Development of Cost-Effective, High-Performance Feeds for Chinese Catfish *(Clarias fuscus)*

General Information

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$35,000

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Objectives

The overall goal of the proposed project is to improve production efficiency and increase the overall production of Chinese catfish statewide. This is to be achieved by improving the profitability of this enterprise by identifying the most cost effective commercial diet for use in the culture of this species.

Project Objectives

1. Conduct a thorough literature review of the nutritional requirements of *Clarias fuscus* and other species with similar biological requirements.
2. Based on the literature review, develop and recommend different practical feed formulations for *Clarias fuscus* for subsequent testing and evaluation.
3. Conduct an experimental feeding trial to compare current commercially available feeds with the new feed formulations.
4. Conduct a thorough analysis of the results of the feeding trial from a nutritional, production, and economic standpoint.

Principal Accomplishments

Objective 1: Conduct a thorough literature review of the nutritional requirements of Clarias fuscus *and other species with similar biological requirements.*

With the assistance of Lois Cain and Carol Hasegawa through the PRAISE program, a literature search for the existing literature of Chinese catfish and its relatives has been completed and reviewed. In summary, of the 27 manuscripts and articles found no information was found regarding the protein and fat requirements for the target species, *Clarias fuscus*. The reports that were found focused mainly on feeding frequency and comparison of growth between different culture facilities and between diploid or triploid individuals. There was one reference found that addressed protein requirements in other *Clarias* species (e.g., *C. batrachus*) that indicated a diet containing 30% crude protein resulted in optimal growth (Chuapoehuk 1987). This, however, is contradictory to the preliminary evidence the project work group had obtained and it would appear that direct testing with *Clarias fuscus* will be necessary to obtain the desired outcome.

The species grouped within the genus have been described as being a piscivore, carnivore, and ominivore in several reports. In the wild, *Clarias* feed on micro-crustaceans, insects, and their larvae. Crustaceans and fish flesh have been reported to apparently be their choice food and also helps in their gonadal maturation (Debabrat et al. 1999). They clearly can consume almost any feed material (e.g., trash fish, poultry viscera, kitchen refuse, soybean cake) that is offered and one of the reasons they have been so attractive for culture activities.

What was found for the target species and what needs to be taken into consideration in addition to the nutrient content of the feeds used was that the feeding regimen could significantly impact the rate of

growth and survival of Chinese catfish. For example, using an automated means of measuring several parameters (e.g., light intensity, temperature, barometric pressure, etc.) and using a demand feeder it was clearly illustrated that the Chinese catfish exhibits two peaks in its daily feeding patterns (Fast et al. 1997). The peaks were coincident with dawn and dusk and was observed for both triploid or diploid individuals. Those observations are consistent with results obtained by Burma and Diana (1994) where the feeding frequency provided to Chinese catfish was shown to have a significant impact on growth and survival. Essentially multiple feedings in a day resulted in a significantly faster rate of growth versus a single feeding of the same ration per day. The results indicate the limiting factor being the rate of assimilating nutrients from the diets presented. In their culminating experiment fish fed two meals to satiation per day grew 47% faster than those given only one satiation meal and therefore feeding strategy in addition to nutritional requirements must also be considered in the culture of Chinese catfish.

Objective 2: Based on the literature review, develop and recommend different practical feed formulations for Clarias fuscus *for subsequent testing and evaluation.*

Producing test diets consisting of 50% crude protein and varying the fat content (e.g., 5%, 10%, 20%) was considered with the collaborative efforts of Warren Dominy, Ph.D., at the Oceanic Institute. However, manpower and budgetary constraints prevented pursuing that approach and use of already available commercial diets was decided to be the best alternative means of addressing the objective and goals of the project.

To gain insight into what the nutrient requirements of Chinese catfish might be a baseline proximate analyses was done on wild caught individuals (n=2 from Kaneohe Stream). For comparative purposes two cultured individuals of approximately the same size (250 g body weight) were also subjected to the analyses. Likewise, four of the currently available Silver Cup commercial feeds produced by Nelson and Sons Inc., were also subjected to the same analyses done by the Diagnostic Laboratories at the University of Hawaii at Manoa. The use of Nelson and Sons' Silver Cup in this study is not an endorsement of the product and the data is summarized in Table 1 in this report's Appendix section.

