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Evaluation of practical diets for the Caribbean spiny lobster *Panulirus argus* (Latreille, 1804): effects of protein sources on substrate metabolism and digestive proteases

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Abstract

The formulation of artificial diets is a fundamental issue in the development of lobster aquaculture. The impact of inclusion of clam, squid, chiton, and high-quality fish meal in a local fish meal-based diet on substrate metabolism and digestive proteases in juveniles *Panulirus argus* was evaluated by using two dietary protein levels, 25% and 35%, with 20% protein the basal level. The oxygen consumption/ammonia excretion ratio showed that lobsters fed clam and chiton diets used protein for oxidation at the two dietary protein levels, while lobsters fed high-quality fish meal and squid diets used protein–lipid at 25% protein. Higher protein levels led to an increase in the contribution of protein to energy metabolism. Digestive protease activity increased with squid meal in diets. Our results suggest that the inclusion of squid and high-quality fish meal in local fish meal diets increases the nutritional value of the diet for *P. argus* juveniles and that squid enhances digestive proteases activities in the hepatopancreas. However, grow-out trials are needed to fully demonstrate the growth-enhancing effect of these protein sources in formulated diets for juveniles *P. argus* and to decide whether the growth rate increase is sufficient to warrant using these protein sources.

Keywords: Spiny lobster; *Panulirus argus*; Protein sources; O/N ratio; Metabolism; Digestive proteases

1. Introduction

Spiny lobsters are among the worlds most valuable seafood and support some of the largest commercial fisheries in the world. The spiny lobster *Panulirus argus* is the most important fishery resource in the

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Great Caribbean and the species of highest commercial value in Cuba, accounting for US$90–100 million per year. There is an intense interest in the aquaculture of spiny lobsters all over the world due to their high value in international markets and because most stocks are exploited at or above sustainable levels.

Despite numerous advances in culturing phyllosoma larvae (Kittaka, 1997; Ritar et al., 2002; Smith et al., 2003), hatchery production of spiny lobsters is not yet technically feasible. However, the development of programs to catch large numbers of pueruli has motivated the growout of spiny lobsters in some Asiatic countries including Vietnam, Philippines, Indonesia, India, Thailand, Burma, China, Taiwan, Malaysia, Tahiti, and Singapore (Jeffs and David, 2002) and New Zealand (Jeff and Hooker, 1999).

Commercially, lobsters are successfully fed fresh fish, crustaceans, and mollusks, although sometimes the inconsistency in quality of those foods leads to reduced growth. At higher scales, the restricted access to the appropriated natural items and their storage would become a problem. In addition, if caged aquaculture system is used, as in the case of most of the Asiatic countries mentioned above, cages can release entirely untreated wastewater to the environment. Thus, formulated diet development is one of the key issues in successful aquaculture of lobsters in term of both profitability and sustainability.

Natural foods have proved to promote higher growth than pelleted diets in spiny lobsters (Crear et al., 2000, 2002; Smith et al., 2003, Thomas et al., 2003). It has been suggested that the differences in spiny lobster growth between fresh foods and formulated diets are probably due to differences in efficiency of the utilization of protein (Crear et al., 2000; Tolomei et al., 2003). The most commonly used

Table 1
Formulations (%) and proximate composition of the experimental diets

Ingredient	Experimental diets							
	1	2	3	4	5	6	7	8
Basal diet (%)								
Gelatin	5.78							
Whole wheat	32.87							
Vitamin and mineral premix	5							
Soya oil	2							
Shark oil	2							
Calcium carbonate	2							
Dicalcium phosphate	1							
Vitamin C	0.10							
Vitamin E	0.25							
Agglutinant[a]	2							
Local fish meal	17							
Stuff[b]	22	7	23	10	23	9	23	9
Total	92	77	93	80	93	79	93	79
Crude protein in basal diet (%)	19.99							
Clam meal	8	23						
Squid meal			7	20				
Chiton meal					7	21		
High-quality fish meal (from Chile)							7	21
Total	100	100	100	100	100	100	100	100
Proximate								
Crude protein (%)	25.14	34.94	25.24	34.99	25.05	35.17	24.9	34.7
Crude fat (%)	6.24	6.9	6.24	6.37	6.8	7	6.2	6.23
Carbohydrate (%)	23.75	24.44	24.1	24.73	24.03	24.59	23.99	24.5
Gross energy (kJ/g)	11.6	14.0	11.6	13.8	11.8	14.5	11.5	13.7
P/E ratio(mg protein/kJ)	21.7	25.0	21.8	25.4	21.2	24.3	21.7	25.3

[a] Carboxymethylcellulose.
[b] Talc Protein sources: clam (*Arka zebra*), squid (*Loligo* sp.), chiton (*Acanthopleura granullata*).