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Economic Feasibility of Polyculture of Tiger Shrimp (*Penaeus monodon*) with Nile Tilapia (*Oreochromis niloticus*) in Brackishwater Ponds

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Abstract

The polyculture of tiger shrimp (*Penaeus monodon*) with milkfish (*Chanos chanos*) has been practiced in the Philippines, but little is known about the possible polyculture of the shrimp with tilapias in spite of increasing consumer acceptance for tilapias in the country. Shrimp monoculture, two rates of *Oreochromis niloticus* monoculture, and two polyculture treatments were compared for economic feasibility. The stocking combination of 6,000 ha^{-1} shrimp with 4,000 ha^{-1} tilapia generated the highest total production and net income with 283.57 $kg \cdot ha^{-1}$ and P11,849 ha^{-1}, respectively. Two crops per year provide a 70% return on investment and 1.2 years payback. A sensitivity analysis indicated that shrimp polyculture with tilapia is profitable up to a 20% decrease in the selling price of both species.

Introduction

Polyculture systems increase production per unit area when compatibility and optimum stocking combinations are considered. In the Philippines, brackishwater ponds are traditionally used for milkfish and tiger shrimp production either in a monoculture or polyculture system.

Another economically important species for culture in combination with the shrimp is Nile tilapia (*Oreochromis niloticus*). The culture of this fish has gained wide acceptance among local fishpond operators due to its many qualities such as resistance to handling and disease, efficient conversion of low protein diets, ease of breeding (Guerrero 1985; PCARRD 1985) and increasing marketability.

Though tilapia culture is limited mostly to freshwater, its culture in brackishwater ponds could provide an alternative species to fish

farmers. Tilapia species tolerate varying degrees of salinity, a trait which enhances the possibility for expansion of their culture into brackishwater or marine systems (Watanabe et al. 1984). In an experiment conducted to test the effect of chicken manure, 16-20-0 fertilizer, feeds and their combinations on growth and production of Nile tilapia (*O. niloticus*) in brackishwater, fish production of 1,158 kg·ha^{-1} was obtained from the chicken manure and feed combination (Fortes et al. 1986). Another experiment on the integrated farming of broiler chickens with milkfish, tilapia (*O. niloticus*) and tiger shrimp (*Penaeus monodon*) in brackishwater ponds, obtained an average net production of 192-284 kg·ha^{-1} shrimp; 75-117 kg·ha^{-1} milkfish; 337-670 kg·ha^{-1} tilapia; and 181-217 kg·ha^{-1} chicken broilers (Pudadera et al. 1986).

Shrimp can be cultured simultaneously with tilapia. However, the culture of tilapia in brackishwater ponds has been tried by few operators. Hence, this study aims to evaluate the economic feasibility of the low intensity polyculture of tiger shrimp with Nile tilapia in brackishwater ponds.

Methodology

Technical data used in the economic feasibility analysis of the polyculture of tiger shrimp with Nile tilapia were derived from the experiment of Gonzales-Corre (1988) conducted at the Southeast Asian Fisheries Development Center's Research Station in Leganes, Philippines. A comparative economic analysis was performed on the monoculture of *P. monodon* (6,000 ha^{-1}), monoculture of *O. niloticus* at 6,000 ha^{-1} and 4,000 ha^{-1}, polyculture of *P. monodon* (6,000 ha^{-1}) with *O. niloticus* (6,000 ha^{-1}), and polyculture of *P. monodon* (6,000 ha^{-1}) with *O. niloticus* (4,000 ha^{-1}). The production data are presented in Table 1.

Calculations are presented on a per-hectare basis using June 1991 prices (Philippines). Annual computations were based on two runs per year for all culture systems. The production costs were composed of supplies, salaries and wages, marketing expenses, repair and maintenance, miscellaneous expenses and depreciation. Marketing and harvesting, and miscellaneous expenses were each estimated to be 2% of gross revenue. Repair and maintenance cost was estimated at 2% of the cost of physical facilities, i.e., pond development, caretaker's hut and equipment. Depreciation was computed using the straightline method.

The acquisition costs of ponds were not included in the computations of investment since it was assumed that entrepreneurs who venture

Table 1. Average harvest weight and mean net production of shrimp and tilapia in monoculture and polyculture systems. (Source: Gonzales-Corre 1988).

