THE NUTRITION AND FEEDING OF FARMED FISH IN AUSTRALIA

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Summary

Fish farming in Australia, which commenced in the 1960s is still a relatively new industry. At least five fish species were commercially farmed in Australia in 1991/92 and the hatchery production and farming potential of many more species covering a wide range of environments are being investigated. The selection of target species for aquaculture is greatly dependent on the ability to maintain broodstock in captivity and reliably produce large numbers of fingerlings. Australian fish diets are still rather expensive because of an over reliance on imported fishmeal and the limited local production of soybean meal. To counteract this problem evaluation of cheaper, locally produced fishmeal substitutes like oilseeds and grain legumes is being undertaken. Diet formulation for the introduced cold water species is largely based on overseas data. However, the economic viability of the farming of our (wild) native fish species is hampered by a lack of scientific data, although this is being addressed gradually. Only a few behavioral studies of our native fish species have been carried out, but they have already proven to be beneficial for feeding practices. The development of cost effective diets and feeding practices is required for the future economic viability of fish farming in Australia.

I. INTRODUCTION

The main species of fish farmed in Australia in 1991/92 (O'Sullivan 1994) were the carnivorous cold water Atlantic salmon (*Salmo salar*) in Tasmania (3300t) and rainbow trout *(Oncorhynchus mykiss)* in the southern states (2178t); barramundi *(Lates calcarifer)* grown indoors in NSW and SA and outdoors in Queensland (151t); southern blue fin tuna *Thunnus maccoyii* (120 t/year) in SA and the omnivorous species, silver perch *(Bidyanus bidyanus)* in NSW and Queensland (26t). Atlantic salmon and southern bluefin tuna are farmed in sea water only. Rainbow trout and barramundi are farmed in both fresh and sea water and although silver perch has so far only been farmed in fresh water it also grows in brackish water of 10% salinity. Fish farming is a relatively recent activity in Australia. Rainbow trout have only been farmed since the 1960's, Atlantic salmon and barramundi since the 1980's (Treadwell et al. 1992) and silver perch and southern bluefin tuna since the 1990's. Production of the main species apart from rainbow trout is rapidly expanding (Treadwell et al. 1991; O'Sullivan 1994). Farmers and scientists are investigating the aquaculture potential of a wide range of other species, some of which are likely to go into commercial production, to offset annual imports of 38000t of whole fish and fillets valued at $126 million annually (ABARE 1993).

II. LARVAL FEEDING

Larval fish have a poorer developed digestive system than adults and require easily digested ingredients in their diet (Wee 1992). The choice of food sources for larval fish is also

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influenced by the physical requirements of the diet such as particle size and buoyancy. Particular care must be taken to ensure that the supply of the long-chain fatty acids 20:5 n-3 and 22:6 n-3 is not limiting (Watanabe et al. 1983). Atlantic salmon and rainbow trout larvae are hatchery reared in freshwater and fed artificial diets (Nell 1983; Helland et al. 1991), whereas much smaller and less developed larvae of barramundi and silver perch are reared on live zooplankton. Silver perch larvae are extensively reared on wild zooplankton in fresh water ponds (Rowlands 1983). Barramundi larvae are either reared extensively on wild zooplankton in salt water ponds (Rutledge 1991) or intensively on cultured zooplankton (rotifers *Brachionus plicatilis* and brine shrimp *Artemia sp.)* in hatcheries (MacKinnon 1987). Rotifers are produced in local fish hatcheries where they are fed live microalgae and bakers yeast, whereas brine shrimp nauplii are hatched from imported vacuum packed cysts. Brine shrimp nauplii and rotifers should be given a fish oil supplement or specially selected microalgae to boost their essential fatty acid content prior to the feeding of larvae of marine fish. Atlantic salmon larvae and juvenile barramundi are fed imported starter diets, which are very expensive. There is however, an increasing use of Australian manufactured diets for the weaning of barramundi larvae.

