in Bangladesh. Results showed that although stocking egg-covered water hyacinths directly into rice fields is a simple low cost option, the yields and profits are much higher from incubating eggs in cloth *hapas* and nursing hatchlings before stocking them into rice fields.

Introduction

As in other parts of Asia, studies undertaken in Bangladesh have indicated the viability of integrating agriculture and aquaculture in rice-fish systems (Rahman et al. 1995; Gupta et al. 1996). The ODA (now Department for International Development)/UK-funded Northwest Fisheries Extension Project (NFEP) and CARE-Bangladesh projects have been actively promoting rice-fish farming in northwest Bangladesh since 1991. In this region it is possible for rice farmers to integrate fish with rice during the rain fed (*amon*) and irrigated dry seasons (*boro*), with fish culture strategies differing with seasons. In the *amon* season when water depth is greater, farmers usually stock fingerlings (>50 mm in length) during July-August, and harvest small-size table fish in October-November. Low water level in *boro* season is not congenial for growing fingerlings to table size; therefore using rice fields as nurseries for raising fingerling could be a better option.

In the northwestern region of Bangladesh, common carp (*Cyprinus carpio*) spawn naturally from December through February. Farmers can exploit this behavior to collect cheap or even free fish seed to stock in their irrigated rice fields. Farmers place water hyacinth *(Eichhornia crassipes)* in ponds containing common carp brood fish and confine the weed using a rectangular bamboo frame or a single bamboo pole placed across one corner of the pond. After the brood fish have spawned, farmers have two options to produce hatchlings: either stock the egg-covered water hyacinth directly into a ditch in the rice field, or incubate eggs in a *hapa*. Hatchlings are subsequently grown in the rice field in February-March and harvested in April-May, as fingerlings. The first option is the easiest, while the second involves higher investments in time and money. The study reported here was undertaken during the *boro* season to assess which method would provide farmers with higher returns.

Materials and Methods

Rice Field Management

The study was undertaken in a 0.7 ha replicated rice-fish trial plot facility at the Northwest Fisheries Extension Project, Parbatipur, Dinajpur in June 1993. The facility consisted of 18 plots; each with an approximate area of 220 m^2, surrounded by 40-45 cm high dikes. A small fish refuge measuring 1 x 1 x 0.4 m was excavated in each plot. Cross trenches 0.45 m wide and 0.3 m deep, were also dug perpendicular to each other, linking the ditch with the rest of the field.

The plots were ploughed and leveled in mid-February 1993. During ploughing, organic fertilizer consisting mainly of composted cattle manure and rice straw was added at 11 000 kg/ha. This is much higher than normally used by farmers in the region but was applied at a higher rate to increase the soil organic matter of the new plots. Standard recommended practices for rice management in the region were then followed. During final ploughing, inorganic fertilizers such as triple superphosphate, gypsum, muriate of potash and zinc sulphate were applied at 120, 100, 100 and 25 kg/ha, respectively.

Rice seedlings of BR-16 variety were transplanted on 27-28 February 1993, with a spacing of 20 cm between lines and rows. The plots were irrigated as necessary from a deep tubewell. Water level in the plots varied from 6 cm at the start of the season to an exceptionally high level of 40 cm after heavy rain (92 days after transplanting) when water levels almost flooded the dikes. The plots were weeded periodically starting 18 days after transplantation. Nitrogen top dressing with urea (225 kg/ha) was carried out in two equal applications 37 and 55 days after transplantation. No pesticides were applied to the crop after transplanting. The rice was harvested 107 days after transplantation.

Fish Seed Production

Eight female and nine male common carps (1.5 kg each) were bred in two concrete cisterns which were injected with carp pituitary gland extract 31 days after transplantation of rice seedlings. Water hyacinth was used as the spawning substrate. Each cistern had a floating frame made of jute sticks, divided into 16 compartments. Equal amounts of washed water hyacinth were put into each compartment. The compartments were randomly assigned to a particular treatment, as in Fig. 1. The four treatments were as follows:

- Es = Eggs on the water hyacinth substrate stocked directly into the rice field;
- Ec = Eggs for counting, to estimate the number of eggs in hatching water hyacinth substrate;
- Hs = Hatchlings for stocking in the rice field after nursing in a *hapa;*
- Hc = Hatchlings for counting after nursing in a *hapa*, to estimate the survival and the number of hatchlings stocked in the rice field.

Each treatment had four replicates. By using two cisterns it was possible to increase the chances of getting a more even distribution of eggs for each treatment.

After spawning, the spawning substrate was transferred either directly to randomly assigned ditches in the rice fields as in the case of treatment Es, or to *hapas* (0.95 x 0.6 x 0.6 m) set in a pond adjacent to the rice plot as in the case of treatments Ec, Hc and Hs. The eggs hatched 48 hours after spawning. Hatchlings were collected and counted from the four *hapas* of treatment Ec. The mean was used to estimate the number of yolk sac fry hatching from the eggs stocked on water hyacinth. This would be a rough estimate since there could be differences in hatching rates, as the conditions in the *hapa* do not represent the conditions in the rice field fish refuge.

