International Fishmeal & Oil Manufacturers Association

THE PROTEIN REQUIREMENT OF MARINE SHRIMP

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Summary and Recommendation

The publications reporting the determination of protein requirements of shrimp are reviewed. A wide range of values are reported. Factors affecting the requirement are outlined. For *Penaeus monodon* (tiger shrimp farmed) which represents 65% of farmed production world-wide, 0.5 to 1g animals are reported to require 40% to 46% protein.

For nutrition trials with these shrimp to investigate fish meal, it is recommended that the protein content of the diet does not exceed 40%.

Marine shrimp make up around 95% of all those farmed. The most widely farmed species - Penaeids, have been the subject of most work to determine protein requirement. Of the farmed penaeids, *P. monodon* is the most common species representing about 65% of total farmed shrimp production.

Protein requirements vary with species of shrimp. Amongst the penaeids the amount of dietary protein required is in the order *P. japonicus*> *P. monodon*> *P. stylirostris*> *P. vannemi. P. chinesis* which represents about half the shrimp production in China is believed to be similar to *P. monodon* in its dietary protein requirement.

Far less is known about protein requirements for shrimp than for any other farmed land animal or widely farmed fin-fish. Determination of protein requirement of shrimp is more complex, as can be seen from the factors affecting it, namely:

i) species of shrimp

ii) size

iii) availability of biomass

iv) frequency of moulting (shredding exo skeleton)

v) water salinity

vi) use of protein as energy source

vii) limited and variable use of carbohydrates

viii) limited use of amino acids which are subject to leaching

ix) inability to tolerate more than 10% total dietary lipid

Most estimates of protein requirement are based on obtaining maximum growth in tanks. Factorial methods based on the sum of maintenance and growth requirement have not been very satisfactory because of lack of reliable data on protein utilisation, etc.

Amino acid requirements have been estimated based on the composition of the shrimp (see Table 1). Attempts to grow shrimp with synthetic amino acids have not been successful - they appear to be poorly utilised in non-peptide form, though small amounts added to correct one or two amino acid deficiencies have been effective in some cases - e.g. addition of arginine and lysine to casein. Casein is not 'ideal' as a protein to determine protein requirements because of its arginine deficiency in relation to the shrimp's requirement (see Table 1). Other proteins such as those from crab or the short-necked clam have also been used as 'ideal' but none appear to achieve this for shrimp.

A variety of proteins has been used to determine protein requirement. These include casein, casein plus albumin, shrimp meal, crab meal, squid meal, fish meal and mixtures.

In view of the difficulty in finding an 'ideal' protein to work with, plus the other factors which affect requirement (see list earlier), it is not surprising a wide range of values has been obtained - from 30% to 60%. Much of the variability appears to arise between species; within species the range was narrower. For *P. monodon* the range was from 40% to 46% for shrimp with initial weight 0.5g to 1.0g (see Table 2). It can be assumed that the majority of the dietary protein came from the feed. On the other hand, shrimp from 0.5/1.0g in ponds would be expected to get appreciable quantities of biomass which would contribute towards the protein they require. At higher stocking densities (10+ per sq m) of semi intensive/intensive production this would rapidly diminish as they grow.

Recommendation

Working with *P. monodon* shrimp over 1g initial weight in cages in ponds to test different inclusions of fish meal and vegetable protein, the diet should contain not more than 40% protein.

TABLE I Optimal dietary protein level for penaeids[1]

