



Status and cost analysis of giant river prawn (*Macrobrachium rosenbergii*) farming in Taiwan

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Abstract. Among the various aquaculture species, the giant river prawn (*Macrobrachium rosenbergii* de Man, 1879) is a popular and high economic value species in Taiwan. This study aimed to understand the current production situation and operating costs of giant river prawn farming in Taiwan using a survey. The produced shrimp by the farmers were mainly sold to wholesalers and some regular customers. Also, farmers opined that the development of new markets is required to increase their profit margin. However, interestingly farmers are not considering changing their jobs. Our survey emphasized that the major cost of farm production are larvae, feed, and labor. Altogether, this study will benefit from framing an appropriate fishery policy towards the development of shrimp farming activities and attaining sustainable giant river prawn culture development in Taiwan.

Key Words: aquaculture, giant river prawn, operation cost, survey.

Introduction. Of the freshwater invertebrate species, giant river prawn (*Macrobrachium rosenbergii* de Man, 1879) is one of the famous and highly economically valued species in the global aquaculture industry. Global aquaculture production of giant river prawn was 237124 metric tons in 2018. The countries with leading production include China, Bangladesh, Thailand, India, and Taiwan (FAO 2020).

Because of economic development, cultural technology support, and environmental factors, giant river prawn farming has been on the rise in southwestern Taiwan since the 1980s (Miaw 2003; Liao 2005). The giant river prawn in Taiwan consists of two interrelated sectors: larvae propagation and grow-out farms. It is noteworthy that the giant river prawn industry in Taiwan is still popular with market demand and artificial propagation. The current giant river prawn aquaculture annual production is 6,782 metric tons in Taiwan (Fisheries Agency 2020).

Generally, the aquaculture industry depends on a combination of natural, human, and capital resources, including fry, larvae, broodstock, good-quality water, labor, equipment, land, and infrastructure. The operating costs of fish farming are critical in determining producers' profit margins (Tisdell 2012; Lee et al 2015). The aquaculture industry's production costs can be divided into both fixed and variable costs (Shang 1990; Huang et al 2011; Young 2015). The producers cover the fixed costs of renting land, labor, insurance, loan interest, and depreciation costs (Shang 1990; Huang et al 2011; Young 2015).

Despite the increasing production of giant river prawns in global aquaculture industries, most related research of operating costs has been reported for extensive and semi-intensive systems (Hossain et al 2000; Mohanakumaran 2006; Ahmed et al 2008). Furthermore, giant river prawn aquaculture is a main aquaculture species in Taiwan. However, there is a lack of fundamental aquaculture operations cost analysis for intensive systems. Therefore, we conducted a farm survey that focused on the types of giant river prawn aquaculture practices in Taiwan to understand the current business

situation better and operating costs that might limit the giant river-prawn aquaculture industry.

Material and Method

Questionnaire design. A questionnaire was designed based on the s previous surveys in the industry (Hartley 2007; Lee et al 2015; Young et al 2021). Purposeful sampling was used to select survey participants (Palinkas 2015). The survey was conducted from 1 January to 31 December 2018. A total of 130 giant river prawn aquaculture-related personnel were sampled from the primary farm from the Fisheries Agency in Taiwan. The questionnaires comprised single and multiple-choice questions. Before distributing the formal questionnaire, it was first proofread by reliability test and validity evaluation to confirm accurate wordings or prevent possible errors (DeVellis 1991; Lynn 1986). Once the questionnaires were collected, the respondents were directly contacted for clarification in case of any queries to avoid deviation from the standard results. Because all 130 questionnaires were valid, the effective return ratio was 100%. In addition to the primary content in questionnaires, aquaculture's operating status, and their marketing methods and operating costs were analyzed.

Statistical analysis. After collecting the questionnaire data, responses were subjected to encoding and archiving. Predictive Analytics Software (PASW) 18.0 (IBM, USA) was then used to determine questionnaire reliability and conduct statistical analyses.

Percentile method (frequency distribution). Frequency distribution statistics were used to describe the sample structure's percentage distribution and evaluate the consistency of responses.

Nonparametric method. The significance of response differences was determined using the nonparametric Wilcoxon signed-rank test (Conover & Iman 1981).

Net private profitability. The net private profitability (NPP) of the Taiwanese giant river prawn aquaculture industry was analyzed. NPP is defined as the total revenue minus the total operating costs (Lee et al 2003; Young et al 2021).

Results

Basic information of respondents. As a result of the PASW 18.0 questionnaire reliability analysis, the α value of the questionnaire survey was 0.82, and consequently, the questionnaire showed high reliability. Most respondents were grow-out farm producers (Table 1).

Table 1
Basic information on the 130 respondents to the giant river prawn farming questionnaire

Question	Options	%
Sector	Larvae propagation	7.7
	Grow-out farm	92.3

Operational status. According to the result, the farm acreage of respondents had mostly 1 to 5 hectares, as farms less than 5 hectares accounted for 89.2% of all samples. Fish farms less than three people accounted for 92.3% of the total samples. Shrimp seed was mostly purchased from others. The commercial feed was used significantly higher than natural feed in prawn farming. Most farming production facilities had earth ponds (76.9%), concrete ponds (36.9%), and recirculating aquaculture systems (RAS) (7.7%) (Table 2).