The hatchlings in the remaining eight *hapas* of treatments Hc and Hs were fed with boiled egg yolk for five days. The *hapas* were changed daily. Six days after hatching, the hatchlings from treatment Hs were stocked in four different plots. The hatchlings in

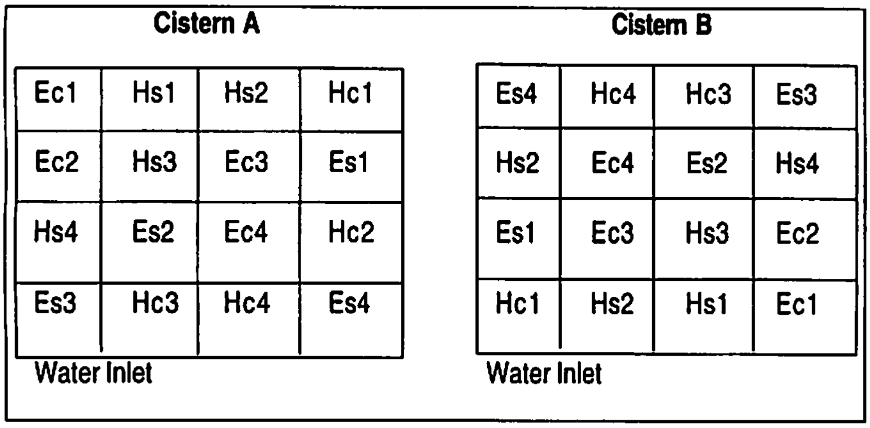

Fig. 1. Plan of the two breeding frames for separating the water hyacinth substrate, with treatment labels for each replicate.

the remaining four *hapas* (Hc) were counted and the number in each replication recorded. The mean number was used as the estimate of the number of hatchlings stocked. The fish were not fed after stocking in the rice fields.

The fingerlings were harvested 73-77 days after the stocking of hatchlings, by which time the rice had matured and harvested. Water was drained out of the plots and the fingerlings were picked up by hand.

Results and Discussion

Treatment Ec was used to estimate the number of eggs that hatched in treatment Es. The mean number of eggs hatched was 3 983 (Table 1), equivalent to a stocking density of 181 000/ha. Likewise, treatment Hc was used to estimate the number of hatchlings that were stocked in treatment Hs. The mean number of hatchlings stocked was estimated at 3 062 equivalent to a stocking density of 139 000/ha. This is lower than the 400 000/ha stocking density recommended by Noble (1992), and the 500 000/ha reported by Gregory and Kamp (in press). The survival of hatchlings, from hatching to release in rice field estimated at 77%, was used to estimate the survival rate of fingerlings in the two treatments (Table 2).

The mean number of fingerlings harvested from treatment Hs, where hatchlings were stocked, was significantly greater ($p<0.05$) at 166 per plot compared to 20 per plot from treatment Es where eggs were stocked on water hyacinth (Table 3). The number of fingerlings recovered from plot Hs4 was very low compared to other plots in the same treatment. This could be due to the escape of fry/fingerlings as plot Hs4 was situated close to the water outlet of the trial plot. Crabs and rats burrowing into plot dikes made it impossible to guarantee that plots were 100% water tight. Therefore the data from this plot have been excluded from the statistical analysis.

The mean individual weight of fingerlings harvested from treatment Hs (5.5 g) was significantly less ($p<0.01$) than treatment Es (49.5 g). This was probably due to lower mortality in treatment Hs, resulting in higher stocking density. The mean total biomass of fingerlings harvested per unit area from the Es treatment (44.57 kg/ha) and the Hs treatment (42.06 kg/ha) was not significantly different ($p>0.05$).

The 5.43% survival in treatment Hs, where first feeding hatchlings were stocked, was significantly greater ($p<0.01$) than 0.49% survival in Es, where the eggs were stocked. One of the probable reasons for this could be higher predation of eggs than hatchlings in the rice field ecosystem by aquatic invertebrates including plankton. Unlike in a nursery pond, no special measures were taken to control invertebrate predators in the rice field. In addition, the composted cattle manure applied promotes the production of zooplankton.

Economics

The partial budget outlined in Table 4 used data from the trial scaled up to the average size of rice field plots (0.22 ha) in the northwestern part of Bangladesh, and assumes that:

- the costs for a farmer are the same whether eggs or hatchlings are stocked except for the additional cost for *hapa* and feeding in the case of hatchling stocking;
- fingerlings (mean weight 5 g) are harvested if hatchlings are stocked;

Table 1. Number of yolk sac hatchlings counted to estimate number of hatchlings in the rice field.

