On-farm Shrimp (*Penaeus vannamei*) Production Trials during the Rainy Season

Honduras Special Topics Research

Bartholomew W. Green, David R. Teichert-Coddington, and Claude E. Boyd
Department of Fisheries and Allied Aquacultures
Auburn University,
Auburn, USA

John Wigglesworth, Hector Corrales, Rafael Zelaya, Brian Boudreau, John Harvin, and Wayne Toyofuku
Grupo Granjas Marinas, S.A.
Choluteca, Honduras

Delia Martinez and Eneida Ramírez
Laboratorio de Calidad de Agua
La Lujosa, Choluteca, Honduras

Introduction

The majority of Honduras PD/A CRSP shrimp production research is conducted on one farm because of infrastructure availability. Production systems developed through this research are then reported to shrimp farmers throughout southern Honduras. These farmers decide individually whether or not to adopt a particular system. There has not been a systematic effort to evaluate variability of developed production systems in relation to geographic variation in southern Honduras. Teichert-Coddington et al. (1996) evaluated the effect of stocking rate on shrimp yield, mean weight, and survival on three different farms during the rainy and dry seasons.

The objective of this study was to evaluate shrimp growth, yield, and survival in ponds all managed similarly on four different commercial farms in southern Honduras.

Methods and Materials

Sixteen randomly selected, earthen ponds ranging in size from 0.3 to 2.3 ha and located on four commercial shrimp farms (four ponds per farm) were used for this study. Farms were located on riverine estuaries or on an embayment of the Gulf of Fonseca, Honduras. Farms B and C were located on the same riverine estuary, while farm A was located on a different riverine estuary. Farm D was located on an embayment of the Gulf of Fonseca. Ponds were stocked with hatchery-spawned, post-larval (PL) *P. vannamei*, from the same production run at 250,000 PL ha^{-1} (25 PL m^{-2}) on 15 August 1996. A survival rate of 25% was assumed because of Taura Syndrome effects on hatchery-produced larvae. Most of the mortality was assumed to occur during the first month following stocking. Shrimp were harvested 110 days after stocking by completely draining ponds. Total weight of shrimp was recorded for each pond. Mean individual weight was determined by weighing a sample of 300 shrimp per pond.

Shrimp were fed a 30% protein commercial ration (Table 1) six days per week beginning on 10 September 1996. Feed rate for each treatment was 75% of a theoretical feeding curve for *P. vannamei*:

$$\mathrm{Log}_{10}\, y = -0.899 - 0.56\mathrm{Log}_{10}\, x$$

where y is the feed rate as a percent of biomass and x is the mean shrimp weight in grams.

Feed was offered once daily. Feed rate was calculated for individual ponds and then averaged by treatment, so that all ponds within a treatment received the same quantity of feed on a daily basis. Shrimp growth was monitored weekly by cast net samples of each pond's population. Feed rate was adjusted weekly based on shrimp samples. Feed conversion ratio (FCR) was calculated as the weight of feed offered divided by the gross yield of whole shrimp.

Table 1. Composition of shrimp diet formulated to contain 30% crude protein.

Ingredient	Formulated Ration (30% Protein)
Soybean Meal (48.5% Protein)	26.1
Fish Meal (67% Protein)	15.0
Meat and Bone Meal	2.0
Wheat Midds	33.5
White Corn	14.0
Rice Semolina	4.5
$CaCO_3$	2.9
Maxi-bond	2.0
Total	100.0

No water was exchanged during the first three weeks of culture. Water was exchanged at 20% of pond volume once weekly starting week 4. In addition, if early morning dissolved oxygen concentration was ≤ 2.5 mg l^{-1}, then 5% of the pond volume was exchanged. In all water exchanges, water was first discharged and then replacement water was added to refill ponds.

Water quality variables in each pond were measured upon initiation of the experiment and monitored weekly in discharge and intake water beginning with week four, the initiation of scheduled water exchange. Intake water was sampled from supply canals, while discharge water was sampled from each pond's outfall. Initial pond water and replacement water samples were obtained with a column sampler. Water samples were analyzed for pH (measured potentiometrically), nitrate-nitrogen (measured by cadmium reduction) (Parsons et al., 1992), total ammonia-nitrogen (Parsons et al., 1992), soluble reactive phosphorus (SRP) (Grasshoff et al., 1983), chlorophyll *a* (Parsons et al., 1992), total alkalinity (measured by titration to pH 4.5 endpoint), salinity, and BOD_2 at ambient temperature. Total nitrogen and total phosphorus were determined by nitrate and phosphate analysis, respectively, after simultaneous persulfate oxidation (Grasshoff et al., 1983).

