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An Economic Analysis of Floating Cage Culture of Tinfoil Barb, *Puntius schwanenfeldii*, in East Kalimantan, Indonesia, Using Chicken Manure and Other Fresh Feeds

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Abstract

Tinfoil barb, Puntius schwanenfeldii, in floating cages can be fed a variety of fresh feeds, but some cannot be consumed whole. It was found that 96% and 65% of tubers and leaves of cassava, Manihot esculenta, and 70% of banana bunches could be ingested by tinfoil barb. The leaves of water spinach, lpomea aquatica, and of a climber, Passifiora sp., were less practical, as only 49% and 34%, respectively, were edible. Preparation and distribution times were determined for these feeds, as well as for dried fish, two home-made pellet feeds and two commercial pellets. Only 1-3 min were required to prepare and feed one kilo of cassava leaves or dried fish to tinfoil barb. Water spinach leaves required 5 min, bananas 12 and cassava tubers 26 min. Home-made pellet feeds required 27-39 min. Feeding commercial pellets by hand took 14 min·kg"1, whereas with demand feeders it only took 2 min·Itg-1.

Cost-benefit analyses of 14 small-scale cage culture syst.ems were conducted us-ing these data. Gross income, excluding labor and interest payments, varied from a loss of Rp 34,225 to a profit of Rp 38,925·m-3·year·1. Returns on labor for the 10 prof-itable culture systems ranged from Rp 50 to Rp 1,725·m·3·day·1 per person. Protein production costs ranged from Rp 9,200 to Rp 24,000·kg"1.

The best incomes and returns were generated from fish-cum-chicken systems. Little labor and low cash inputs were required when feeding cassava leaves only. The implications for village-based tropical culture syst.ems in Southeast Asia are discussed, bearing in mind the fact that free time has a high social value and cash for invest-ment is often lacking.

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Introduction

Village-based cage aquaculture systems in Indonesia are usually small-scale enterprises, the principal cost being for feed. This contrasts with large-scale operations where both labor and feed are major costs (Beveridge 1987; Lee and Wickins 1992).

Labor is also an important factor in small-scale systems, but its relevance is measured differently. The return per unit of labor is often more important to a small-scale farmer in the tropics than the return per unit of investment. This is because abundant family labor is available to such households and home-grown products rather than cash will be invested (Christensen 1991). Free time is also disproportionately important, when compared to western societies, in a culture where cooperative village activities are a way of life and time used to cement social contacts is considered well spent (Pringle 1985; Golaszinski 1986; Christensen 1991). It is possible to take these factors into account by conducting cost-benefit analyses to determine the return of a particular system per unit of labor input (Mansfield 1982; Ray 1984).

In addition, village-based aquaculture systems often use fresh feeds which often contain inedible portions, e.g., banana skins and leaf stalks. These portions must be trashed, increasing the cost of the edible part. Secondly, the time taken to prepare and give feed to fish can be considerable, even with commercial pellet feeds. Little information is available on these aspects (Beveridge 1987).

As part of a regional development project funded by the German Government in the Middle Mahakam Area of East Kalimantan in the 1980s, extensive research into the culture of local fish species in floating cages was conducted. One of the species tested was the tinfoil barb, *Puntius schwanenfeldii*. Previously, data were presented on the growth and feed conversion rates of tinfoil barbs fed a variety of fresh and pelletized feeds (Christensen 1991, in press). The effect of giving the fish access to fresh chicken excreta falling into their cages was also tested and described.

This study reports on the edible portions of the same fresh feeds, and on feed preparation and feeding times for these systems. These results are then used for a series of cost-benefit analyses of small-scale tinfoil barb culture. Their use and implications for extension services at the village level are discussed.

Materials and Methods

The portion of various fresh feeds that was consumed by tinfoil barb was estimated as follows: Samples of the feed were weighed on purchase and inedible portions removed (banana skins, stalks of leaves, fibrous parts of cassava tubers). After preparation (peeling, cutting, grating), the weight of the portion to be fed was determined. The time taken to prepare and to dispense various feeds was obtained by timing five people with a stopwatch as they prepared and fed fish.

