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Practical Diet Development for Broodstock of *Colossoma macropomum* and *Piaractus brachypomus*

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Progress Report

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Abstract

Proximate analyses of broodstock and grow-out feeds for gamitana (*Colossoma macropomum*) and paco (*Piaractus brachypomus*) and their constituent feedstuffs were conducted. Literature values for specific nutrients known to affect fish reproduction were calculated from published sources for the broodstock diet. Broodstock eggs have not yet been obtained for proximate analysis. However, similar analyses conducted previously on eggs of similar species in Brazil have been described. Analytical information on the feedstuffs and diets currently being used in Iquitos, Peru, together with published information on the natural diets of colossomids and broodstock nutrition of other species were combined to formulate preliminary recommendations for the nutrition and feeding of gamitana and paco broodstock.

Introduction

Colossomid culture in Iquitos, Peru, may be limited currently by several factors, including the inability to obtain consistent spawning of captive broodstock. Inadequate nutrition of the broodstock may be contributing to this problem. However, little is known about broodstock nutrition in fish (De Silva and Anderson, 1995). Therefore, the objectives of this study were to identify nutritional factors that may be hindering reproductive success in captive colossomid broodstock and to formulate recommendations for improvement of broodstock diets.

Methods and Materials

Proximate analyses of feedstuffs and broodstock diets were conducted using standard methods (Association of Official Analytical Chemists, 1984). Protein was analyzed using the Kjeldahl method. Total lipid was analyzed using the Folch method (Folch et al., 1957). Other data used in this report were obtained from published sources. Small-scale feeding trials are being performed with paco to bracket their dietary requirements for vitamins C and E.

Results and Discussion

The analyzed protein content of the broodstock diet was approximately 32%. The calculated energy: protein (E:P) ratio (kcal of energy per gram of protein) of the current broodstock diet is about 8.7. This is lower than the range of values reported for good growth of colossomid species (10.7 to 13.9) (Castagnolli, 1991). Adult fish require more energy than juveniles simply for maintenance, and even more energy for production of gametes. The relative abundance of protein compared to energy in the diet may cause the fish to metabolize a large percentage of protein for basic maintenance requirements, possibly at the expense of gamete production. This imbalance is also not cost-effective, as protein is a more expensive energy source than lipid or carbohydrate. The E:P ratio of the current broodstock diet could be increased by replacing some of the wheat husks with lipid. Some of the broodstock fish are reportedly "fatty" (Fernando Alcántara, pers. comm.). If this is the case even on a relatively low-energy diet, there may be a lipid transport problem. This problem has multiple potential causes but might be relieved by including dietary lipid in the form of soybean lecithin (1%). Lecithin functions in lipid digestion and transport and improves performance in some fish (Hertrampf, 1992).

No supplemental lipid has been added to the broodstock diet, but it contains 7% lipid. Most of the lipid comes from fish meal (2.9%), wheat husks (1%), soybean meal (0.7%), and corn flour (0.7%). Lipids from fish meal supply n-3 fatty acids, while the other ingredients supply mainly n-6 fatty acids. Both families of fatty acids are necessary for reproduction. A ratio of 50/50 of n-3 to n-6 fatty acids has been suggested as optimal for most fish functions, including reproduction (Tacon, 1987). However, wild-spawned eggs of colossomids reportedly contain higher levels of n-3 fatty acids than eggs from captive broodstock (Araujo-Lima and Goulding, 1997). Therefore, it is still necessary to measure the fatty acid content of broodstock eggs to see if fatty acids are limiting spawning success of gamitana or paco in Peru. Until these data are available, 1% fish oil could be added to the broodstock diets.

There is little or no information on vitamin requirements of colossomid species. The natural diets of these fish are especially rich in vitamins C and E and carotenoids. All of these nutrients are known to affect reproduction in at least some fish species (De Silva and Anderson, 1995).

The broodstock diet is currently supplemented with 500 mg kg^{-1} of vitamin C. This supplement is critical, as the intrinsic vitamin C content of the feedstuffs is very low. Five hundred mg kg^{-1} of vitamin C meets or exceeds the known requirements

of other fish species for weight gain and prevention of deficiency signs (National Research Council, 1993). The stability of vitamin C is poor under conditions of high heat and humidity, as found in Iquitos. Therefore, the form of vitamin C is critical—a stabilized form should be used. If this is not the case currently, a different form can be used and/or other antioxidants (e.g., ethoxyquin or equivalent) can be added to the diet to ensure stability.

The swine vitamin/mineral premix currently used in the broodstock diet supplies about 100 mg kg^{-1} of vitamin E, and the feedstuffs supply another 20 to 30 mg kg^{-1}. One hundred mg kg^{-1} meets or exceeds the vitamin E requirements of most fish species for weight gain and absence of deficiency signs (National Research Council, 1993). However, only alpha-tocopherol has high biological activity. The form of vitamin E in the premix is not specified. The form should be verified since the supplement supplies most of the dietary vitamin E. Also, a stabilized form of vitamin E should be used (e.g., alpha-tocopherol-acetate). Vitamin E is very prone to oxidation under conditions of high heat and humidity. In addition, vitamin E is quickly used up in the presence of unsaturated lipids (as from fish oil) because it is a powerful antioxidant. The amount of vitamin E should be increased proportionately if unsaturated lipids (especially those found in fish oil) are increased in the diet. Furthermore, there are studies showing that broodstock diets containing large amounts of vitamin E have positive effects when given to broodstock just prior to spawning (Kanazawa, 1988). In carp, vitamin E increases gonadosomatic index, facilitates vitellogenesis, and protects essential fatty acids in the oocytes. The specific amount of vitamin E needed to optimize these activities is not known, but vitamin E nutriture has not been investigated in gamitana or paco.

Of pigments reported to have beneficial effects in fish or other animals, only xanthophylls (about 17 mg kg^{-1} from the corn flour) are present in the broodstock diet. Other carotenoids such as beta-carotene are important for egg viability in some fish and are prevalent in the natural diets of colossomid species. Therefore, carotenoid supplementation of the broodstock diet may be beneficial for spawning success of gamitana or paco. Further research is necessary to identify inexpensive, available sources of carotenoids (e.g., fruits, vegetables, and/or flowers) that could be used in Iquitos.

The combination of fish meal (25%) and soybean meal (30%) should meet all of the essential amino acid requirements of the fish, as well as the available phosphorus requirement (National Research Council, 1993). However, reduction of the fish meal in the diet should be considered for environmental and/or economic reasons. Most studies indicate that there is little or no benefit to using fish meal in vegetarian or omnivorous colossomid species diets. The fish meal in the broodstock diet could be reduced to 10% (with a concomitant increase in soybean meal) without creating any amino acid deficiencies. If fish meal is reduced, available phosphorus may become limiting and a supplement should be considered (there is no phosphorus in the swine premix).

Large juvenile *Piaractus brachypomus* are now at the aquaculture research facility in Pine Bluff, Arkansas. Preliminary feeding trials to bracket the dietary vitamin C and vitamin E requirements of this species are underway.

ANTICIPATED BENEFITS

Improving the nutritional status of colossomid broodstock should increase spawning success and possibly the quality of resulting fry. These changes would enhance the economic viability of commercial colossomid farming in Peru.

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