Major differences in crude ash, protein and fat were detected between wild and cultured individuals, although this is not an unexpected result. The fat content is notoriously elevated in a variety of cultured fishes and ultimately deflates the crude protein and ash levels. The amount of crude fat found in the wild caught specimens (e.g., 21.9%) is relatively high in comparison to other fishes and should therefore be of consideration when choosing an appropriate commercial diet. Also interesting to note is that there are only a few differences in the mineral content of both wild and cultured individuals and commercial feed preparations apparently are well suited to be able to provide these amounts. There was a very noticeable difference in the iron content of the wild caught individuals and although all of the commercial diets apparently have suitable levels of iron in their mineral content it apparently does not transfer to the cultured individuals. The reason(s) for these observations go well beyond the scope of the current project and requires further investigation. In summary, from and ingredient standpoint all of the commercial diets appear to have all of the basic requirements needed for supporting growth and survival of Chinese catfish albeit in different proportions. The question remains as to which would be the most cost-effective feed for growing Chinese catfish and would require a side by side growth trial where the various diets can be compared.

Objective 3. Conduct an experimental feeding trial to compare current commercially available feeds with the new feed formulations.

Adult catfish were spawned during the reporting period and resulting larvae were to be grown up to be used for the trials to test the commercially available diets. The availability of first feeding catfish larvae provided an opportunity to investigate the ability of this species to utilize commercially available feeds in comparison to a live food organism (e.g., *Moina*). The experiment was conducted as described by Tamaru et al. (2003) and carried out for a duration of 10 days. The average percent survival of larvae provided with various commercially available diets and a live food organism is presented in Figure 1. There were three commercial larval diets investigated and they were Encapsulon III from Argent Chemical Company ($7.21/lb), Salmon Starter from Nelson and Sons' Silver Cup ($1.10/lb), and Hikari Larval Diet from Aquatic Ecosystems Inc. ($12.50/lb). No significant differences in survival were found among the various feed items presented to the first feeding catfish larvae. Based solely on survival, the results clearly indicate that first feeding Chinese catfish larvae are able to utilize a variety of commercial diets as an initial feed item and consistent with what has been reported in the literature for *Clarias gariepinus* (Verreth et al. 1993). The individual body weights from each of the replicate tanks from each treatment were determined and the data summarized in Figure 2. Larvae that were provided the live food organism were significantly larger than those that were provided the commercial diets. There were no statistical differences between growth between the three commercial diets used for the first feeding larvae. The data obtained are also consistent with the practice of presenting first feeding *Clarias gariepinus* larvae with live food for the first few days post hatching and then switching to a dry diet. When this particular species switches from utilizing its yolk supply to exogenous feeding the larvae exhibits an advanced digestive system that is capable of nutrient adsorbtion but lacks a stomach and pepsin digestion and may not be fully able to digest commercially prepared diets (Verreth et al. 1987; 1993). It has also been reported that during this early developmental period the response by the digestive enzymes when presented larvae with artificial diets is similar to that of a starved larvae indicating that the developmental sequence of events has also been altered as the larvae adapts to a different kind of food stuff than what it would normally encounter (Segner and Verreth 1995).

In summary, based on survival and growth the best treatment for first feeding Chinese catfish larvae would be the live food *Moina* during the period when larvae start their exogenous feeding. More than likely *Moina* could be substituted with *Artemia* nauplii as practiced previously and reported in the literature for other *Clarias* species (Segner and Verreth 1995). While the growth of Chinese catfish larvae is lower than that when using live feeds, it is also clear that they will survive and grow on dry diets without the use of live food organisms. Among the commercial diets examined the salmon starter from Nelson and Sons' Silver Cup is the least expensive @ $1.10/lb and would be a suitable recommendation for use by Hawaii's growers.

A side by side growth trial was attempted during the reporting period but was terminated prematurely due to poor survival in the majority of the experimental tanks. Low water temperatures experienced during the November–December is thought to have contributed to the poor survival as the experiments were being conducted in 60-gallon tanks.

A laboratory-scale (12 x 10 gallon aquaria) was conducted by students of the Department of Molecular Biosciences and Bioengineering as part of their undergraduate requirements and on the University of

Hawaii Manoa Campus. The work was supervised by Harry Ako, Ph.D. Each tank was stocked with four individuals (average body weight 12 grams) and were provided with four different commercially available diets. Each treatment (e.g., diet) was triplicated and the duration of the growth trial was for one month. Commercial diets that were examined were Nelson and Sons' Silver Cup trout, flounder and catfish diets. The fourth diet examined was Moore Clark's marine grower which is currently used for culture of the Pacific Threadfin and has been investigated previously for use in freshwater ornamental fish culture (Ako and Tamaru 1999). The results of the activities were summarized in a presentation made at the19th Annual CTAHR Student Research Symposium. April 5–6, 2007. Laboratory-scale trials allow for a closer examination of certain parameters and the investigation would also take into account feed intake which in turn could be used as a measure of feed palatability. No significant differences were observed in survival for the different treatment. There were, however, significant differences in many indices revolving around growth and they are summarized in Table 2.