Average prices for the fresh feeds used were obtained in the production area over a one-year period in 1986, as was the selling price for tinfoil barb at the local market and at the provincial capital's market. They were updated in 1991/92 and used to conduct cost-benefit analyses. Both net and gross incomes were calculated, i.e., with and without labor and capital costs. The former is the return that an investor receives, whereas the latter is that earned by a small-scale farmer using family labor. The return on labor is also determined, which shows what the small-scale farmer would earn per day worked.

A number of assumptions were made for all analyses and these are shown in a sample cost-benefit analysis (Table 1). In cases where tinfoil barb were cultured with chickens, calculations do not include costs and incomes of the chicken production. Other assumptions below relate to the feed and to opportunity costs.

Feed data: Feed conversion rates (FCR) and average feed prices are given below. Feed requirements are reduced by 25% when chickens are kept above the cage.

Costs: Average per kilo prices in Rupiah of the feed ingredients were: bananas, 69; cassava leaves, 147; cassava tubers, 169; water spinach leaves, 270; *Passiflora* leaves, 596; dried fish, 750; fresh fish, 300; commercial pellet feeds (*Bama* and *Comfeed*), each 480; rice bran, 150; maize meal, 500.

Composition and FCR.

- Cassava leaves • FCR 10.4
- *Passiflora* leaves • FCR 18.3
- Fresh mixture of bananas (60%), water spinach leaves (20%) and dried fish (20%) • FCR 7.5.
- Fresh mixture of cassava tubers (60%), cassava leaves (20%), and dried fish (20%) • FCR 5.6

- Home-made pellets of dried fish (45%), rice bran (10%), cassava tubers (25%) and cassava leaves (10%) • FCR 5.5
- Home-made pellets of fresh fish (40%), maize meal (40%), cassava tubers (10%) and cassava leaves (10%) • FCR 6.0.
- Commercial pellets; *Bama*, FCR 4.5 and *Comfeed*, FCR 3.4.

Opportunity (capital) costs: Interest is charged on 50% of the variable costs and on 100% of the fixed costs at an annual rate of 20%. The former reflects the fact that spending on variable costs is spread throughout the culture period. Total expenditure on vari-

Table 1. Cost-benefit analysis of the culture of tinfoil barb, *Puntius schwanenfeldii*, in a 9m^3 floating cage in East Kalimantan, Indonesia, when fed cassava leaves only.

	Description	Amount	Unit	Unit Price	Totals
Benefits					
I.	Fish harvest (1,197 fish weighing 300 g each)	359	Kg	2,000	718,000
II.	Sum of benefits				718,000
Variable costs					
III.	Stocking material	1,260	Fish	50	63,000
IV.	Fish feed (cassava leaves)	3,079	Kg	147	452,625
V.	Maintenance costs	12	Months	1,000	12,000
VI.	Transport to market	—	—	—	40,000
VII.	Sum of variable costs				567,625
Fixed costs					
VIII.	Write-off costs for fish cage	12/30	Cage	75,000	30,000
IX.	Sum of fixed costs				30,000
Labor costs					
X.	Unskilled labor	17	Man-days	3,000	51,000
XI.	Sum of labor costs				51,000
Opportunity costs					
XII.	On 50% of variable costs	20%	Rp	—	56,775
XIII.	On 100% of fixed costs	20%	Rp	—	6,000
XIV.	Sum of opportunity costs				62,775
Income and returns					
XV.	Gross income (without labor and capital costs; II-(VII+IX))				120,375
XVI.	Net income (with labor and capital costs; II-(VII+IX+XI+XIV))				6,600
XVII.	Unit gross income (Rp·m^{-3}·year^{-1}; XV/9)				13,375
XVIII.	Unit net income (Rp·m^{-3}·year^{-1}; XVI/9)				750
XIX.	Return on labor (Rp·m^{-3}·person-day^{-1}; XVII/No. person-days)				775

Assumptions: Mortality rate 5%; feed conversion ratio 10.4; culture period 12 months; cage lasts 30 months; 1 US$ = Rp 2,040 (all costs rounded to Rp 25).

able costs is therefore not paid out at the beginning and should not incur the full interest costs for the entire period. Economists thus charge 50% as the best estimate.

Opportunity costs are calculated to compensate for on-paper losses, i.e., the "cost" of not investing the goods used and the money spent on the cages in some other way (Galapitage 1982). Interest is not usually paid by rural farmers, however, unless they have taken a government credit with a subsidized interest rate of 12% as compared to bank rates of 20-25%. When costs are financed with personal capital, which is the normal system for small-scale farmers, computations of interest rates only have a calculatory value, as the farmer's capital cannot be invested elsewhere (rural areas rarely have banks). Such analyses are necessary, however, in order to be able to compare results with other published data which usually include capital costs.

