A preliminary study on the feasibility of using fenced brushparks for fish production in Lake Chilwa, Malawi

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Abstract

A study to investigate the feasibility of using fenced brushparks for fish ranching in Lake Chilwa was conducted for five months at the Kachulu Harbor. In a water depth of 1.4 m enclosures constructed from bamboo sticks embedded in the sediment and surrounded by a 13 mm seine net, were filled with three different substrates (*Typha*, bamboo, and *Sesbania* branches) and a no substrate enclosure served as a control. Netting materials contributed 57 per cent towards the total cost (US$ 0.24-0.30/m^2) of brushpark construction. Fish productivity was highest in the *Typha*, bamboo and control treatments and lowest in the *Sesbania* treatments. The decomposition of substrates did not affect water quality. The results indicate that enclosed brushparks may be a feasible technology for enhancing fish yields and providing alternative income sources to fisherfolk in small lakes and water bodies.

Introduction

Lake Chilwa, the third largest lake in Malawi (twelfth in Africa), has an average surface area of 750 km^2 (250-2 500 km^2) and an average depth of 2 m, temperatures of 21-37°C, and a fish productivity of 0.016 kg/m^2/y. The lake, which has no outlet, is surrounded by a 1 000 km^2 marsh. The marshes annually produce a vegetation biomass of 25-30 t/ha/yr and are responsible for the lake's high productivity as the turbid waters (from muddy bottoms) prevent light penetration development of primary productivity from algal blooms. The lake is slightly saline with electrical conductivities ranging from 700-2 500 µmhos/cm^2 depending on season and rainfall. The lake ecosystem is extremely fragile and dynamic and the lake has dried up eight times in the last hundred years. The average annual fish catch from the lake is estimated at 17 000 t and is dependent on lake levels. Three species (*Oreochromis shiranus chilwae*, *Barbus* sp. and *Clarias gariepinus*) out of the fourteen recorded for the lake contribute about 80 per cent to the biomass of the total annual catch.

The fishery is jointly managed by representatives of the fishing communities along with their traditional authorities who comprise the membership of the Lake Chilwa Management Association and with the Fisheries Department (EAD/DANIDA 2000). By-laws of the association include a minimum mesh size of 70 mm for seine nets and a closed season (1 December-31 March) to allow the fish to breed.

Fishing is the most rewarding economic activity in Lake Chilwa and its surrounding catchment. Fish yields are worth US$ 16 300/km^2 compared to livestock grazing and agriculture (US$ 2 680/km^2 and US$ 1 880/km^2, respectively (Schuijt 1999). The enforcement of a closed season and gear restrictions by local committees has been a problem due to the loss of economic opportunities arising from the closed season. A management plan formulated for Lake Chilwa (EAD/DANIDA 2001) identified fish ranching using brushparks as one of the potentially lucrative activities that could provide employment and income to fishers during the closed season.

Brushparks offer a number of biological and economic advantages in the management of small scale fisheries in coastal lagoons, lakes and rivers and these include stocking of open waters through "overflow" of fingerlings from brushparks, conservation of fishery resources, and local employment (Welcomme and Kapetsky 1981). Brushparks have been shown to increase productivity of coastal lagoons and inland waters through migration, reproduction and growth of fish inside the brushpark (Hem and Avit 1996). Fish yields in a brushpark vary from 0.01-3.8 kg/m^2/yr (ICLARM–GTZ 1991; Welcomme and Kapetsky 1981). The Lake Chilwa wetland has a variety of vegetation types including *Typha* reeds (*Phragmites mauritianus*) and nitrogen-rich shrubs like *Sesbania sesban*, which could potentially be used as substrate. The introduction of fish ranching through brushparks in Lake Chilwa could therefore increase potential fish yields, and if harvesting was timed to coincide with the closed season, the brushparks could provide alternative and continued income from fish to individuals or community groups.

Although traditional brushpark systems exist in Lake Chilwa (Williamson 1972), there is little information available that would form the basis for the introduction of brushparks. Hence, this study was undertaken to evaluate the feasibility of fish ranching using brushparks in Lake Chilwa, specifically to conduct trials on the productivity, species composition, recruitment, and construction costs of brushparks and to identify existing local knowledge on their use.

