Relative efficacies of lobsters (*Panulirus ornatus* and *P. homarus*) cultured using pellet feeds and "trash" fish at Binh Ba Bay, Vietnam

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Panulirus ornatus.

Aquaculture feeds and feeding regimes play a major role in determining the potential environmental impacts of finfish and crustacean farm effluents[1]. In aquaculture, on-growing of wild-caught juvenile spiny lobsters (Palinuridae) to market size is an emerging sector in Asia, Oceania and Central America but most notably in Vietnam[2]. In Vietnam, lobster culture commenced in the 1990s[3] and is regarded as the biggest lobster culture industry with a production of 1,800 tonnes in 2005[4]. The main culture areas are Khanh Hoa, Phu Yen and Ninh Thuan provinces[5] for species of *Panulirus ornatus* and *P. hormarus*[3,6]. However, the use of artificial feeds for lobster culture is still limited in the world and it is so in the case of Vietnam also. This sector has developed for more than 20 years but none of aquafeed companies produce artificial feeds for lobster[7]. Traditionally, lobster is fed "trash fish" or "low valued fish" such as snails, green mussel, clams, crabs, lizardfish, red big-eye, which are thought to contribute to environmental degradation and disease issues[5].

The aim of this research is to survey the environmental and economic efficiency of lobster culture in Binh Ba Bay in the traditional manner using trashfish and pelleted feed (product of the national research project KC.06.23/06-10).

Approach

This research was carried out from May 2009 to June 2010. Six sampling sites were chosen for surveying environmental quality (Table 1). Water and mud samples were collected regularly every two-months and transported to the laboratory of Environmental Management, Faculty of Aquaculture, NhaTrang University for determining the total suspended solids (TSS), biochemical oxygen demand (BOD), total nitrogen and phosphate concentration, organic matter in mud by using standard protocols[8]. Surface temperature, salinity, pH, dissolved oxygen (DO), depth, and transparency were measured at site.

Table 1. Environmental sampling sites at Binh Ba Bay.

Site code	Characteristics	Latitude	Longtitude
(TAV)	Site for lobster (*P. ornatus* and *P. homarus*) cultured using pelleted feed	11°50'42.59N	109°13'25.55E
(100M)	Site without lobster cages	11°51'01.10N	109°13'38.64E
(CAT)	Site for lobster culture using trash fish / low value fish	11°50'37.50N	109°14'00.75E
(DC)	Binh Ba Port	11°50'23.08N	109°14'19.66E
(CN)	Small gate (to the Western sea)	11°51'09.45N	109°14'49.39E
(CL)	Large gate (to the Western sea)	11°48'17.45N	109°13'36.69E

Table 2. The result of environmental analysis at sampling sites in Binh Ba Bay.

Sampling site	TAV	CAT	100M	DC	CN	CL
Depth (m)	22.0	19.5	16.0	5.2	3.7	(-)
Salinity (‰)	34.33 ± 1.37	34.37 ± 1.47	34.00 ± 1.67	34.17 ± 1.47	34.50 ± 1.38	34.17 ± 1.47
Surface temp.(°C)	27.78 ± 1.88	28.01 ± 1.47	27.72 ± 2.10	28.04 ± 1.62	28.11 ± 1.45	28.14 ± 1.21
DO (mg/L)	7.79 ± 0.67^{bc}	7.31 ± 0.58^{ab}	7.34 ± 0.57^{ab}	6.78 ± 0.61^{a}	7.25 ± 0.70^{ab}	8.10 ± 0.23^{c}
BOD (mg/L)	2.30 ± 0.41	2.41 ± 0.76	2.39 ± 0.55	1.89 ± 0.55	1.22 ± 0.79	0.65 ± 0.34
pH	7.82 ± 0.22	7.54 ± 0.45	7.86 ± 0.23	7.75 ± 0.20	7.78 ± 0.29	8.08 ± 0.10
$P\text{-}PO_4^{3}$- µg/L)	0.766 ± 0.023	0.763 ± 0.025	0.758 ± 0.017	0.762 ± 0.020	0.756 ± 0.017	0.742 ± 0.019
$N\text{-}NO_3$- (µg/L)	0.522 ± 0.016	0.515 ± 0.004	0.506 ± 0.023	0.510 ± 0.014	0.507 ± 0.010	0.504 ± 0.018
Transparency (m)	7.2	7.1	6.3	To bottom	To bottom	12.4
TSS (mg/L)	0.400 ± 0.191	0.378 ± 0.206	0.353 ± 0.180	0.338 ± 0.240	0.326 ± 0.183	0.284 ± 0.133
Benthic organic (%)	0.0292	0.0186	0.0244	0.0100	0.0125	(-)

Data in the same row with different superscripts are significantly different (P < 0.05); (-): no data collected.

Efficiency of traditional lobster culture, biology and economics, was also evaluated using rapid rural appraisal (RRAs) methods[9] to preliminarily compare with those cultured using pelleted test feed.

Results were expressed as mean ± standard of deviation (SD) and group mean difference compared using one – way ANOVA. When there were differences, the group means were further compared using Duncan's multiple range test. All computations were performed with SPSS 16.0. A significant level of P < 0.05 was employed in all cases.

Formulated test feed.

Findings

Environmental quality and efficiency of lobster culture in Binh Ba Bay

Results of analysis of samples collected from sites in Binh Ba Bay indicated that there were no significant differences (P > 0.05) of the environmental parameters (except for dissolved oxygen) between sites with lobster cages and others. The fluctuation of these factors was not high during the year of 2009 – 2010 (Table 2).