Production costs of meat: The costs of producing 1 kg of live fish were calculated to include labor and capital costs. These costs were then used to determine production costs for fish flesh and protein, bearing in mind that carcasses of *Puntius* spp. contain 49.4% meat and 17.6% protein (Sarnianto et al. 1983).

Results

The proportion of marketed produce that was consumed by tinfoil barb was determined for cooking bananas, fresh cassava tubers and fresh leaves of cassava, water spinach *(Ipomea aquatica)* and a climber *(Passiflora* sp.*)* (Table 2). Between 34 and 65% of the leaves consisted of edible parts, whereas almost 70% of banana bunches and 96% of cassava tubers could be fed to the fish. Prices for the edible portions were determined based on these proportions (Table 2) and used for all cost-benefit analyses.

The times taken to prepare and to feed the fish with these fresh feeds, as well as with dried fish and with home-made and commercial pellet feeds are shown in Table 3. Cassava leaves, dried fish and commercial feeds with demand feeders required $<2\ \mathrm{min \cdot kg^{-1}}$, whereas one home-made pellet feed took $<38\ \mathrm{min \cdot kg^{-1}}$ to prepare and feed by hand.

Gross and net incomes and returns on labor for the systems are given in Tables 4 and 5. Six of the seven feeding regimes were

Table 2. Determination for a variety of fresh feeds of the edible portion and their per kilo prices calculated on the basis of 1991/92 market prices in East Kalimantan, Indonesia.

	Market Product				
	Cooking bananas	Cassava tubers	Cassava leaves	Water spinach leaves	*Passiflora* leaves
Sales unit	Bunch	Kg	Bundle	Bundle	Bundle
No. of fruit, leaves, stalks, etc.	39.0	-	94.0	96.0	10.3
Sample no.	20	5	225	13	28
Unit weight (g)	3411.9	1000.0	779.3	562.8	197.3
Edible portion (g)	2379.4	960.2	508.7	277.7	67.1
Edible portion (%)	69.7	96.0	65.3	49.2	34.3
Price·unit^{-1} (Rp)	150-175	150-175	50-100	50-100	30-50
Price·kg^{-1} of the edible portion (Rp)	63-74	156-182	98-196	180-360	447-745

Table 3. Average time required to prepare and/or dispense 1 kilogram of feeds to tinfoil barb in floating cages.

Feed type	Type of labor	N*	Labor requirement (min·kg^{-1} ± SD)
Bananas	Preparation	16	2.8 ± 0.72
	Feeding	5	9.3 ± 1.23
	TOTAL TIME		12.1
Cassava tubers	Preparation	16	12.3 ± 3.00
	Feeding	6	13.6 ± 4.85
	TOTAL TIME		25.9
Cassava leaves	Preparation/Feeding	4	1.8 ± 0.72
Passiflora leaves	Preparation/Feeding	3	0.8 ± 0.30
Water spinach leaves	Preparation/Feeding	16	4.4 ± 3.23
Dried fish	Preparation/Feeding	4	1.9 ± 1.03
Home-made pellets	Preparation of cassava flour	4	11.4 ± 3.15
	Preparation of pellets	4	15.4 ± 5.23
	Feeding	4	11.7 ± 5.53
	TOTAL TIME		23.1 - 38.5
Commercial pellets	Preparation	14	1.0 ± 0.22
	Feeding by hand	6	12.9 ± 4.40
	Feeding using demand feeders	7	0.7 ± 0.41
	TOTAL TIME		1.7 - 14.6

*N = number of time measurements

Table 4. Income, returns on labor and production costs of various cage culture systems of tinfoil barb, *Puntius schwanenfeldii*, with access to fresh chicken excreta.

