Profitability of tilapia (*Oreochromis* spp.) at various farming scales in Honduras

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Abstract

Questionnaires were conducted to determine the production status, operating costs and profitability of tilapia (*Oreochromis* spp.) aquaculture in Honduras. Between 2016 and 2020, Honduran tilapia farming occurred on small, medium, and industrial levels in both polyculture and monoculture systems. On average, farms were less than five hectares and fewer than five farmworkers were employed throughout the production cycle. The majority of surveyed farms used commercial feed rather than natural feed. The farming cycle on the surveyed farms was less than 6 months, with the produced fresh tilapia being sold directly to buyers and regular customers. Most fish farmers (83.87%) were not considering a job change. The main costs in tilapia farming production were feed (60.88%–75.13%), labour (2.83%–12.88%) and fry (4.19%–8.24%). Industrial-level farms had higher profitability due to high product value and lower feed costs.

Keywords: Aquaculture, Central America, Freshwater fish, Profit, Survey.

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Introduction

Tilapia (*Oreochromis* spp.) farming (major farming species was Nile tilapia *Oreochromis niloticus*) has been increasing in profitability in the Republic of Honduras (hereafter, Honduras) since the 1970s due to economic development, market demand, food security and environmental factors; the suitable product market size was 250–750 g with local market price of United States (US)$ 2.20/kg and export price of US$ 5.54/kg (Teichert-Coddington and Green, 1993; Hernández-Rodríguez *et al*., 2001; Martinez *et al*., 2004; Young, 2015).

High demand from the US ensures that the tilapia aquaculture industry in Honduras is still popular (Watanabe *et al.*, 2002; Prabu *et al.*, 2019; NOAA, 2021).

Honduras produced approximately 65,000 tonnes of aquaculture in 2018, and fish farming accounted for ~51.5% of this (FAO, 2021). The primary farmed species are tilapia and white shrimp (*Litopenaeus vannamei*) (FAO, 2021). The Honduran tilapia industry is the second largest fresh tilapia fillet producer in the US seafood market (Table 1).

Table 1: Sources and value of United States fresh tilapia fillet imports in 2020.

Country	Value (US$)
Colombia	48,370,526
Honduras	41,300,645
Costa Rica	18,255,417
Mexico	13,690,162

Source: National Oceanic and Atmospheric Administration (NOAA), 2021

The aquaculture industry depends on environmental, economic, and public services e.g., fry, broodstock, clean water, equipment, land, electricity, and infrastructure (Stickney, 2005; Bunting, 2013). Operating costs are critical in determining the profit margins for producers, and a number of factors such as stocking density, price, fishery production, survival rate and farming techniques affect profits (Tisdell, 2012; Young *et al.*, 2021). There are fixed and variable production costs in aquaculture (Shang, 1990): producers cover the fixed costs of land rental, labour, insurance, loan interest and depreciation, while variable costs include those of fry, feed, drugs, utilities, maintenance, equipment, pond preparation, part-time labour and transportation (Huang *et al.*, 2011; Young *et al.*, 2021).

Despite the increasing production of tilapia in Honduras, most research has focused on operating costs and profitability of small-scale farming practices (Kurbis, 2000; Martinez *et al.*, 2004; Tveteraas, 2015). However, Honduras tilapia aquaculture faces main challenges, including lack of aquaculture facilities, low quality feed, natural disasters and a lack of personnel and financial support (Molnar *et al.*, 1996; Morales, 2001; Watanabe *et al.*, 2002; Wurmann, 2011). Therefore, in this study, a survey was conducted that focused on the types of tilapia aquaculture practices in Honduras, to better understand the current business situation and operating costs that might limit this industry.