Data were analyzed by ANOVA and regression analysis (Haycock et al., 1992). Percent data were arcsine transformed prior to analysis. Differences were declared significant at alpha level 0.05.

Results

Taura Syndrome had a greater than expected impact on shrimp survival during this study: global survival averaged 5%; however, shrimp survival differed significantly among farms. The greatest survival was observed on the farm located on the embayment of the Gulf of Fonseca (Table 2). Coefficients of variation for shrimp survival were 17.1%, 2.0%, 40.4%, and 16.0% for farms A through D, respectively. Production data from one pond on farm B was excluded from analyses because they were classified as outliers. Gross shrimp yields were low and ranged from 120 to 325 kg ha^{-1} (Table 2). Coefficients of variation for gross yield were 35.5%, 9.2%, 96.3%, and 31.4% for farms A through D, respectively. Shrimp yield increased significantly with increased survival ($r^2 = 0.885$, $P < 0.001$), while average individual weight decreased significantly with increased survival ($r^2 = 0.263$, $P < 0.05$). Shrimp growth is shown in Figure 1. Coefficients of variation for individual weight were 10.0%, 6.7%, 2.6%, and 10.8% for farms A through D, respectively. No significant differences in FCR were detected among farms (Table 2). Total feed usage (kg ha^{-1}) varied significantly among farms (Table 2). Total quantity of nitrogen added to ponds as feed increased significantly with total feed usage.

Table 2. Mean production (± SD) of *Penaeus vannamei* in 0.3- to 2.3-ha earthen ponds on four different farms during 110-day rainy season study. Post-larval shrimp were stocked at 25 PL m^{-2}. Shrimp were offered a 30% protein commercial ration.

Variable	**Farm**			
	A	*B*	*C*	*D*
Gross yield (kg ha^{-1})	235 ± 83.4	120 ± 11.0	127 ± 122.4	325 ± 101.6
Mean weight (g $shrimp^{-1}$)	13.8 ± 1.38	13.0 ± 0.87	17.2 ± 0.45	13.0 ± 1.40
Survival (%)	6.3 ± 0.19^{b}	2.9 ± 0.00^{c}	1.8 ± 0.30^{c}	8.9 ± 0.24^{a}
FCR	5.0 ± 1.48^{a}	6.2 ± 0.69^{a}	12.4 ± 7.6^{a}	4.1 ± 1.07^{a}
Total feed offered (kg ha^{-1})	1081 ± 37.7^{b}	738 ± 10.1^{c}	953 ± 4.7^{d}	1262 ± 11.1^{a}

^{abcd} Means with the same superscript designation are not significantly different ($P > 0.05$). Horizontal comparisons only.