According to Lellis and Russell[10], the optimal temperature for post-larval lobster growth is above 27°C and below 33°C. Lobster can only develop when the salinity is above 20 ppt. Like other marine animals, the optimal pH range for lobster is from 7.5 to 8.5[11]. Therefore, the ranges of these factors were still in the suitable ranges for lobster growth.

Compared to other coastal water bodies of Khanh Hoa province such as Van Phong – Ben Goi[12,13], Nha Phu lagoon, Binh Cang and Nha Trang bays[12] and Cam Ranh Bay[13] there was no major differences in the water quality and environmental parameters given in Table 2.

The total solid suspended (TSS) at lobster culture sites (TAV: 0.400 mg/L, CAT: 0.378 mg/L) was higher than others. As Le and Le[14] concluded that the most marked environmental effect of lobster cage aquaculture in Van Phong Bay was the output of suspended solids, dissolved nutrients, organic matter and bacteria. The highest TSS was observed in the rainy season of November, 2009 (0.643 mg/l) and the lowest in the dry season of May, 2010 (0.161 g/L).

The same trend in TSS was observed for biochemical demand (BOD), when it was considerably higher at lobster culture sites TAV and CAT (Table 2) than at the small and large gates to the western sea: CN and CL (Table 2)

Panulirus homarus.

Estimated FCR for *P. ornatus* and *P. homarus* fed by trash/low value fish was 26.60±5.02 and 26.00±1.41. Most of the solid wastes came from mollusc and crustacean species which accounted for 80% of trash fish composition. In addition, their shell weight was approximately 70% fresh body mass. Therefore, to produce one kg of *P. ornatus* and *P. homarus* a discharge of around 15 kg of solid waste to Binh Ba Bay and surrounding areas occurs. Consequently, in a large area close to the Binh Ba Port (DC) and concentrated lobster culture areas that used trash fish/low value fish (CAT) there was a lot of solid wastes such as plastics, broken bricks, and shells of shellfishes. These materials covered a thick layer on the seabed. In contrast, at the testing site (TAV) for pelleted feed the sea bed is only mud and the water current easily washed it to the ocean.

The environmental issues were not only limited to solid wastes but also dissolved nutrients such as nitrogen and phosphorus. Le and Lai[15] stated that the waste nitrogen (N) from rearing lobsters using the fresh fish diet was 402 g N/ kg lobster, and is comparable to that calculated for of lobster cage cultured in Xuan Tu Village, Van Ninh district where

Table 3. Economic efficiency to produce 1 kg lobster (*P. ornatus* and *P. homarus*) using "trash" fish compared to pelleted test feeds (product of KC.06.23/06-10 project).

Parameters	"Trash fish" composition (%)				Pellet feed[21,22]
	Squid	Lizard fish	Crabs	Mussels	
Average price for 1 kg of each "trash" fish composition (1000 VND)	20.00 ± 0.00	16.00 ± 4.10	20.18 ± 2.56	5.7 ± 1.92	
Proportion (%) in "trash" fish	2	18	50	30	
Average price for 1 kg of feed (1,000 VND)	APTF = 2% x 20.00 + 18% x 16.00 + 50% x 20.18 + 30% x 5.7 = 15.08				40.00
FCR of *P. ornatus*	26.60±5.02				4.7
FCR of *P. homarus*	26.00±1.41				4.3
Total cost of feed to produce 1 kg of *P. ornatus* (1,000 VND)	401.12±75.70				188.00
Total cost of feed for produce 1 kg *P. homarus* (1,000 VND)	392.08±21.26				172.00

there is an apparent over loading of nitrogen since 2003. This issue is also the main concern of lobster farmers there[16]. The number of lobster cages in Van Ninh has increased to 16,080 cages and total nitrogen discharge was estimated 223 tons[17] and phosphorus 3.352 tons[18].

More than 100 species of marine trash fish comprising of small molluscs, crustaceans and echinoids are used as an aquaculture feed or aquaculture feed ingredient in Vietnam[19] and the supply has become scarer because of over-exploitation[20]. The total amount of trash fish used for aquaculture in Vietnam was estimated to be between 176,420 – 363,440 tons[19]. Therefore, finding alternative sources of protein, lipid, and carbon hydrate compounds from products of plant origin to replace trash fish is needed from a biodiversity conservation view point.

Economic efficiency

According to Le et al.[6,19], the average price of "trash fish" for lobster in 2000 was around 5,000 VND/kg. However, our survey in Binh Ba showed that this price has increased rapidly up to 5,700, 16,000, 20,000, and 20,180 VND/kg for mussels, lizard fish, small squid, and crabs, respectively. The composition of "trash fish" is typically 2% squid, 16% lizard fish, 20.18% crabs, and 30% mussels. Therefore, the average price for 1 kilogram of "trash" fish (APTF) can be calculated in Table 3 to estimate the production cost of lobster. Result of testing pelleted feed was also obtained from Lai[21,22] for comparing the economic efficiency (Table 3).

By using these pelleted feeds, lobster farmers can save around 213,120 VND (11 USD) and 220,080 VND (11.34 USD) to produce 1 kg *P. ornatus* and *P. homarus*, respectively. In Vietnam a US$90 million per annum lobster industry flourishes[2], therefore if pelleted feeds is used in mass production it could bring about great benefit for lobster farmers, contribute to reduce the effect of aquaculture on environment.

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