Species	Initial weight (g)	Protein source	Optimal protein level (%)	Reference
Penaeus aztecus	—	Fish meal + squid meal	29-31	Shewbart and Mies (1973)
	0-135	Fish meal + mixture	< 40	Venkataramiah *et al.* (1975)
Penaeus brasiliensis	0.9	Shrimp meal + casein	55	Liao *et al.* (1986)
	7.8	Shrimp meal + casein	45	Liao *et al.* (1986)
Penaeus californiensis	—	Mixture	> 44	Colvin and Brand (1977)
Penaeus duorarum	—	Soybean meal	30	Sick and Andrews (1973)
Penaeus kerathurus	3.15	Mixture	> 40	Fernandez and Puchal (1979)
Penaeus indicus	0.95	Shrimp meal + yeast	43	Colvin (1976)
	3.9	Mixture	40	Bailly and Cuzon (1984)
Penaeus japonicus		Casein + albumin	> 55	Teshima and Kanazawa (1984)
	Zoea	Casein + albumin	45-55	Teshima and Kanazawa (1984)
	Zoea	Casein + albumin	45	Teshima and Kanazawa (1984)
	—	Squid meal	60	Deshimaru and Shigueno (1972)
	—	Shrimp meal	> 40	Balazs *et al.* (1973)
	0.6	Casein + albumin	54	Deshimaru and Kuroki (1974a)
	0.8	Casein + albumin	52	Deshimaru and Yone (1978)
	0.4	Crab protein	42	Koshio *et al.* (1993a)
Penaeus merguiensis	0.3	Mussel meal	34-42	Sedgwick (1979)
	—	Mixture	50	AQUACOP (1978)
Penaeus monodon	0.5	Casein + fish meal	46	Lee (1971)
	—	Casein	40	AQUACOP (1978)
	—	—	40	Khannapa (1977)

TABLE I continued

Species	Initial weight (g)	Protein Source	Optimal protein level (%)	Reference
Penaeus monodon	—	Mixture	35	Bages and Sloane (1981)
	1.3	Mixture	40	Alava and Lim (1983)
	—	Whitefish meal	35	Lin *et al.* (1982)
	0.9 (brackish-water)	Mixture	44	Shiau *et al.* (1991)
	0.8 (sea water)	Mixture	40	Shiau *et al.* (1991)
Penaeus penicillatus	—	Fish meal	22–27	Liao *et al.* (1986)
Penaeus setiferus	—	Fish meal + collagen + squid meal	28–32	Andrews and Sick (1972)
Penaeus stylirostris	—	Mixture	> 10	Colvin and Brand (1977)
	Various	Mixture	30–35	Colvin and Brand (1977)
Penaeus vannamei	Various	Mixture	> 30	Colvin and Brand (1977)
	1.7	Mixture	30	Cousin *et al.* (1993)
Metapenaeus monoceros	0.017	Casein	55	Kanazawa *et al.* (1981)
Metapenaeus macleayi	—	—	27	Macguire and Hume (1982)

[1]This table includes values derived from experiments where optimal protein level was not accurately determined due to either the small number of protein levels evaluated or other causes.

TABLE 2 Optimal dietary protein level for non-penaeid species of crustaceans[1]

Species	Initial weight (g)	Protein Source	Optimal protein level (%)	Reference
Palaemon serratus	—	Shrimp meal	40	Foster and Beard (1973)
	—	Fish meal	40	Foster and Beard (1973)
Palaemon elegans	0.16	Fish meal	40–45	Olivia Teles (1985)
Macrobrachium rosenbergii	0.10	Mixture	> 35	Balazs and Ross (1976)
	0.15	Fish meal + soy protein	40	Millikin *et al.* (1980)
	—	—	25	Clifford and Brick (1978)
	—	Crab protein	33–35	D'Abramo and Reed (1988)
	4.1	Fish meal + casein + grain	40 (?)	Ashmore *et al.* (1985)
	—	—	30	Fruechtenicht *et al.* (1988)
Crangon crangon	(L = 20 mm)	Fish protein hydrolysate	60	Regnault and Luquet (1974)
	(L = 23 mm)	Fish protein hydrolysate	50	Regnault and Luquet (1974)
	(L = 26 mm)	Fish protein hydrolysate	40	Regnault and Luquet (1974)
	(L = 29 mm)	Fish protein hydrolysate	30	Regnault and Luquet (1974)
Procambarus clarkii	—	Mixture	20–30	Huner and Meyers (1979)
Homarus americanus	—	Mixture	20–23	Capuzzo and Lancaster (1979)
Homarus gammarus	—	Fish meal + shrimp meal + wheat gluten	35	Lucien-Brun *et al.* (1985)