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Materials and methods

Survey design

Questionnaires were designed based on previous surveys from the tilapia aquaculture industry (Hartley, 2007; Lee *et al.*, 2015; Young, 2015; Young *et al.*, 2021). Purposeful sampling was used to select survey participants (Palinkas *et al.*, 2015). The survey was conducted from January 2016 to December 2020. Tilapia aquaculture personnel (n=310) from the Comayagua Department, Yoro Department, Olancho Department, Lempira Department and Cortes Department were surveyed. These departments are the main tilapia producers in Honduras, with a well-developed aquaculture industry (Young, 2015). Questionnaires comprised single and multiple-choice questions. Before distribution, the survey was proofread to confirm accurate wording and prevent possible errors (Lynn, 1986; DeVellis, 1991). Using Cronbach's α coefficient as a benchmark, a total α value of >0.80 shows high reliability with a value between 0.70 and 0.80 presenting acceptable reliability, and a value<0.70 demonstrates low reliability. Once questionnaires were collected, the respondents were directly contacted for clarification to avoid deviation from the standard results. All 310 questionnaires were valid; therefore, the effective return ratio was 100%. In addition to the primary content, the operating status and costs, as well as marketing methods and were analysed.

Statistical analyses

After collecting the questionnaire data, responses were encoded and archived. Predictive Analytics Software (PASW) 18.0 (IBM, USA) was used to determine questionnaire reliability and conduct statistical analyses. After the PASW 18.0 questionnaire reliability analysis, the questionnaire survey's α value was 0.82. Therefore, the questionnaire demonstrated high reliability.

Frequency distribution statistics were used to describe the percentage distribution of the sample structure and evaluate the consistency of responses. The aquaculture scale and operating systems varied because respondents managed operations of different scales; therefore, average proportional costs were listed for four aquaculture scales: small, medium, industrial and polyculture.

Significance of response differences was determined using the nonparametric Wilcoxon signed-rank test and analysed using the PASW 18.0 software (Conover and Iman, 1981). $p<0.05$ was considered statistically significant.

Net private profitability

The net private profitability (NPP), which is the total revenue minus the total operating costs (Lee *et al.*, 2003; Young *et al.*, 2021), of the tilapia aquaculture industry in Honduras was analysed.

Input expenditures are required to calculate NPP, therefore, the production input categories and their relative costs were discussed with respondents. Respondents were then asked about the

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inputs of production activities, which were labelled as one of two factors: tradable and non-tradable. Tradable factors are those that were either exported to earn foreign exchange or domestically used to save foreign exchange, whereas non-tradable factors are inputs that could not be traded and could only be used domestically. The NPP of each tilapia farming system was compared to determine profitability for each producer.

Results

Basic information of respondents

After the PASW 18.0 questionnaire reliability analysis, the questionnaire α value was 0.85; therefore, the questionnaire showed high reliability. Most respondents were producers, and all surveyed farms were located in Honduras (Table 2). Some respondents (32.26%) produced more than two types of species, using either rotational or polyculture methods. The majority of the polyculture species were white shrimp and freshwater fishes: common carp (*Cyprinus carpio*) and jaguar cichlid (*Parachromis managuensis*) accounted for 75.0% and 25.0% of the stocked species, respectively.

Table 2: Basic information on the 310 respondents to the tilapia farming questionnaire.

Question	Options	%
1. Position (single choice)	Producer	91.94
	Marketing operator	8.06
2. Monoculture (single choice)	Yes	67.74
	No	32.26
3. Culture species in polyculture (single choice)	Freshwater fishes	25.0
	Seawater shrimp	75.0

Operational status

Nearly 60% of tilapia producers had farm areas <5 ha. The majority (75.81%) of farms hired <5 labourers, and 59.68% of producers purchased fish fry. The culture period for most (91.94%) respondents was <6 months, and the use of commercial feed (93.55%) was significantly higher than that of natural feed (p<0.05). Most of the farming production facilities were earth pond (88.71%), cage (17.74%), concrete pond (14.52%) and recirculating aquaculture systems (RAS) (8.06%) (Table 3).