Table 2

Operational status of giant river prawn culture in Taiwan, according to 130 survey respondents from the aquaculture industry

<i>Question</i>	<i>Options</i>	<i>%</i>	<i>Wilcoxon signed ranks test</i>
Farm size (Hectare)	Under 1	12.3	
	1 to 5	76.9	
	5 and over	10.7	
Number of laborers	1	15.4	
	2	30.8	
	3	46.1	
	4 or over	7.7	
Larvae source	Own	17.0	
	Buying	83.0	0.02*
Type of feed	Commercial	95.4	
	Homemade	3.1	0.001***
	Natural feed	1.5	
Production facilities (multiple choice)	Earth pond	76.9	
	RAS	7.7	
	Concrete pond	36.9	

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Marketing methods. The results showed that the main customer was through the wholesalers (including broker), which accounted for 87.7% of all respondents' feedback, with only 12.3% of the respondents directly contacting the buyer. Sales to regular customers accounted for 61.5% (Table 3).

In the perception of future operations, 69.2% of the farmers surveyed said it is hard to find new customers. Regarding 76.9% of the respondents, it was increasingly difficult to operate; however, 92.3% had not considered changing jobs. The increased operating costs included high operating costs and a high proportion of disease issues, each at 72.3% and 69.2%, respectively (Table 3).

Table 3

Marketing methods used by giant river prawn culture operations in Taiwan, according to 130 survey respondents from the aquaculture industry

<i>Question</i>	<i>Options</i>	<i>%</i>	<i>Wilcoxon signed ranks test</i>
The main customer	Buyer	12.3	0.02*
	Wholesalers	87.7	
Regular customers or new customers?	Regular	61.5	
	New	38.5	
Are new customers hard to find?	Yes	69.2	
	No	30.8	
Are operations increasingly difficult?	Yes	76.9	0.04*
	No	23.1	
Have considered changing jobs?	Yes	7.7	0.001***
	No	92.3	
Reasons for difficulties (multiple choice)	Lack of guidance	29.2	
	High farming costs	72.3	
	Disease problems	69.2	
	Price instability	29.2	

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Following Wilcoxon signed ranks test results also presented in Table 2 and Table 3, the significant difference item included larvae source, feed type, main customer, and future operations.

Operating cost analysis. In the giant river prawn grow-out farms, the most important costs were feed (63%) and shrimp larvae cost (19.5%). The giant river prawn hatchery had the highest costs with respect to feed, and labor and both constituted more than 30% (Table 4).

Table 4

Annual average proportional costs of giant river prawn culture operations in Taiwan, according to the 130 survey respondents from the aquaculture industry

<i>Items</i>	<i>Grow-out farm</i>	<i>Larvae propagation</i>
Larvae	19.5%	18.5%
Feed and Fertilizer	63%	29.5%
Utilities	3.5%	5.5%
Administrative costs, ^a	3.5%	4%
Labor	7.5%	37.5%
Depreciation	3%	5%

Note: ^a Administrative costs include equipment, medicine, and rent.

NPP of giant river prawn farming aquaculture in Taiwan. Net private profitability (NPP) is a major concern for the farm owners to make decisions on production scale and management. Based on the NPP analysis result, the profitability of giant river prawn cultures is considered as highly profitable farming.

Table 5

NPP of giant river prawn aquaculture in Taiwan, according to 130 survey respondents from the aquaculture industry

<i>Species</i>	<i>Domestic market prices ^a (US\$/kg)</i>	<i>Domestic market prices of tradable ^b (US\$/kg)</i>	<i>Domestic market prices of non-tradable ^c (US\$/kg)</i>	<i>NPP (US\$/kg)</i>
Giant river prawn	13.90	8.76	2.96	2.18

Note:

^a Wholesale prices

^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. From previous studies (Lee et al 2015; Young et al 2018), the national average number of staff on intensive aquaculture farms was 2.2. The farm size of all types of fish farming systems is mainly concentrated in the range of 0.5 to 3 hectares in Taiwan. Our results revealed no significant change in the giant river prawn culture industry compared to previous studies on average farm size and numbers of staff hired in Taiwan.

Shang et al (1998), Liao (2008) and Lee et al (2015) demonstrated the expenditure of the shrimp industry in Taiwan. The feed is the most important cost item and accounted for 40% of the total cost; larvae costs ranged from 8% to 13%. This study showed that the major cost in giant river prawn aquaculture farms were feed and shrimp larvae, with the highest item cost being feed; feed costs 63% of the total cost.

In our study's consciousness of future operations, 76.9% of farmers indicated that the aquaculture industry is increasingly difficult to operate. The increasingly difficult

situation came from overly high operating costs and the high proportion of disease issues, each accounting for 72.3% and 69.2%, respectively. The industry's current operating conditions merely maintained profit, so 92.3% of interviewees would not consider changing jobs since the shrimp farmers spent high cost and lack of new business opportunity that was difficult to abandon.

Based on NPP analysis results, the giant river prawns farming could be considered a highly profitable business. From the farmer's viewpoint, the profitability of raising giant river prawn was higher than that of raising other freshwater invertebrate species since a short culture period was needed together with stable larvae supply for the former. Notably, problems due to disease outbreaks were a major influencing factor for profit in the Taiwan giant river prawn industry; therefore, it severely impacted the production of the giant river prawn.

Conclusions. According to the present results, future policies on giant river prawn farming should be framed. They could be emphasized on the associated measures of cost subsidies and to mitigate the disease problems in the system, which can benefit the farmers leading to a formidable sustainable development of giant river prawn culture industry in Taiwan.

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Conflict of Interest. The authors declare no conflict of interest.

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