Materials and Methods

Participatory Rural Appraisal

The study was undertaken at the Kachulu Harbor, Lake Chilwa between July and November 2001. Prior to commencement, a meeting was held with the local authorities and the beach village

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Harvesting an experimental brushpark in Lake Chilwa

committees (BVC) to introduce the experiment, to seek permission for using the lake for the study and to develop a work plan for implementing the study. The BVC is a lower level committee of the Lake Chilwa Management Association and is responsible for enforcing the association's by-laws at the local level. During the meeting, local knowledge on fish ranching and the use of enclosures in Lake Chilwa was assessed. At the end of the study, an open day for local authorities and BVCs around the study site and from the western shores was conducted to disseminate the results of the study and to plan future activities for the promotion of brushpark technology in the lake.

Experimental design and brushpark construction

The experiment followed that of Hem and Avit (1996) and consisted of eight 10 m x 10 m enclosures each fenced by a 13 mm seine net, and each filled with one of four different substrates (treatments), with two replicates per treatment:

1. Enclosure filled with *Typha* spread over the entire area of the brushpark, and surrounded by bamboo sticks embedded in the mud.
2. Enclosure filled with bamboo sticks at 10 sticks per m^2.
3. Enclosure filled with *Sesbania sesban* (a leguminous shrub with high nitrogen content) at 12 branches per m^2 surrounded with bamboo sticks as in (2).
4. Enclosure with no substrate (control).

All enclosures were cleared of fish using an 8 mm seine net prior to filling with substrate (Hem and Avit 1996). Recruitment of juveniles into the brushpark was through fish entering through the 13 mm enclosing net. Initial colonization dynamics (species, number, weight and length) were determined through sampling (four quadrants per enclosure) using 1.5 m x 1 m x 1 m quadrants that were randomly assigned along the inside perimeter of each park and assessed over a period of one week by daily sampling. Subsequent fish sampling to determine species, number, weight, and total length changes were conducted monthly using a 13 mm x 10 m x 1 m harvesting net. Data were collected and analysed for each sampling. Final harvesting was done five months after the study was initiated by seining the entire brushpark area. In brushparks filled with bamboos, the sticks were removed before sampling. It was planned to have the study for six months, however theft of netting materials from two brushparks led to the premature termination of the study in November 2001.

Data analysis

Individual fish weight and extrapolated gross yield (kg/m^2/yr) were calculated for each treatment using harvest weight. Total input cost was calculated using input cost of labor, bamboo sticks and netting material. Water quality analyses were conducted monthly using APHA standard methods (APHA 1989) and included total suspended solids (TSS), electric conductivity (EC), dissolved oxygen (DO) and chlorophyll *a* (chl a).

Results

Participatory Rural Appraisal (PRA)

Local communities around Lake Chilwa are knowledgeable about the existence of a traditional brushpark system, called 'garages' for short-term storage of fish catches from the open waters. The fish were added to the enclosures daily until the live biomass was economical enough for transfer to the beach where the fish were sold to traders. The fish held in the enclosures/brushparks were fed with kitchen wastes to maintain fish in good condition.

Large mats of floating vegetation (mainly *Typha domingensis*) ranging from 1-100 m^2 each, are periodically blown across the lake by prevailing southwest winds (Cantrell 1985). Their movement blocks bays and fish landing sites and were identified as the single most important threat to the brushparks. To protect the brushparks from the destructive forces of the floating mats, it was agreed that brushparks be constructed in the marshy areas where

Table 1. Cost of constructing brushparks and the average fish productivity for each treatment.

	Substrate type			
	Typha	Bamboo	Sesbania	Control
Input cost				
Netting (MK)	10 987.50	10 987.50	10 987.50	10 987.50
Bamboo cost (MK)	330.00	4 455.00	330.00	330.00
Labor amount (person days)	12.50	12.50	12.50	12.50
Total labor cost @ MK 500/d	6 250.00	6 250.00	6 250.00	6 250.00
Total construction costs (MK)	17 537.50	21 692.50	17 537.50	17 537.50
Average fish productivity				
Estimated annual average fish productivity (kg/m^2/yr)	0.7263	0.5986	0.4384	0.5803
Average fish biomass (kg/ha/yr)	363.70	299.30	219.20	294.60

1US $ = MK (Malawi Kwacha) 75

reeds would protect the brushparks from the floating mats and from strong winds.

Brushpark Construction

Data on the cost of brushpark construction is presented in Table 1. Each brushpark (10 m x 10 m) was constructed using 12.5 man-days of labor. Labor and netting materials made up 51-63 per cent of the total cost of a brushpark. The initial cost of materials for constructing bamboo-filled brushparks was higher than that of brushparks filled with *Sesbania sesban* and *Typha*. The *Typha* brushparks were replenished with substrates once during the experiment.