III. FISHMEAL REPLACEMENT

Fish consume protein for both growth and energy and the feeding habits and diets of different species of fish reflect their type of digestive system. Carnivorous fish have more proteolytic, but lower amylase enzyme activities in the stomach and intestine than herbivorous species (Wee 1992). Some omnivores such as silver perch require less protein (35% or less) (Allan and Rowland 1991) than carnivores such as Atlantic salmon (35-44%) (Helland et al. 1991) and because of more developed digestive systems can tolerate higher contents of cheaper plant protein in their diet.

In Australia, very little fishmeal is produced and imported fishmeal is expensive, can be difficult to acquire and is of variable quality (Foster 1992). As the availability of fishmeal is decreasing and its price increasing, the need to find alternative ingredients for aquaculture diets has become urgent. In contrast, abundant supplies of low-priced domestically grown plant products are available in Australia. Oilseeds and grain legumes with potential use in aquaculture diets include soybeans, canola, cottonseed, peanuts, lupins, chickpeas, field peas and cow peas (Allan and Rowland in press). Animal products such as poultry offal meal (Quartararo et al. 1992) and bloodmeal (Allan and Rowland 1992) may be used to balance amino acid requirements. Although a lot of fishmeal substitution research has been carried out overseas, there are several reasons why more of this research needs to be done in Australia. Our native fish species and fishmeal substitutes are different. In addition we have a large range of lower quality protein sources, of terrestrial plant and animal origin, available in large quantities at relatively lower prices compared with fishmeal.

IV. DIET FORMULATION

Diet formulation and nutrient requirement data for the introduced Atlantic salmon (Helland et al. 1991) and rainbow trout (Cho and Cowey 1991) are based on northern hemisphere research, whereas in the case of native species such as silver perch, which is only found in Australia, all research will need to be done locally. Barramundi (or seabass) farmed in Asia have traditionally been fed on trash fish (Boonyaratpalin 1991). Thus, there is little overseas data available on diet formulation and nutrient requirements for this species. Australian barramundi diets were originally based on Tasmanian Atlantic salmon diets and these are gradually being

modified as research data become available. So far there has been little diet development research done for southern bluefin tuna, which are simply fed cheap bait fish such as local and imported anchovy. This has only been economical because of the high prices paid for fresh tuna for sashimi on the Japanese market and relatively low prices paid for the bait fish. The cost of feeding tuna is nevertheless a concern in this infant industry, where food conversion rates have been in the range of 8-12:1 (wet weight: dry weight). Research into the nutrient requirements and feeding practices for southern bluefin tuna commenced in South Australia in 1994. The high value and large size of tuna however, poses a formidable restriction to experimental design.

V. FEEDING PRACTICES

Atlantic salmon farmed in sea cages (Blyth et al. 1992) are fed to satiation twice a day with sinking pellets, either by hand (better observation of fish) or with automatic feeders. Barramundi, which are farmed in either fresh or sea water ponds or sea cages are usually fed on locally manufactured floating pellets (extruded diets) and hand fed to satiation. Barramundi fry will eat all day, however, feeding activity increases at dusk and ceases in the dark (Barlow et al. 1993). The study by Barlow et al. (1993) demonstrates the practical benefit of behavioural studies and shows the need for doing similar work with fish of different ages and species for various farming conditions. Silver perch are farmed in fresh water ponds and fed sinking pellets. Juvenile silver perch and barramundi are fed up to eight times a day but frequency is gradually reduced to twice a day for 450g fish. Southern bluefin tuna are hand or pump fed bait fish diets supplemented with a vitamin mix twice a day for six days a week. Research into the development of artificial diets (moist pellets) for southern bluefin tuna commenced in 1993.

Fish weight should be checked and feeding rates adjusted regularly and pellet size increased as fish size increases, however, the amount of feed supplied as a percentage of body weight decreases as fish grow. For example, juvenile silver perch and barramundi (5g) consume an amount of food equivalent to 10% and 6% of their body weight respectively and for 450g fish this declines to 3% and 1.5% respectively. The stability of the pellets and the leaching rate of water soluble vitamins and amino acids are other important factors to consider in diet formulation and method of pelleting. Both are greatly influenced by the feed processing method and the choice of ingredients and binders.