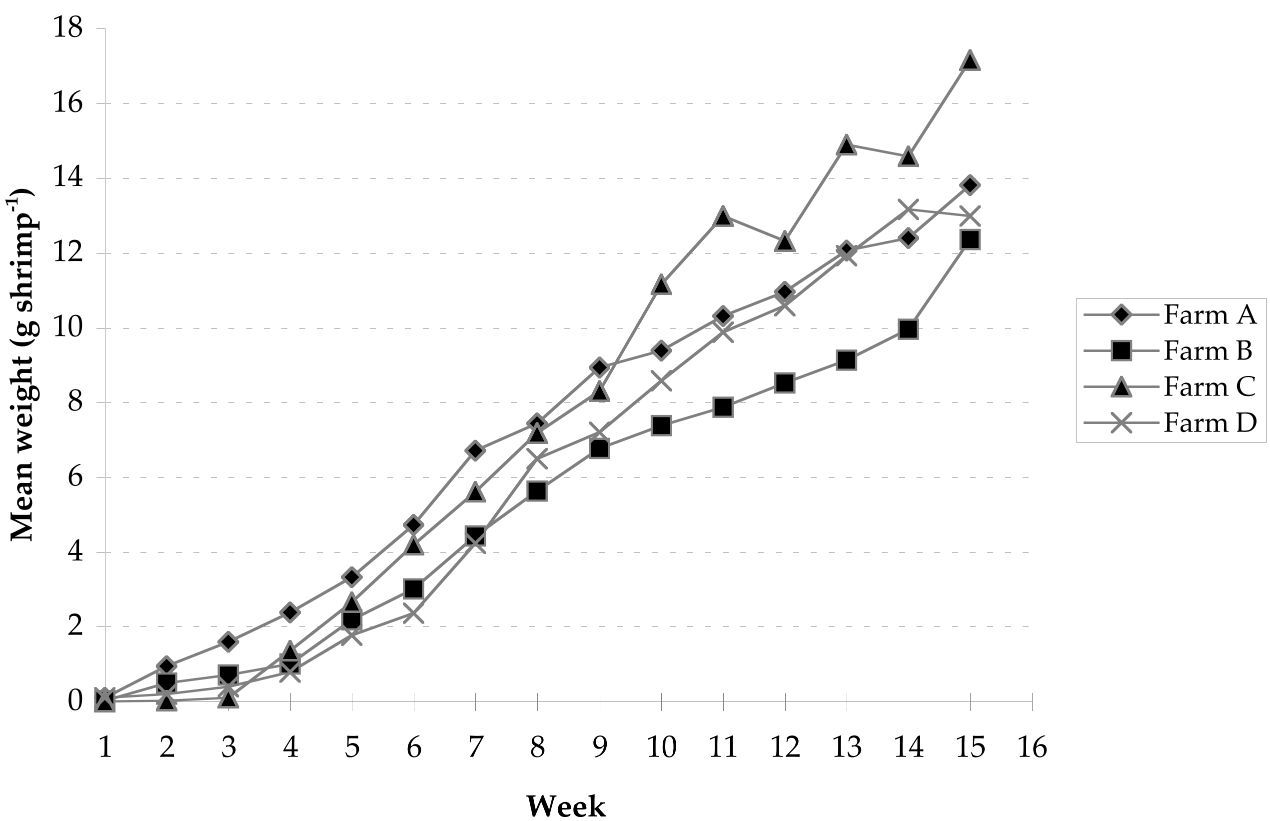

Figure 1. Growth of *Penaeus vannamei* stocked in 0.3- to 2.3-ha earthen ponds at 25 PL shrimp m^{-2} on four different commercial farms during a 110-d grow-out in Honduras. Shrimp were offered a 30% protein ration.

Table 3. Mean (± SD) nutrient concentrations of intake and discharge water in 0.3- to 2.3-ha earthen ponds stocked with *Penaeus vannamei* (25 shrimp m^{-2}) during a rainy season study implemented on four different farms. Three farms were located on two different riverine estuaries, and the fourth farm was located on an embayment of the Gulf of Fonseca, Honduras. Shrimp were offered a 30% protein commercial ration.

Variable	**Farm A[1]**		**Farm B[2]**	
	Intake	*Discharge*	*Intake*	*Discharge*
Total Nitrogen (mg l^{-1})	0.78 ± 0.015^{a}	$1.66 \pm 0.511^{a*}$	0.73 ± 0.000^{a}	$1.12 \pm 0.296^{a\S}$
Total Ammonia-N (mg l^{-1} NH_3-N)	0.08 ± 0.044^{a}	$0.05 \pm 0.016^{a*}$	0.06 ± 0.000^{a}	$0.06 \pm 0.038^{a*}$
Oxidized N (mg l^{-1} NO_2-NO_3-N)	0.042 ± 0.035^{a}	$0.006 \pm 0.008^{a*}$	0.100 ± 0.000^{a}	$0.014 \pm 0.017^{b*}$
Total phosphorus (mg l^{-1})	0.20 ± 0.035^{a}	$0.30 \pm 0.089^{a*}$	0.23 ± 0.000^{a}	$0.17 \pm 0.043^{a\S}$
Sol. reactive phosphate (mg l^{-1} PO_4-P)	0.11 ± 0.027^{a}	$0.14 \pm 0.112^{a*\S}$	0.11 ± 0.000^{a}	$0.05 \pm 0.033^{a*}$
Chlorophyll *a* (mg m^{-3})	33.0 ± 3.80^{a}	$95.2 \pm 50.88^{a*}$	38.1 ± 0.00^{a}	$47.9 \pm 15.33^{a\S}$
BOD_2 (mg l^{-1})	2.9 ± 0.46^{a}	$6.8 \pm 1.92^{a*}$	3.2 ± 0.00^{a}	$4.5 \pm 0.84^{a\S}$

Variable	**Farm C[2]**		**Farm D[3]**	
	Intake	*Discharge*	*Intake*	*Discharge*
Total Nitrogen (mg l^{-1})	0.83 ± 0.000^{a}	$0.76 \pm 0.050^{a\S}$	0.47 ± 0.000^{a}	$0.57 \pm 0.065^{a\dagger}$
Total Ammonia-N (mg l^{-1} NH_3-N)	0.10 ± 0.000^{a}	$0.06 \pm 0.010^{b*}$	0.04 ± 0.000^{a}	$0.05 \pm 0.020^{a*}$
Oxidized N (mg l^{-1} NO_2-NO_3-N)	0.22 ± 0.000^{a}	$0.010 \pm 0.003^{b*}$	0.003 ± 0.000^{a}	$0.002 \pm 0.001^{a*}$
Total phosphorus (mg l^{-1})	0.23 ± 0.000^{a}	$0.22 \pm 0.08^{a\S}$	0.04 ± 0.000^{a}	$0.04 \pm 0.003^{a\dagger}$
Sol. reactive phosphate (mg l^{-1} PO_4-P)	0.15 ± 0.000^{a}	$0.21 \pm 0.063^{a\S}$	0.004 ± 0.000^{a}	$0.002 \pm 0.001^{a\dagger}$
Chlorophyll *a* (mg m^{-3})	34.1 ± 0.00^{a}	$25.7 \pm 2.09^{b\S}$	13.1 ± 0.00^{a}	$14.4 \pm 2.90^{a\dagger}$
BOD_2 (mg l^{-1})	4.2 ± 0.00^{a}	$3.4 \pm 0.23^{b\S}$	1.2 ± 0.00^{a}	$2.0 \pm 0.26^{a\dagger}$