Water Quality

Values of water quality parameters remained relatively stable over time and were similar among treatments. The average concentrations (± S.D.) were: chlorophyll 15.2 ± 2.1 mg/l, electrical conductivity 1310 ± 204 μmhos/cm, suspended solids 134 ± 82 mg/l and dissolved oxygen 4.7 ± 0.8 mg/l.

Fish colonization and species composition

Barbus paludinosus, *Oreochromis shiranus chilwae*, *Haplochromis callipterus* and *Clarias gariepinus* were the main fish species that colonized and established within the brushpark. Colonization rates among the species groups and between treatments were generally similar.

Population sizes (in numbers) of *O. shiranus chilwae* and *C. gariepinus* marginally increased from the month of September until harvest in November, while *B. paludinosus* and *H. callipterus* populations did not show any distinct trend (Figures 1 and 2). There were generally no differences in the total number of fish between treatments at harvest. *O. shiranus chilwae* was the most dominant species in the *Typha*, bamboo and *Sesbania* treatments followed by *H. callipterus*, while both *O. shiranus chilwae and H. callipterus* were equally dominant in the control (Figure 2).

Fenced Brushpark Fish Production

Data on individual fish weight and gross yield of fenced brushparks are presented

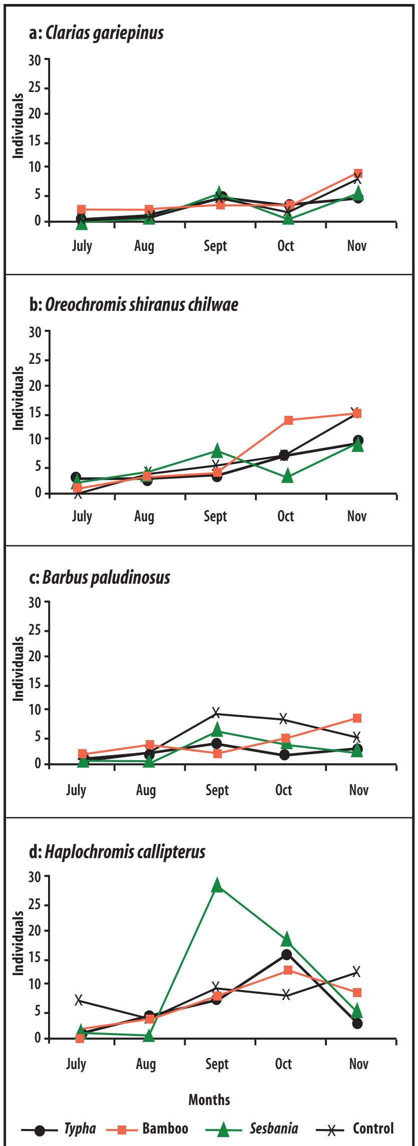

Fig. 1. Occurrence of main fish species by numbers of individuals in fenced brushparks using different substrates in Lake Chilwa marshes.

in Figure 3, Tables 1 and 2 respectively. The lowest fish production and biomass were recorded in the *Sesbania* treatment while highest fish biomass was recorded in the *Typha* treatment. The bamboo and control treatments had similar fish production values. Specific growth rates ranged between 0.9-3.2 (per cent/day) (Table 3) and were generally similar between treatments.

Dissemination of results through an Open Day

Results of the study with respect to construction and materials required for construction of brushparks, productivity and management were disseminated to the participants and other potential users of the technology during an open day that was conducted on site at the Kachulu Harbor. The participants were encouraged by the outcome of the study and decided to implement the technology, starting with a larger community-owned brushpark and then later expanding to individually-owned brushparks. The problem of theft that was encountered during this study was not seen as a deterrent to the adoption of the technology and conflicts between fishers and navigators were ruled out because the brushparks were sited in areas that were not used by these two groups.

Discussion

The observation from the open day revealed that brushparks were not an entirely new technology in the Lake Chilwa fishery. Williamson (1972) also reported of the existence of traditional aquaculture on the lake but did not describe their structure. The fishers reported that the brushparks were an improvement in the existing technology with respect to fish holding duration, productivity enhancement and stocking procedures, and expressed their perception that the technology could be easily adopted.