Culture system	Net production ($kg \cdot ha^{-1}$)		Total production ($kg \cdot ha^{-1}$)	Average harvest weight (g)	
	Shrimp	Tilapia		Shrimp	Tilapia
Shrimp monoculture ($6,000\ ha^{-1}$)	123.21	-	123.21	27.96	-
Tilapia monoculture ($6,000\ ha^{-1}$)	-	167.60	167.60	-	88.08
Tilapia monoculture ($4,000\ ha^{-1}$)	-	128.52	128.52	-	66.69
Shrimp-tilapia polyculture (shrimp, $6,000\ ha^{-1}$ with tilapia, $6,000\ ha^{-1}$)	80.91	140.32	221.23	25.81	71.93
Shrimp-tilapia polyculture (shrimp, $6,000\ ha^{-1}$ with tilapia, $4,000\ ha^{-1}$)	137.69	145.88	283.57	29.96	75.19

into shrimp-tilapia polyculture have owned the property for a long time and have been engaged in shrimp or milkfish monoculture systems.

For comparison, identical capital outlay and depreciation schedules were used for each culture system. Working capital was assumed to be equivalent to the operating costs during the first run. A sensitivity analysis considering changes in selling price was performed.

Results

Highest gross revenue of P24,382 ha^{-1} (US$ 1 = P27) was obtained from the shrimp polyculture with tilapia at 4,000 ha^{-1} stocking density (Table 2).

Cost structure for the five culture systems varied (Table 3). For the monoculture system, the cost of pond preparation, salaries and wages, and fertilizer were the major cash items comprising an average of 40, 26 and 15% of total cash cost, respectively. For the polyculture system, major costs were pond preparation (32%), salaries and wages (25%) and fry (18%).

On a per-hectare-per-year (two runs) basis, net income for shrimp monoculture was P11,686, shrimp polyculture with tilapia at equal stocking densities P6,890, and shrimp polyculture with tilapia 4,000 ha^{-1} stocking density P23,697. With the same capital outlay for all culture systems (Table 4), net returns were attributed mainly to volume of production and selling price. Shrimp monoculture had higher sales revenue than tilapia monoculture due to the higher selling price of marketable shrimp, P140 kg^{-1}, compared to tilapia, P35 kg^{-1}. The addition of tilapia as a secondary species to shrimp proved beneficial only at a stocking density of 4,000 ha^{-1}. Net losses resulted in tilapia monoculture. Revenues were insufficient to cover operating costs.

The return on investment in shrimp-tilapia polyculture (70%) was higher than shrimp monoculture (36%). For the polyculture system, payback period was 1.2 years compared to the 2.1 years in shrimp monoculture. Polyculture of shrimp with tilapia yields a higher return on investment than milkfish monoculture and shrimp-milkfish polyculture (Table 5).

A price-sensitivity analysis was done to determine the profit levels resulting from decreases in market prices. Shrimp polyculture with tilapia is profitable up to a 20% decrease in selling prices with return on investment at 42% (Table 6).

Table 2. Gross revenue from monoculture and polyculture of shrimp with tilapia (peso ha^{-1}).

Culture system	Class size: / Market price:	Shrimp 26-30 g P140 kg^{-1}	Tilapia 61-70 g P30 kg^{-1}	Tilapia 71-80 g P35 kg^{-1}	Tilapia 81-90 g P40 kg^{-1}	Total gross revenue
Monoculture						
Shrimp: (6,000 ha^{-1})		17,249	-	-	-	17,249
Tilapia: (6,000 ha^{-1})		-	-	-	6,704	6,704
(4,000 ha^{-1})		-	3,856	-	-	3,856
Polyculture						
Shrimp (6,000 ha^{-1}) and tilapia (6,000 ha^{-1})		11,327	-	4,911	-	16,238
Shrimp (6,000 ha^{-1}) and tilapia (4,000 ha^{-1})		19,277	-	5,106	-	24,382

[a]Prevailing market prices in Iloilo, Philippines as of June 1991.

Table 3. Costs and returns of monoculture and polyculture of shrimp with tilapia (pesos ha^{-1}).