IV. CONCLUSION

Fish farming in Australia is still a relatively new industry with a big future. It is likely that the industry will seek to diversify the range of species that are being farmed. Ideally, each farmer should have a choice of at least two species to farm in order to meet both marketing and environmental challenges. Fish nutritionists are struggling with insufficient information on the feeding value (eg digestibility) of local ingredients for diet formulation. In the case of our native species, little is known about their specific nutrient requirements. Research into protein, amino acid, total lipids and fatty acids as well as protein/energy ratios is a high priority. Much of this research is currently being funded by the Fisheries Research and Development Corporation (FRDC); Cooperative Research Centre (CRC) for Aquaculture; Grains Research and Development Corporation (GDRC) and the Australian Centre for International Agriculture Research (ACIAR). It is being undertaken at State Fisheries and Commonwealth Scientific and Industrial Research Organisation (CSIRO) research laboratories and Universities throughout the country.

REFERENCES

ABARE, (1993). 'Australian Fisheries Statistics 1993' (ABARE: Canberra, ACT).
ALLAN, G. L. and ROWLAND, S. J. (1991). Proc. Nutr. Soc. 16: 210.
ALLAN, G. L. and ROWLAND, S. J. (1992). Austasia Aquaculture 6(3): 39.
ALLAN, G. L. and ROWLAND, S. J. (in press). In 'Proc. Third Asian Fish. Forum' (Asian Fish. Soc.: Singapore).
BARLOW, C. G., RODGERS, L. J., PALMER, P. J. AND LONGHURST, C. J. (1993). Aquaculture 109: 131.
BOONYARATPALIN, M. (1991). In 'Handbook of nutrient requirements of finfish' p. 5, ed R. P. Wilson (CRC Press: Boca Raton, LA).
BLYTH, P. J., PURSER, G. J. AND FOSTER, C. K. (1992). In 'Proc. Aquaculture Nutr. Workshop' p. 227, eds G. L. Allan and W. Dall (NSW Fisheries, Salamander Bay, NSW).
CHO, C. Y. and COWEY, C. B. (1991). In 'Handbook of nutrient requirements of finfish' p. 131, ed R. P. Wilson (CRC Press: Boca Raton, LA).
FOSTER, C. K. (1992). In 'Proc. Aquaculture Nutr. Workshop' p. 221, eds G. L. Allan and W. Dall (NSW Fisheries, Salamander Bay, NSW).
HELLAND, S., STOREBAKKEN, T. and GRISDALE-HELLAND, B. (1991). In 'Handbook of nutrient requirements of finfish' p. 13, ed R. P. Wilson (CRC Press: Boca Raton, LA).
MacKINNON, M. R. (1987). In 'Proc. Int. Workshop, Darwin, NT', ACIAR Proceedings No. 20, p. 148, eds J. W. Copeland and D. L. Grey (ACIAR, Canberra, ACT).
NELL, J. A. (1983). In 'Proc. First Freshwater Aquaculture Workshop', p. 145, (Dept. Agric., Sydney, NSW).
O'SULLIVAN, D. (1994). 'Status of Australian Aquaculture (1991-92)' Aquaculture Sourcebook No. 11 (Turtle Press: Sandy Bay, Tas.).
QUARTARO, N, ALLAN, G. L. AND BELL, J. D. (1992). In 'Proc. Aquaculture Nutr. Workshop' p. 125, eds G. L. Allan and W. Dall (NSW Fisheries, Salamander Bay, NSW).
ROWLANDS, S. J. (1983). In 'Proc. First Freshwater Aquaculture Workshop', p. 121, (Dept. Agric., Sydney, NSW).
RUTLEDGE, W. P. (1991). Asian Fish. Sci. 4: 435.
TREADWEL, R., MCKELVIE, L. and MAGUIRE, G. B. (1991). 'Profitability of selected aquacultural species' (ABARE: Canberra, ACT).
TREADWELL, R., MCKELVIE, L. and MAGUIRE, G. B. (1992). 'Potential for Australian Aquaculture' (ABARE: Canberra, ACT).
WATANABE, T., KITAJIMA, C. and FUJITA, S. (1983). Aquaculture 34: 115.
WEE, K. L. (1992). In 'Proc. Aquaculture Nutr. Workshop' p. 17, eds G. L. Allan and W. Dall (NSW Fisheries, Salamander Bay, NSW).