Feed type	Annual income ($Rp{\cdot}m^{-3}$)		Daily return on labor (Rp)	Production costs ($Rp{\cdot}kg^{-1}$)	
	Gross	Net		Meat	Protein
Cassava leaves	25,950	15,225	1,725	3,275	9,200
Bananas, cassava leaves and dried fish (60-20-20)	27,925	14,750	575	3,850	10,775
Cassava tubers and leaves and dried fish (60-20-20)	22,875	-13,825	250	4,650	13,050
Home-made pellets:					
- Dried fish, rice bran, cassava tubers and leaves (45-10-25-20)	-3,100	-67,375	-25	6,600	18,550
- Fresh fish, maize meal, cassava tubers and leaves (40-40-10-10)	12,325	-77,750	50	7,000	19,650
Commercial pellets:					
- "Bama"	27,500	-5,900	400	4,250	11,875
- "Comfeed"	38,925	12,825	750	3,625	10,150

Calculated in Indonesia Rupiah ($Rp{\cdot}m^{-3}$), where 1US$ = Rp.2,040. Costs and benefits from chicken production were omitted. Gross income excludes labor costs and interest payments, net income does not.

Table 5. Income, returns on labor and production costs of various cage culture systems of tinfoil barb, *Puntius schwanenfeldii*, without access to fresh chicken excreta.

Feed type	Annual income ($Rp{\cdot}m^{-3}$)		Daily return on labor (Rp)	Production costs ($Rp{\cdot}kg^{-1}$)	
	Gross	Net		Meat	Protein
Cassava leaves	13,375	750	775	4,000	11,250
Bananas, cassava leaves and dried fish (60-20-20)	11,500	-18,000	175	4,825	13,550
Cassava tubers and leaves and dried fish (60-20-20)	4,775	-42,725	50	5,900	16,575
Home-made pellets:					
- Dried fish, rice bran, cassava tubers and leaves (45-10-25-20)	-34,225	-118,300	-175	8,550	24,000
- Fresh fish, maize meal, cassava tubers and leaves (40-40-10-10)	-13,675	-97,675	-75	7,775	21,800
Commercial pellets:					
- "Bama"	-10,575	-53,950	-125	5,875	16,475
- "Comfeed"	17,375	-15,875	250	4,575	12,875

Calculated in Indonesia Rupiah ($Rp{\cdot}m^{-3}$), where 1US$ = Rp.2,040. Costs and benefits from chicken production were omitted. Gross income excludes labor costs and interest payments, net income does not.

profitable when tinfoil barb were cultured with chickens, with gross incomes of Rp 12,325-38,925$\cdot$m$^{-3}\cdot$year^{-1} and daily returns on labor of Rp 50-1,725$\cdot$m^{-3} per person. Three of the seven culture systems tested without chickens resulted in losses on the investment, and the returns on the others were about one quarter to one half lower than with chickens.

Only three feeding regimes for tinfoil barb resulted in satisfactory annual net incomes (with chickens): cassava leaves (Rp 15,225$\cdot$m^{-3}); bananas, cassava leaves and dried fish (Rp 14,750$\cdot$m^{-3}); one commercial pellet (Rp 12,825$\cdot$m^{-3}).

Production cost for meat was Rp 3,275-8,550$\cdot$kg^{-1}, and for protein Rp 9,200-24,000$\cdot$kg^{-1} (Tables 4 and 5).

Discussion

Considerable differences were found in the time taken to prepare and distribute the tested fish feeds, which ranged from 2 to 38 min$\cdot$kg^{-1}. This is equivalent to 15-213 man-days to prepare and feed the amount required during a one-year culture period for a 9 m^3 cage. Labor requirements when feeding cassava leaves and one commercial pellet feed using demand feeders are only $\approx$ 2 min$\cdot$kg^{-1}. When the pellets are fed by hand, this increases to 14 min$\cdot$kg^{-1}. This is because leaves only need to be placed in the cage and pellets in the feeder after weighing, whereas handfeeding must be done slowly. These data underline the importance of determining the times taken to use a particular feed, as the economics of a particular system are significantly affected by labor requirements.

The average feed and labor costs of all systems make up 57% ($\pm$5.2%) and 22% ($\pm$8.4%) of total operating costs, when these include interest payments. Both feed and labor costs are similar to those determined for estuary grouper and tilapia production in cages (Chua and Teng 1980; Galapitage 1982).

The return on labor earned by a small-scale farmer when culturing tinfoil barb in floating cages without chickens is only positive for four of the seven feed types tested. When chickens are cultured above the fish, six of the seven feed types result in positive returns. The best annual return on investment at Rp 38,925$\cdot$m^{-3} was earned when tinfoil barb were fed a commercial pellet. The highest daily return on labor, however, was obtained when fish were fed cassava leaves, Rp 1,725$\cdot$m^{-3} per person.