The proximate crude protein and fat levels of the four commercial diets tested are presented in Table 1 along with the final body weight for reach of the treatments. Because of the small scale of the experiment the results from each of the triplicates had to be pooled to obtain the reported values. None the less there is a clear difference in the growth obtained between fish fed catfish feed versus the other three diets used. The fish provided the marine grower diet were found to be the largest at the end of the experiment and is consistent with what has been observed previously with other freshwater ornamental fish species (Ako and Tamaru 1999).

Objective 4. Conduct a thorough analysis of the results of the feeding trial from a nutritional, production and economic standpoint.

From a production and economic standpoint there are many other considerations that need to be taken into account to make a particular recommendation as to what is the best feed to be used for growing Chinese catfish. In Table 2, there are other indices used to characterize which food item would be the best to use. While the catfish diet is the least expensive of all of the diets tested its poor performance in overall growth (e.g., lowest daily growth rate), highest FCR (most food to be converted into fish) equates to a relatively high ranking (No. 3) in estimated feed cost(s) to produce a kg of Chinese catfish. It should be noted that it is still less than that of the marine grower. However, the slow growth also further impacts the economic considerations of using catfish feed as the calculated grow-out time to reach market size is also the longest for the feeds examined adding on a significant labor cost to the overall enterprise budget. If catfish food was used the Chinese catfish would go to market approximately five months later than if any of the other feeds were to be used. Clearly, all of these indices strengthens the recommendation of not using catfish feed for growing out Chinese catfish even though the landed costs per bag are less than that for the other feeds.

The flounder diet was found to have the lowest FCR ratio indicating that of all the feeds examined it is the most efficient at converting feed into fish. This will obviously impact or translate into a cost savings as the flounder diet is not as expensive as the marine grower diet and when taking into account the resulting growth, FCR and cost of the feed, the flounder diet appears at this point to be the most cost-effective diet (e.g., $1.08 to achieve a kg of Chinese catfish produced). Interestingly, the second most cost-effective feed is the trout diet as it has a similar growth performance to that of flounder and the marine grower diets and has the added advantage of being the least expensive of those two other

feeds. In terms of the feed costs to produce a kg of Chinese catfish the trout diet is second (e.g., $1.28/kg Chinese catfish) and because it has a similar time element to attain market size the differences between trout and flounder diets begin to get less and less. As the testing was done at laboratory-scale clearly there is going to be a need to repeat the experiment at a larger scale to obtain statistical validity as well as a closer approximation to farm site conditions. Based on the preliminary results to date that all things considered it would appear that the flounder diet is the most cost-effective of the commercially available diets tested for growing out Chinese catfish in Hawaii.

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Impacts

None to date with the exception that the results obtained in the current project confirms the practices and recommendations that have been made to commercial producers of Chinese catfish in that the use of the catfish diet is not a recommended diet for growing out Chinese catfish in Hawaii.

Recommended Follow-Up Activities

The preliminary results obtained during student-lead research activities clearly need to be repeated and validated at a larger scale. Plans are underway for a larger scale trial to be conducted in the summer of 2007.

Publications in Print, Manuscripts, and Papers Presented

Ako, H., S. Morihara, H. Kane, K. Lee, and C. Kapono. 2007. Preliminary investigation of cost-effective feed for Chinese Catfish *Clarius fuscus.* Presentation made at the 19th Annual CTAHR Student Research Symposium, Honolulu.

Tamaru, C. S., D. .Bybee, H. Ako, S. Morihara, H. Kane, K. Lee, and C. Kapono. 2007. AquaTips: Preliminary findings in the determination of the most cost effective commercial diet for Chinese Catfish, *Clarias fuscus,* in Hawai'i. CTSA *Regional Notes* 18(2):4–5.

Appendix

TABLE 1. Summary of proximate analyses of Chinese catfish and assorted commercial feeds (Silver Cup). Values for catfish are the averages (n=2) and ash protein and fat values are in units of % dry weight. Minerals are in units of ppm.