Marketing methods

Almost all harvested yield was sold alive (93.55%). Direct buyers (72.58%) were the primary customers, whereas 93.55% of sales were for frequent customers. Only 14.52% of surveyed aquaculture farms indicated that it would be difficult to identify new customers, and only 16.13% of respondents said that it was increasingly difficult to maintain farming operations. Therefore, 83.87% of the respondents did not consider changing their jobs. The primary difficulties for managing a

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farm was increased operating costs (67.74%), disease outbreaks (24.19%) and poor farm location (12.90%) (Table 4).

Table 3: Operational status of tilapia farming in Honduras, according to 310 survey respondents from the aquaculture industry.

Question	Options	%	Wilcoxon signed-rank test (*P*-value)
1. Farm size (single choice)	< 5 ha	59.68	
	6–10 ha	19.35	
	11–15 ha	8.06	
	16–20 ha	3.23	
	21–25 ha	9.68	
2. Number of labourers (single choice)	1–5 persons	75.81	0.031*
	6–10 persons	6.45	
	11–15 persons	6.45	
	16–20 persons	8.06	
	>20 persons	3.23	
3. Fry source (single choice)	Having	40.32	
	Buying	59.68	
4. Culture length (single choice)	Under six months	91.94	0.001 ***
	6 months to 1 year	8.06	
5. Type of feed (single choice)	Commercial feed	93.55	0.001 ***
	Natural feed	1.61	
	Home made	1.61	
6. Production facilities (multiple choice)	Raceway	4.84	
	Cage	17.74	
	Concrete pond	14.52	
	RAS	8.06	
	Earth pond	88.71	0.01**

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

There were significant differences ($p<0.05$) between respondents for the number of labourers (0.031), feed type (0.001), farming length (0.001), production facilities (0.01), approach to processing after harvest (0.001), primary customer (0.04) and future operations (0.01) (Tables 3 and 4).

Operating costs

The main costs identified in the four farm scales were fry (4.19%–8.24%), feed (60.88%–75.13%) and labour (2.83%–12.88%) (Table 5).

NPP of tilapia aquaculture in Honduras

Based on the NPP analyses, medium, industrial-scale aquaculture farms and polycultures were considered highly profitable (Table 6).

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Table 4: Marketing methods used by tilapia farming operations in Honduras, according to 310 survey respondents from the aquaculture industry.

Question	Options	%	Wilcoxon signed-rank test (*P*-value)
1. Processing after harvest (single choice)	Sold live	93.55	0.001***
	Self-processed	6.45	
2. Primary customer (single choice)	Processor	8.06	
	Wholesaler	3.23	
	Restaurant	4.84	
	Exporter	11.29	
	Direct buyer	72.58	0.04*
3. Regular customers or new customers? (single choice)	Regular	93.55	0.001***
	New	6.45	
4. Are new customers hard to find? (single choice)	Yes	14.52	
	No	85.48	0.01**
5. Are operations increasingly difficult? (single choice)	Yes	16.13	
	No	85.48	0.01**
6. Have respondents considered changing jobs? (single choice)	Yes	12.3	
	No	83.87	0.01**
7. Reasons for difficulties (multiple choice)	Operating costs are too high	67.74	0.037*
	Disease problems	24.19	
	Poor farm location	12.90	
	Price instability	9.68	

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Annual average proportional costs of tilapia culture operations in Honduras, according to the 310 survey respondents from the aquaculture industry.

Items	Small scale (<5 ha)	Medium scale (>5 ha)	Industrial scale (For export market)	Polyculture
Fry/fingerling	8.24%	6.81%	4.19%	6.14%
Feed	75.13%	62.36%	61.76%	60.88%
Fertiliser	0.80%	0.65%	0.36%	2.50%
Labour	5.71%	9.10%	12.88%	2.83%
Harvesting and marketing cost	1.23%	4.14%	5.21%	3.58%
Utilities	0.50%	3.90%	4.36%	6.64%
Administrative costs, [a]	2.30%	4.90%	3.81%	7.99%
Loans and interest	0.17%	2.07%	0.76%	1.40%
Depreciation	5.92%	6.07%	6.67%	8.04%

[a] Administrative costs include equipment, medicine and rent.