When calculated for a commercial-sized fish cage of 9-10 m^3, these earnings are good. For comparison, total annual earnings of farmer and fisher families in East Kalimantan range between Rp 500,000 and Rp 3,000,000 and daily return on labor between Rp 150 and Rp 9,800 (Golaszinski 1986; Christensen 1991).

Incomes and returns on labor have also been calculated for common carp, *Cyprinus carpio*, and jelawat carp, *Leptobarbus hoevenii*, cultured in floating cages in East Kalimantan (Christensen 1991). These data were recalculated using 1992 prices. Common carp cannot utilize cassava leaves as a sole feed, but for the other feeds, annual gross incomes were Rp 75,875-184,900$\cdot m^{-3}$, and daily return on labor Rp 225-1,450$\cdot m^{-3}$ per person. Like tinfoil barb, jelawat carp can utilize cassava leaves and gross annual incomes reached Rp 14,775 to 53,300$\cdot m^{-3}$ and daily return on labor Rp 500 to 3,325$\cdot m^{-3}$. These incomes and returns are higher than those earned from the ten profitable culture combinations of tinfoil barb of Rp 4,775-38,925 and 50-1,725, respectively.

Various factors account for these differences. Firstly, tinfoil barb only fetch Rp 2,000$\cdot kg^{-1}$, whereas common carp sell for Rp 2,500 $\cdot kg^{-1}$ and jelawat carp for Rp 2,000$\cdot kg^{-1}$ in East Kalimantan. Tinfoil barb also utilize feed less efficiently and ingest feed more slowly than the other species, increasing feed costs and labor requirements (Christensen 1991).

Yet tinfoil barb and jelawat carp cage culture systems without chickens generate similar incomes and returns on labor, if the two fish fetch the same price on the market. When tinfoil barb are cultured with chickens, earnings are about 10-15% higher than from jelawat carp, assuming equivalent sale prices. This is because tinfoil barb fingerlings are cheaper and the fish can be stocked at greater densities. Common carp continue to earn incomes that are twice as high as from tinfoil barbs, even if the two species fetch the same price. The biggest advantage to the tinfoil barb culture system is that it can be combined with chickens, so reducing feed costs. Neither common carp nor jelawat carp can utilize chicken excrement directly in this way. In addition, tinfoil barb and jelawat carp are herbivores and can utilize cassava leaves.

These results are significant. It has been suggested that "Because there are constraints to the use of grass carp in the tropics ... other macrophagous fish such as ... the tropical carp, *Puntius gonionotus,* require evaluation" (Edwards 1987, p. 311). The tinfoil barb is closely related to this species and has been shown to be an effective herbivore (Christensen 1991). This fish may thus also have considerable potential for use as a herbivore in polyculture systems.

In addition to this, tinfoil barb produced one kilogram of protein in East Kalimantan at an average cost of US$5.01 ± 0.50 (N=2) when fed leaves, and $7.73 ± 2.10 (N=12) when fed fresh or pelletized feeds. This compares well with production costs of $10.48 for herbivorous aquatic species, $30.16 for omnivores and $41.25 for carnivores in Taiwan and Mexico (Shang 1981). These low costs for tinfoil barb protein production may be partially due to the low labor costs ($ 1.47$\cdot$day^{-1}) and feed prices in East Kalimantan, although Mexico is also a developing country with low wage levels.

In spite of these apparent advantages, tinfoil barb have not been cultured as extensively in Southeast Asia as have jelawat carp (Pantulu 1979; Little and Muir 1987). Indeed, they are used mostly as a secondary species in pond polyculture systems. The culture of tinfoil barb gives a good return on labor and labor requirements are low, especially when cassava leaves are fed, either with or without chickens. This could be of advantage to farmers, as it means that the process does not tie up too much labor (Golaszinski 1986). Combined with the possibility of feeding the fish with a product easily grown on a small-scale farmer's plot, this makes the tinfoil barb an interesting candidate for small-scale cage culture systems in certain areas. Extension services could thus consider propagating its culture in Southeast Asia in such cases and areas where it sells for a good price and/or where cassava leaves are in abundant supply.

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