ab Means with the same superscript designation are not significantly different ($P > 0.05$). Horizontal comparisons only within farm.
*†§ Means followed by the same symbol are not significantly different ($P > 0.05$). Horizontal comparisons only among farm discharges.
1 Farm A is located on a riverine estuary.
2 Farm B and C are located on a different riverine estuary.
3 Farm D is located on an embayment of the Gulf of Fonseca.

Total nitrogen, total ammonia-nitrogen, total phosphorus, and soluble reactive phosphorus concentrations did not differ significantly between pond intake and discharge water on individual farms (Table 3). Intake water had significantly greater oxidized nitrogen concentrations than discharge waters on farms B and C (Table 3). Significantly greater chlorophyll *a* and BOD_2 concentrations were detected in intake water on farm C (Table 3). Total ammonia-nitrogen and oxidized nitrogen concentrations in discharge water did not differ significantly among farms (Table 3). Concentrations of all other water quality variables in discharge water generally were significantly greater on farm A, intermediate on farms B and C, and significantly lower on farm D (Table 3). No significant relationship was detected between total quantity of feed added per pond and concentration of any nutrient in discharge water. Among farms, chlorophyll *a* and BOD_2 concentrations in pond water were independent of total ammonia-nitrogen concentration ($r^2 = 0.034$, $P = 0.509$ and $r^2 = 0.006$, $P = 0.789$, respectively) and soluble reactive phosphorus concentration ($r^2 = 0.005$, $P = 0.800$ and $r^2 = 0.010$, $P = 0.726$, respectively).

Discussion

Comparison of shrimp production data among farms was not possible because of the unexpectedly high shrimp mortality; 25% survival of the stocked populations had been expected. Differences among farms, if they exist, would only become evident once the shrimp biomass had attained the critical standing crop. Both shrimp yield and mean final weight were significantly correlated with survival, which varied significantly among ponds. Shrimp yields in the present experiment were 17 to 58% of rainy season yields reported for Taura Syndrome-affected ponds in Honduras (Teichert-Coddington et al., 1996; Teichert-Coddington et al., 1997). Production data from farm A, the farm where PD/A CRSP production research is implemented, were intermediate to results from the other farms.

Feed conversion ratios were very high for this experiment because shrimp in ponds were overfed. The computer-generated feed curve incorporated the expected mortality (75% of stocked animals) but, because mortality exceeded anticipated levels by 27%, feed inputs were overestimated. While it is impossible to make inferences regarding farm effects on FCRs, these results clearly demonstrate the difficulty in achieving efficient feed management in ponds affected by Taura Syndrome.

No differences were detected in total nitrogen concentrations in pond effluent among farms during weekly water exchange events even though nitrogen was added as feed to ponds. Although high FCRs indicated that feed was wasted and not consumed by shrimp, pond water quality did not appear to be affected significantly. However, observed nutrient concentrations in discharge water (measured as total nitrogen, total phosphorus, chlorophyll *a*, and BOD_2) were higher than in intake water, which indicates a net discharge of nutrients. As has been reported previously (Teichert-Coddington et al., 1996; Teichert-Coddington et al., 1997), weekly exchange events discharged organic-rich water to estuaries. Inorganic nitrogen and phosphorus entering ponds was converted to organic matter that was discharged to estuaries. Nutrient loads in pond effluents were lower on farm D (located in an embayment of the Gulf of Fonseca) probably because of the lower nutrient content of intake water (Teichert-Coddington, 1995).

Anticipated Benefits

This study was designed to evaluate shrimp growth, yield, and survival in similarly managed ponds on four different commercial farms in southern Honduras. Data would provide information on expected results when PD/A CRSP-developed management systems were implemented on other farms in the region. However, because shrimp survival only was 20% of the expected value, it was impossible to evaluate among farm variability, which is unfortunate given the major logistical effort required for this experiment. This experiment should be repeated if producers are interested and willing to make facilities available again.

Acknowledgments

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