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Table 6: The net private profitability (NPP) of tilapia aquaculture in Honduras, according to 310 survey respondents from the aquaculture industry.

Farm scale	Domestic market prices [a] (US$/kg)	Domestic market prices of tradable [b] (US$/kg)	Domestic market prices of non-tradable [c] (US$/kg)	NPP (US$/kg)
Small scale	2.18	0.83	0.21	1.14
Medium scale	2.93	0.80	0.52	1.61
Industrial scale	5.63	0.69	1.91	3.03
Polyculture	2.45	0.59	0.51	1.35

[a] The wholesale price of tilapia aquaculture product.
[b] Tradable factors are those that are either exported to earn foreign exchange or used domestically to save foreign exchange.
[c] Non-tradable factors represent those inputs that cannot be traded and can only be used domestically.
NPP = a–b–c; NPP> 0, the producers make profits from the production; NPP = 0, the production is at a breakeven point; NPP< 0, the producers face a deficit in the production.

Discussion

Survey responses indicated that the primary costs of tilapia aquaculture in Honduras are feed, labour and fry; this is consistent with studies on tilapia aquaculture in Central America (Green *et al.*, 1994; Hartley, 2007; Young, 2015), the Philippines (Pillay and Kutty, 2005), Taiwan (Lee *et al.*, 2015), China (Zhang *et al.*, 2016) and Saudi Arabia (Young *et al.*, 2021). Parker (2012) demonstrated that variable costs were proportionally higher than fixed costs in aquaculture; therefore, feed and fry were the major expenditures in fish farming. Similar to other leading tilapia production countries that sell to the export market (Prabu *et al.*, 2019); the majority of Honduras tilapia was exported.

Wurmann (2011) and Young (2015) indicated that economic and environmental issues for Honduras tilapia farming included a lack of quality fry, low management expertise, weak financial support and natural disasters. Alam *et al*. (2019) and Khan *et al*. (2021) reported that aquaculture policies should focus on establishing better training, which has also been hypothesised to reduce production risk in tilapia farming. In this study, difficulties in aquaculture management are mainly attributed to high production costs, poor farm location and disease. Currently, the Honduras tilapia industry is maintaining a profit; therefore, 83.87% of respondents reported that they would not consider changing jobs because of the high profitability in fish culture and lack of other highly paid jobs in the same region. Most aquaculture companies in Honduras are either small or medium-scale businesses. This is important in developing countries because the scale of aquaculture operations makes a significant difference. For example, Young *et al*. (2021) reported that industrial-scale producers in Saudi Arabia spent less on feed because they could produce feed in their own facilities. By contrast, Zhang *et al*. (2016) found that small-scale Chinese tilapia producers were economically inefficient. Due to limited economic factors, higher-cost

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production facilities were more common for industrial-scale than for small-scale tilapia farms in Honduras. Industrial-scale farms in Honduras produced fresh tilapia fillets for the import market, which had higher profitability.

The NPP analysis is a key concern for farmers' production and decision making. According to the questionnaire responses, industrial scales are considered highly profitable, which is consistent with reports on tilapia aquaculture in Saudi Arabia (Young *et al.*, 2021), inland aquaculture in Taiwan (Lee *et al.*, 2015) and Pangas (*Pangasius hypophthalmus*) farming in Bangladesh (Khan *et al.*, 2021). Al-Ghanem *et al.* (2011), Young (2015), Chithambaran (2019) and Young *et al*. (2021) also suggested polyculture has high profitability for tilapia farming. In this survey, 32.26% of respondents would apply to polyculture. Hence, the NPP analysis showed that polyculture had higher profitability than small-scale tilapia farming.

In the Honduran tilapia industry, the majority of aquaculture is in monoculture systems; most farms are smaller than five hectares and employ less than five farmworkers. Fish products are primarily sold to buyers and regular customers. The major operating costs in tilapia production were reported to be feed, labour and fry. Furthermore, due to high product value and lower feed cost, industrial-level farms in a monoculture system were advantageous. Future policies should focus on cost and disease prevention for all producers.

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