Category	Cultured	Wild	Flounder	Trout	Steelhead	Catfish
dry matter						
ash	9.53	19.36	-	-	-	-
protein	48.80	60.67	50.98	42.12	47.28	36.27
fat	38.22	21.87	8.68	9.71	13.12	5.72
Minerals						
phosphorus	0.62	0.80	1.61	1.09	1.42	0.96
Potassium	0.23	0.25	0.50	0.85	0.81	1.02
Calcium	0.91	1.88	2.20	1.30	1.96	1.19
Magnesium	0.04	0.07	0.19	0.20	0.24	0.27
Sodium	0.13	0.18	0.44	0.51	0.61	0.21
boron	0.44	1.09	4.00	11.00	10.00	13.00
copper	1.50	3.00	22.00	12.00	11.00	13.00
iron	28.00	264.00	182.00	287.00	327.00	201.00
manganese	1.50	8.00	36.00	74.00	44.00	85.00
Molybdenum	n.d.	n.d.	n.d.	1.00	1.00	1.00
zinc	14.50	19.50	134.00	141.00	114.00	107.00
Selenium	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

TABLE 2. Summary of laboratory-scale comparison of commercial diets for growing Chinese catfish.

Feed Type	Protein %	Fat %	Final Mean BW (g)	FCR	$/kg Gained	Daily Growth (%)	Months to 400 g BW
Catfish	35	7	64.9	1.22	1.30	1.0	12.0
Trout	39	10	78.3	0.91	1.28	1.8	7.3
Flounder	49	10	80.4	0.75	1.08	2.0	6.8
M.Grower	49	14	86.4	0.95	1.80	2.1	6.3

FIGURE 1. Summary of percent survival of first-feeding Chinese catfish larvae presented various commercial diets and the live food item Moina. *Bars with ** are statistically different (P<0.01) from each other.*

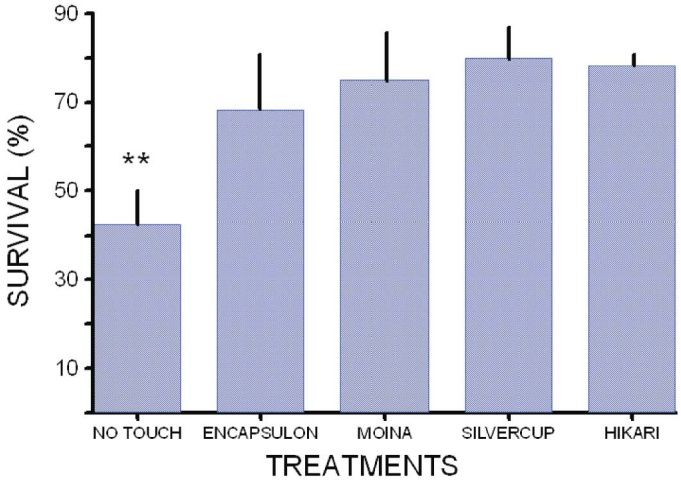

FIGURE 2. Summary of average body weight of Chinese catfish larvae provided a variety of commercial and live feeds. Bars that do not share an alphabet are statistically different (P<0.05) from each other.

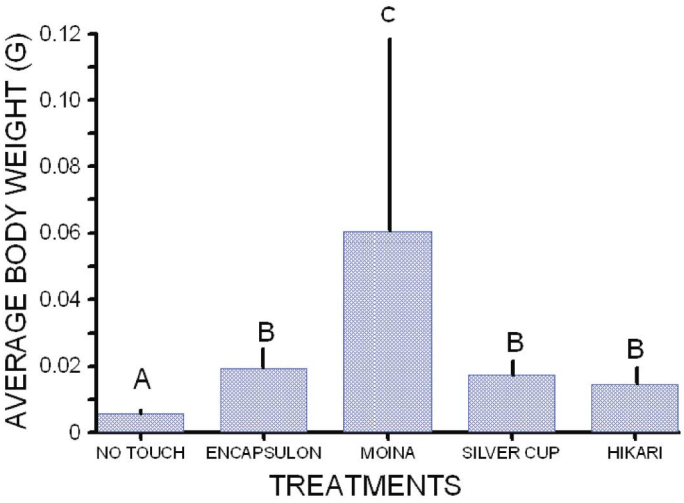

FIGURE 3. Chinese catfish, Clarias fuscus, *was the target species for this feeds project.*