Item	Monoculture			Polyculture		
	Shrimp (6,000 ha^{-1})	Tilapia (6,000 ha^{-1})	Tilapia (4,000 ha^{-1})	Shrimp (6,000 ha^{-1}) Tilapia (6,000 ha^{-1})		Shrimp (6,000 ha^{-1}) Tilapia (4,000 ha^{-1})
Revenue						
Shrimp	17,249	-	-		11,327	19,277
Tilapia	-	6,704	3,856		4,911	5,106
Total revenue	17,249	6,704	3,856		16,238	24,382
Operating cost						
Fry	1,050	1,002	592		2,227	1,642
Pond preparation	3,380	3,380	3,380		3,380	3,380
Fertilizer	1,310	1,310	1,310		1,310	1,310
Caretaker's salary	1,800	1,800	1,800		1,800	1,800
Hired labor	596	346	346		846	846
Marketing expenses	345	134	77		325	488
Repair and maintenance	430	430	430		430	430
Miscellaneous	345	134	77		325	488
Depreciation	2,150	2,150	2,150		2,150	2,150
Total operating cost	11,406	10,687	10,163		12,793	12,534
Net income (loss) per run	5,843	(3,983)	(6,307)		3,445	11,849
Net income (loss) per year	11,686	(7,965)	(12,614)		6,890	23,697
Return on investment	36%	-	-		21%	70%
Payback period (years)	2.1	-	-		3.1	1.2

Return on investment = net income before tax/total investment
Payback period = total investment/net income + annual depreciation

Table 4. Investment requirement for shrimp and tilapia culture system (peso ha^{-1}).

Investment	Monoculture			Polyculture	
	Shrimp (6,000 ha^{-1})	Tilapia (6,000 ha^{-1})	Tilapia (4,000 ha^{-1})	Shrimp/tilapia (6,000/6,000)	Shrimp/tilapia (6,000/4,000)
Capital outlay*	21,500	21,500	21,500	21,500	21,500
Working capital (one run)	11,406	10,687	10,163	12,793	12,534
Total investment	32,906	32,187	31,663	34,293	34,034

*Capital outlay

Item	Quantity	Value per ha	Economic life	Annual depreciation
Pond development	1 ha	15,000	5 years	3,000
Caretaker's quarters	1 unit	5,000	5 years	1,000
Equipment		1,500	5 years	300
Total capital outlay		21,500		4,300

Table 5. Comparative profitability of extensive monoculture and polyculture systems in brackishwater ponds (peso ha^{-1}).

Item	Monoculture			Polyculture	
	Shrimp[a]	Milkfish		Shrimp-milkfish[d]	Shrimp-tilapia
		Straight-run[b]	Modular system[c]		
Stocking density (per ha)					
Shrimp	10,000	-		4,000	6,000
Milkfish	-	3,000	1,132	600	-
Tilapia	-	-		-	4,000
Survival rate (%)					
Shrimp	70	-	-	50	76
Milkfish	-	88	93	90	-
Tilapia	-	-	-	-	50
Number of runs/year	2	3	6	2	2
Production/ha/run (kg)	280	545	314	215	284
Initial investment	131,906	18,946	18,216	4,348	34,034
Revenues/ha/run	42,000	11,445	6,599	5,745	24,382
Total cost/ha/run	33,626	7,676	4,615	4,348	12,534
Net income/ha/run	8,374	3,769	1,984	1,397	11,849
Net income/ha/year	16,748	11,306	11,904	2,795	23,697
Return on investment (%)[e]	13	60	65	64	70
Payback period (years)	4.6	1.6	1.3	1.5	1.2

[a]Posadas 1988.
[b]Bombeo-Tuburan et al. 1989.
[c]Agbayani et al. 1989.
[d]Apud et al. 1983.
[e]Return on investment = net income before tax/initial investment

Table 6. Sensitivity analysis of shrimp (6,000 ha^{-1}) polyculture with tilapia (4,000 ha^{-1}).

Item	Percentage decrease in selling price			
	10%	20%	30%	40%
Gross revenue/run (P)	21,951	19,506	17,068	14,629
Total cost/run (P)	12,436	12,339	12,241	12,144
Net profit/run (P)	9,515	7,167	4,827	2,486
Net profit/year (P)	19,030	14,335	9,653	4,972
Return on investment (%)	56	42	29	15
Payback period (years)	1.5	1.8	2.4	3.6

Discussion

The polyculture of shrimp with tilapia in brackishwater ponds is economically feasible. This grow-out system provides an alternative species for shrimp-milkfish farmers and allows for the diversification of shrimp monoculture ponds. Shrimp polyculture with tilapia is well suited for adoption by smallscale producers because the initial capital

investment is affordable. Absence of serious problems in the marketing of Nile tilapia implies bright prospects for its culture as a secondary species which generates additional income for shrimp farmers. Finally, further research on the improved survival rate and growth of tilapia in brackishwater should be stressed.

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