Replicate	No. eggs counted
Ec1	6 003
Ec2	3 603
Ec3	3 941
Ec4	2 383
Mean	3 983
sd	1 504

Table 2. Number of first feeding hatchlings counted, to estimate the number of hatchlings stocked.

Replicate	No. hatchlings counted
Hc1	5 607
Hc2	2 068
Hc3	2 741
Hc4	1 831
Mean	3 062
sd	1 740

Table 3. Number, weight and biomass of fingerlings harvested from each plot.

	Number of fingerlings harvested per 220 m² plot		Mean weight of fingerlings harvested (g)		Biomass harvested (kg/ha)	
Replicate	Hs	Es	Hs	Es	Hs	Es
1	179	35	6.15	48.86	49	77
2	105	22	4.67	54.09	22	53
3	215	7	5.67	37.14	55	12
4	4	14	90.00	57.86	16	36
Mean	166 (126)	20	5.50 (26.62)	49.49	42.06 (35.59)	44.57
sd	56 (93)	12	0.76 (42.26)	9.02	17.58 (19.33)	27.48

The mean and standard deviation in parentheses include plot Hs4.

- fingerlings (mean weight 50 g) are harvested if eggs are stocked.

Based on the partial budget, producing fingerlings by hatchling eggs attached to water hyacinth in *hapas* and subsequently stocking rice fields with the hatchlings yields slightly higher profits because of the higher survival rate, in spite of the lower price for smaller size fingerlings.

Table 4. Cost and benefits of stocking eggs and hatchlings in rice fields for fingerlings production.

Item	Hatchlings	Eggs
A. Investment		
i) *Hapa* (x 2) @ Tk. 80 (can be used 5 times)	32	0
ii) Feeding (egg yolk)	15	0
Total cost	47	0
B. Income		
1 660 fingerlings (5 g) @ Tk. 0.5 each*	830	
200 fingerlings (50 g) @ Tk. 3 each*		600
C. Profit	783	600

*Price based on June 1995 prices at the fingerling trading center at Parbatipur railway station (US$1 = Tk. 40).

Conclusion

Stocking egg covered water hyacinth directly into rice fields is a simple low cost option but yields fewer, bigger fingerlings and lower profits. Incubating eggs in cloth *hapas* and nursing the hatchlings before stocking them into rice fields requires additional labor and investment, but yields a larger number of small size fingerlings with a higher profit margin.

Farmers have to consider their own stocking needs and their ability to market any excess fingerlings. Depending upon the farmer's needs and ability, using a *hapa* to hatch and nurse hatchlings is probably a more reliable method. Through stocking hatchlings, farmers can keep track of what has been stocked, which is more difficult to quantify if the eggs are hatched in the rice field.

Since a *hapa* can be used repeatedly, the cost can be depreciated over several crops. This option also allows farmers to produce several crops of hatchlings during the breeding season, which can be sold to other farmers. Alternatively, a farmer who is not able to nurse hatchlings in a *hapa* but still requires a larger harvest of fingerlings, could adopt a strategy of multiple stocking of eggs to compensate for the higher mortality rate. Given the unpredictability and the risks involved in raising fingerlings in rice fields, a lower investment strategy of this nature may be more attractive to poor rice farmers.

In the northwestern region of Bangladesh many small ponds and ditches are situated close to the family homestead. Women can easily become involved in *hapa* nursing and have successfully done so in the CARE projects. In villages, a proper *hapa* may not even be needed because in Bangladesh, cloths in the form of sari and lungi, traditional dress for women and men, respectively, can easily be improvised as *hapas*.

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Fish Seed Production and Marketing in Northeast Thailand

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Abstract

In Northeast Thailand, fish seed production by private hatcheries is being encouraged by the Department of Fisheries. Dissemination of technical knowledge to hatcheries has considerably improved fish seed availability over the last decade, which has stimulated the adoption of fish culture.

Introduction

Fish seed, mostly produced by private entrepreneurs who have supplanted government fisheries stations, is easily available to farmers in northeast Thailand who stock and raise them in ponds and rice fields. The Thai Department of Fisheries (DOF) has encouraged this trend by supporting private hatchery development through training, extension and marketing assistance. The production characteristics of private hatcheries have been assessed (Little et al. 1987; Purba 1990) but the current status of production and marketing in this dynamic environment is not known. In recent years, hatcheries have been concentrated in certain areas and mobile seed vendors have emerged as major players in fish seed distribution. The results of a study undertaken to assess the current practices of fish seed production and the role of mobile vendors in the distribution are reported here.

The Study

Distribution and Classification of Fish Hatcheries

Official statistics indicate that the fish hatcheries in Northeast Thailand are concentrated in Nong Khai and Mahasarakham provinces with 500 and 200 hatcheries, respectively, while isolated hatcheries are distributed all over the region. The hatchery situation was classified according to location within or outside a concentration