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An evaluation of the nutritional value of alternative lipid sources to juvenile southern rock lobster, *Jasus edwardsii*

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ABSTRACT

Experimental lobster feeds are currently based on fish meal and fish oil formulations, and although survival and growth similar to that of lobsters fed fresh blue mussels has been achieved, varying the protein level in previous experimental feeds has not increased growth beyond that of lobsters fed natural food. This experiment assessed the growth performance of lobsters fed pelleted feeds containing constant amounts of protein, lipid and energy where the lipid was provided by a range of oil-rich ingredients (fish oil, FO; fish oil with added soybean lecithin, FOL; canola oil, CO; tuna oil, TO; mussel meal, MM; and squid meal, SQM). Feed performance was assessed by lobster growth rate, survival, final biochemical composition, nutrient retention and nutrient efficiency. Twenty tanks containing 15 post-larval lobsters each (1.5 ± 0.04 g) were randomly allocated one of six test feeds in triplicate, and the two remaining tanks were fed freshly opened blue mussels (FRM) as a reference feed. Lobsters were fed daily to excess for 10 weeks. Final individual weights of whole body and digestive gland were measured, and tissue chemical composition analysed. There were no significant differences in survival ($88.4 \pm 3.3\%$), or specific growth rate ($1.3 \pm 0.1\%.\text{day}^{-1}$) among the formulated feed fed lobsters, which were significantly lower than the survival ($100 \pm 0.0\%$) and SGR ($2.2 \pm 0.1\%.\text{day}^{-1}$) of FRM fed lobsters. The SQM fed lobsters had a significantly lower lipid efficiency ratio and lipid productivity value than lobsters fed TO, FOL and MM feeds. The digestive gland lipid content (g.100 g wet tissue^{-1}) of lobsters fed the feeds TO (3.7 ± 0.4), FO (3.5 ± 0.3) and SQM (2.2 ± 0.2) were significantly lower than lobsters fed feeds MM (9.9 ± 1.1), FOL (9.0 ± 2.3) and FRM fed lobsters contained most digestive gland lipid (12.3 ± 1.5).

1. Introduction

Southern rock lobster *Jasus edwardsii* form the basis of economically important fisheries in Australia and New Zealand (Jeffs and Hooker, 2000; Stevens and Sykes, 2000), where the combined value of the fisheries in 2006 was approximately US$922 M (ABARE, 2007). Commercial lobster aquaculture is rapidly expanding in many parts of south east Asia and in particular Vietnam where the industry is worth US$90 million per annum (Williams, 2007). The production of hatchery reared juveniles will provide a sustainable supply for future commercial culture and enhancement, and recent success with experimental hatchery rearing of temperate *J. edwardsii* and *Sagmariasus verreauxi* has highlighted the need to develop formulated feeds for hatchery reared juvenile lobsters (Smith, et al., 2007). Recent research on juvenile *J. edwardsii* has established baseline information on environmental (Crear et al., 2000; Thomas, et al., 2000), health (Tolomei, et al., 2004) and basic nutritional requirements (Crear et al., 2000; Ward, et al., 2003; Ward, 2005). Feed development that improves the delivery of available nutrients to lobster is essential to optimise growth rates in culture. While blue mussels (*Mytilus edulis*) have been suggested as a viable lobster feed in New Zealand, and provide a useful reference feed for experimental comparison, high prices and inconsistent supply exclude blue mussel as an economical commercial feed in Australia. Consequently the development of a cost-effective formulated feed specific to requirements for rock lobster is seen as a research priority for commercial culture (FRDC, 2000; Jeffs and Hooker, 2000; Williams, 2007).