Brushparks compete with adjacent fisheries through the attraction of juveniles from the open water to the brushparks, i.e. these constitute a competition for space and resources (Welcomme and Kapetsky 1981). The conflict between the brushparks and capture fisheries is exacerbated when the brushpark is used as a fish aggregation device or fish attractant device (FAD). This occurs when short harvest intervals (three months) are used which do not allow breeding to occur inside the brushpark (Hem and Avit 1996). The prolific spread of brushparks in Benin has also been shown to result in serious social conflicts between brushpark owners and navigators (Pliya 1980). In this study, conflicts arising from multiple use of brushpark construction sites for navigation and fishing were ruled out by the local people as the "garages" and the sites chosen for the brushparks are

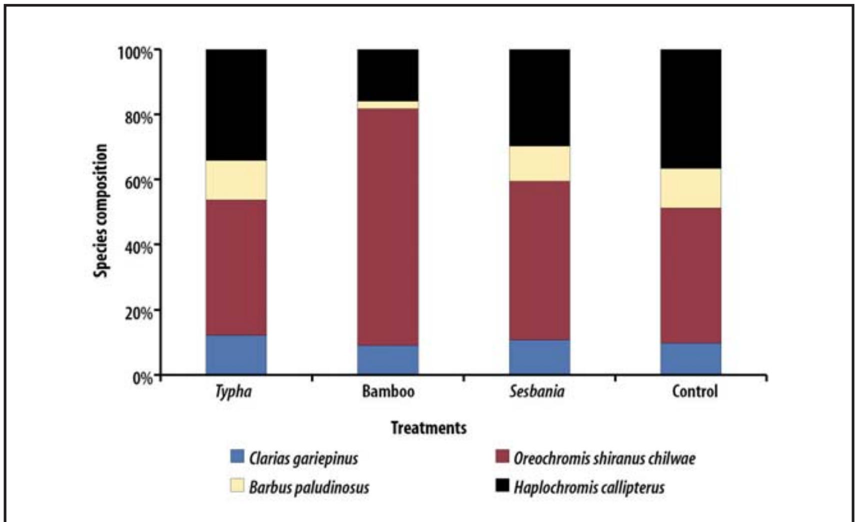

Fig. 2 Composition of main fish species (by number of individuals) at harvest after five months of operation of fenced brushparks using different substrates in Lake Chilwa marshes.

located in areas with little navigation and fishing activity.

Hem and Avit (1996) reported that conflicts arise between brushpark owners and fishermen when adult fish are attracted to the brushparks by abundant food supply and subsequently reduce the fish biomass in open waters. To reduce this conflict, net enclosures have been introduced in brushparks as they allow for selective colonization of juveniles in the brushpark and their rearing in a protected environment. The attraction of larger individuals into the enclosures, which would otherwise be fished, is avoided. In this study, netting materials were used. However, they contributed to the high initial cost of brushpark construction and could make the technology unattractive to users. Use of locally available natural materials such as closely spaced bamboos for selective colonization could reduce the initial construction costs.

Labor costs (MK 500 per man-day) were much higher than the prevailing wage rate (MK 35 per man-day). This was due to the tight deadlines that were set for the commencement of the study and the fact that most of the labor consisted of out of work fishers who had set their wages based on their daily income from fishing. The use of regular wage labor and more careful planning of construction schedules would significantly reduce the cost of labor in the construction of the brushparks.

The number of *O. shiranus chilwae* started to increase during the month of September and this increase in numbers coupled with fish growth resulted in increased fish biomass in the bamboo enclosures, while reduced growth was observed in the *Sesbania,* and *Typha* treatments as well as the control. The increase in fish numbers during this period can be explained by the fact that the open water fish species in the lake i.e. *O. shiranus chilwae, C. gariepinus and B. paludinosus* migrate into the swamps to escape the inhospitable environment of the open waters in the dry season and to spawn (Furse et al. 1979). The suppression of *O. shiranus chilwae* growth in the *Typha*, *Sesbania* and control treatments could be attributed to the low availability of feed and increased competition for feed resources.

In enclosures where bamboo acted as substrates the fish did not exhibit any decreased growth during this period. Bamboos were covered with a thick green mat of algae, which might have provided a continuous source of feed for *O. shiranus chilwae*, which allowed the fish to grow during this period. The observed cessation of growth in *B. paludinosus* two months after colonization is normal and has also been observed in fishponds. The continued growth of *C. gariepinus* during the study could be attributed to its low population size which resulted in less intraspecific competition for food resources within the brushpark.

In Malawi, fish ranging from 5 g (small haplochromines and barbs) to over 1 kg (Bagriid catfishes) are sold in the markets. The fish weights at harvest, which ranged from 10 g for *B. paludinosus* to 40 g for *C. gariepinus* were all of marketable size.

The annual fish production (extrapolated) in all the brushparks was much higher than the annual fish production reported for the lake (Schuijt 1999), and this could be attributed to the ability of the brushparks to support higher densities of fish. *H. callipterus* whose natural habitat is the marshy areas of the lake contributed a significant proportion to the total

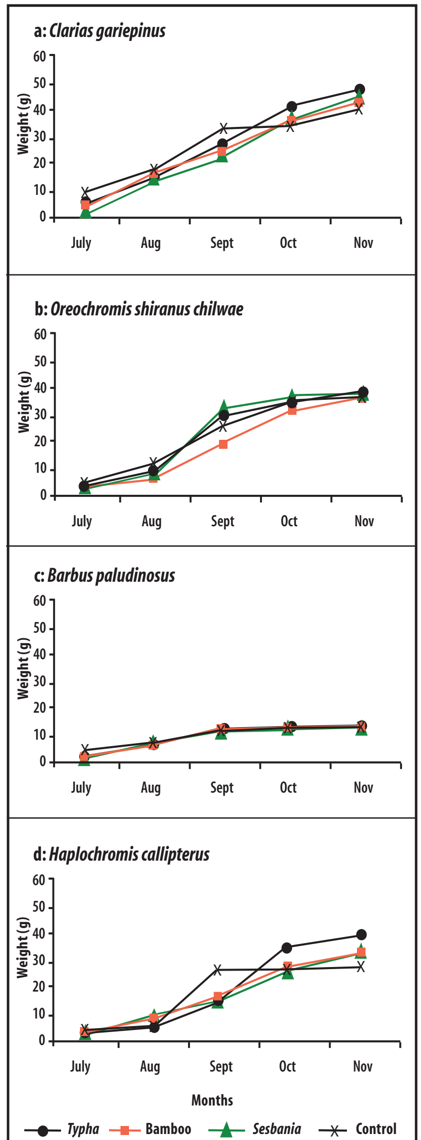

Fig. 3. Average weight of individual fish of main species colonizing fenced brushparks using different substrates in Lake Chilwa marshes

Table 2. Gross yield per treatment by species.

Treatment	Gross yield by species (kg/m²/5mo)			
	Clarias gariepinus	***Oreochromis shiranus chilwae***	***Barbus paludinosus***	***Haplochromis callipterus***
Typha	0.1235	0.3123	0.0290	0.2615
Bamboo	0.0659	0.443	0.006	0.0838
Sesbania	0.0614	0.2324	0.0132	0.1315
Control	0.0754	0.2902	0.0232	0.1915
Total	0.3262	1.2779	0.0714	0.6683

Table 3. Effect of substrate type on fish specific growth rate.

Treatment	Specific growth rate (% per day over 5 months)			
	Clarias gariepinus	***Oreochromis shiranus chilwae***	***Barbus paludinosus***	***Haplochromis callipterus***
Typha	2.1	2.0	1.1	1.8
Bamboo	2.0	1.8	1.4	2.0
Sesbania	3.2	2.2	2.0	2.0
Control	1.3	1.9	0.9	1.5

number of fish in the *Typha, Sesbania* and control (no substrate) treatments compared to the bamboo treatment. The higher contribution of *H. callipterus* to the total population coupled with the relatively high weights that were recorded at harvest contributed to the high catch values in the control.

The low average biomass in the *Sesbania* treatment could be attributed to the low number of fish in this treatment compared to the other treatments. In this treatment, branches devoid of leaves were used as substrates and very little decomposition occurred to promote periphyton growth around the *Sesbania* branches. The higher contribution of *H. callipterus* to fish biomass and production of the *Typha* treatment have significant implications to the economic performance of the *Typha* brushparks. As *H. callipterus* are not economically important to the Lake Chilwa fishery, one would expect low income from *Typha* brushparks because of the low proportion of the economically important fish species (*Barbus* sp. and *O. shiranus chilwae*) in the harvest relative to the abundant and less economically important *H. callipterus*. Although economic analysis (gross margins) was not conducted, the data suggest that *Sesbania* and bamboo brushparks could result in higher income compared to the *Typha* brushpark system.

This preliminary study has demonstrated that the use of fenced brushparks to produce fish during the closed season of the Lake Chilwa fishery is feasible and that the communities using the latter could easily adopt the technology. However, issues of profitability and productivity during long harvest intervals need to be addressed using action research conducted in community-managed brushparks.

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