Feeds for commercial aquaculture are currently reliant on the full or partial inclusion of fish meal and oil as the protein and lipid source. Recent reduction in supply, increased prices of fish meal and oils, and an environmental need to find alternatives to wild fish products have prompted efforts to replace fish-based ingredients to support development of economical and sustainable aquafeeds (Bell, 1998; Carter and Hauler, 2000; del Mar Otero-Villanueva, et al., 2004). The replacement of fish oil with alternative marine oils, waste processing products containing oils and the partial substitution of fish oil with plant oil sources, are potential avenues to meet lipid requirements of

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cultured species (Bell, 1998; Bell, et al., 2003; Carter, et al., 2003). Preliminary data from nutrient requirement studies in temperate rock lobsters have shown that fresh mussels support the best growth (Crear et al., 2000, 2002; Tsvetnenko, et al., 2000; Glencross et al., 2001; Ward, et al., 2003). In comparison, the lobsters fed formulated feeds containing fish meal and fish oil exhibited both slower growth and poor lipid storage in the digestive gland, suggesting inadequate lipid retention possibly due to inappropriate lipid sources or inclusion levels (Ward, et al., 2003). Tropical spiny lobsters, *Panulirus ornatus*, fed pellets containing a combination of fish meal and krill products (krill meal and krill hydrolysate), where lipid was not provided as crude fish oil, but provided endogenously within ingredients (fish meal 360 g.kg^{-1}, krill meal 300 g.kg^{-1} and soybean lecithin 12.5 g.kg^{-1}) grew faster than lobsters fed frozen blue mussels (Barclay, et al., 2006). While frozen blue mussel has previously supported lower growth rates in *J. edwardsii* than fresh blue mussels (James and Tong, 1997), the provision of lipids from new ingredients may provide potential to improve growth rates further.

Lipids have been recognised as important energy sources in various life stages of the rock lobster (Jeffs, et al., 1999; 2001; 2002; McLeod, et al., 2004), and are preferentially metabolised before carbohydrates and proteins in larval *J. edwardsii* (Jeffs, et al., 1999). When considering dietary crude lipid requirements; both the gross energy content of the feed, and the quality and concentration of the fatty acid profile may influence the resultant levels of lipid storage, lipid biosynthesis and growth (D'Abramo, 1997). Poor lipid storage in the digestive gland through the intermoult phase may reduce the potential growth increment at moult, and in extreme cases of malnutrition, to successfully complete ecdysis (Cockcroft, 1997). The mobilisation of dietary lipid to the haemolymph may be restricted in lobsters fed feeds deficient in dietary phospholipids (D'Abramo, et al., 1985), and phospholipid (in particular phosphatidylcholine) deficiency may contribute to poor tissue lipid deposition (Conklin, et al., 1980). The inclusion of either crude soybean lecithin or a purified phospholipid source at inclusion levels between 0.5–7.5% improved growth and survival in a range of crustacean species (Coutteau, et al., 1997), however the dietary phospholipid requirement for *J. edwardsii* has not been established. In the current study, fish oil was supplemented with crude soybean lecithin to investigate any compositional and growth effects that may benefit from including soybean lecithin in rock lobster feed formulations. This study has measured the effect of different oil sources on lobster growth performance, feed efficiency, tissue composition and nutrient retention.

2. Methods

2.1. Feeds

Feeds were made at the National Centre for Marine Conservation and Resource Sustainability (former School of Aquaculture), University of Tasmania. Feeds were formulated to provide a range of lipid containing ingredients (oils and lipid-rich meals) with potential for commercial use in lobster feeds in their commercially available form. Feeds were formulated to contain identical gross values of protein (40%), lipid (13%) and energy (18 MJ.kg^{-1}) from different lipid sources; 4 purified oil sources and 3 oil-containing marine meals (Table 1). The lipid sources were cold pressed canola oil (Golden Fields, NSW), South American fish oil (Skretting Australia, TAS), tuna oil (Hi-DHA®, donated by Clover Corporation, VIC), a blend of soy lecithin (Sigma Chemicals, NSW). The marine meals: South American fish meal (Skretting Australia, TAS), squid meal (Ridley Aquafeeds, QLD) and powdered blue mussel (National Institute of Water and Atmospheric Research, New Zealand) were incorporated at 450 g.kg^{-1}. Pre-gelatinised maize starch (BO11C, Sigma Chemicals, NSW) and 70% vital wheat gluten (Sigma Chemicals, NSW) were used to balance the energy and protein levels of the feeds. A vitamin premix was made from individual vitamins (Sigma Chemicals, NSW) according to D'Abramo (1997), Stay C vitamin C and carophyll pink (Roche Australia, NSW), were included with the antioxidant Banox E (Sigma Chemicals, NSW). The alginate binder Manucol DM (Geraldton Industries, NSW) was combined with trisodiumpyrophosphate (TSPP) (Ajax Chemicals, NSW) to avoid premature calcium binding until the final pellet form was achieved.

Table 1
Ingredient inclusion rates and chemical composition of feed formulations.

	CO	FOL	FO	TO	SQM	MM
Ingredient g kg^{-1}						
Fish oil		18.4	63.9		69	70.7
Canola oil	64.5					
Tuna oil				64.3		
Soy lecithin		50.8				
Fish meal	599	599	599	599		
Squid meal					556.0	
Mussel meal						649.1
Prawn meal	90	90	90	90	90	90
BO11C starch	170	170	170	170	170	170
Diatomaceous earth	51.0	46.9	50.9	0	85.0	1.0
Manucol	60	60	60	60	60	60
TSP phosphate	20	20	20	20	20	20
Vitamin premix	2	2	2	2	2	2
Vitamin C	1	1	1	1	1	1
Choline chloride	0.5	0.5	0.5	0.5	0.5	0.5
Banox E	0.2	0.2	0.2	0.2	0.2	0.2
Cholesterol	0.1	0.1	0.1	0.1	0.1	0.1
Yttrium oxide	1	1	1	1	1	1
Ytterbium acetate	1	1	1	1	1	1
Chemical composition g kg^{-1}						
Crude protein	404.5	414.9	402.8	401.4	400.7	365.6
Crude lipid	117.5	130.0	123.0	122.5	164.2	155.2
Gross energy (MJ kg^{-1})	17.8	18.1	17.7	17.9	18.4	20.0
CHO	353.2	324.9	308.7	361.2	302.4	288.7
Ash	152.0	135.7	160.9	167.1	139.2	103.9
Moisture	64.8	76.3	60.6	53.1	50.6	72.5

CO = canola oil, TO = tuna oil, FO = fish oil, FOL = fish oil and lecithin blend, MM = mussel meal, SQM = squid meal, FrM = fresh mussel.
The fresh mussel composition (DM basis) was crude protein 477 g kg^{-1}, crude lipid 82 g kg^{-1}, gross energy 18.05 MJ kg^{-1}, ash 17.5 g kg^{-1}.

The dry materials were thoroughly mixed in a Hobart mixer for 1 h. Fish oil was added and mixed for 30 min. Sufficient distilled water was added to form a firm dough, which was then passed through a 3 mm die on a Kenwood mincer attachment. Pellet strands were immersed in a 10% $CaCl_2$ bath for 3 min to set and then dried at 30 °C. When below 10% moisture, strands were transferred to a −20 ºC freezer until feeding. Dried pellets (<10% moisture) were broken into about 1.5 cm lengths and stored at −20 °C until use.

The dry matter loss from pellets prior to consumption was measured by weight difference after immersion in the experimental tanks without lobsters for 17 h (the maximum time feed was available to lobsters). Feed intake was adjusted to account for uneaten feed and the dry matter loss from pellets prior to consumption.

2.2. Experimental lobsters

Juvenile rock lobster *J. edwardsii* were caught using puerulus collectors on the east coast of Tasmania, (August 2001), and transported to the Marine Research Laboratories (Tasmanian Aquaculture and Fisheries Institute) where they were maintained (ambient photoperiod, 18 °C) in three flow-through 400-l seawater tanks. They were fed blue mussels (*Mytilus edulis*) 3 days per week and a commercial penaeid prawn feed (Higashimaru No.12) 4 days per week. The lobster puerulus (non-feeding) were held under these conditions with access to feed until all had developed pigmentation indicating post-larval metamorphosis, and until they accepted pelleted feed. Water quality was measured weekly and managed to control quality to within the recommended ranges for lobsters (35‰, pH 8.4, ammonia <0.1 mg.l^{-1}, nitrate