

## 学位論文全文に代わる要約 Extended Summary in Lieu of Dissertation

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学位論文題目 : Use of insects meal as alternative protein sources for fish meal  
Title of Dissertation (魚粉代替タンパク源としての昆虫ミールの利用)

学位論文要約 :  
Dissertation Summary

Stable supply of feed ingredients and environmentally friendly rearing conditions are the two key factors in sustainable aquaculture development. Insect protein is attracting attention as a raw material for aquafeed, while their application to carp and eels is small. In this research, two insects protein namely mealworm and black soldier fly larvae were tested in carp, and applicability of dry feed and development of digestibility was investigated in eel. Since Japanese commercial eel feeds contain a large amount of fish meal (more than 60%), the reduction of the fish meal in the diet would result in a large impact. However, there is not enough information available on the development of the eel diet, these two basic research were conducted. Moreover, these experiments were conducted with conger eel, due to the difficult availability of Japanese eel as an experimental animal.

The results in chapter 2 showed although there were no significant differences ( $p < 0.05$ ) in the daily feeding rate among the treatments, fish fed the MWMD showed significantly lower weight gain, specific growth rate, and feed conversion rate than those fed the CONT ( $p < 0.05$ ). In contrast, these growth parameters did not differ significantly between fish fed the SBLD and CONT. The protein and lipid retention of fish fed the MWMD was significantly lower than that of fish fed the CONT or SBLD ( $p < 0.05$ ); however, there was no significant difference in nutrient retention between fish receiving the latter two treatments. The plasma components of fish did not differ significantly, with the exception of total protein, which differed significantly between MWMD- and SBLD-fed fish ( $p < 0.05$ ). In addition, at 8 h after feeding following the 3-day “refeeding” period, the plasma triglyceride level of fish fed the MWMD differed significantly from that of fish fed either the CONT or SBLD ( $p < 0.05$ ). In conclusion, 2% SBL supplementation in a diet containing 20% MWM reversed the adverse effects of the MWM diet.

The results in chapter 3 showed although there were no significant differences in daily feeding rate among the treatments, fish fed the DBSFLD and SBLD showed significantly lower specific growth and feed efficiency than those fed the CONT ( $p < 0.05$ ). In contrast, these growth parameters did not differ significantly between fish fed the SBLD and DBSFLD. There were no significant differences in the contents of moisture, crude protein, and crude fat of the whole body among fish groups ( $p > 0.05$ ). However, there were significant differences proximate compositions of all fish groups with those of initial fish body ( $p < 0.05$ ). There were no significant differences in protein retention among all fish groups ( $p > 0.05$ ). However, there were significant differences in lipid retention of SBL group and CONT group ( $p < 0.05$ ). The plasma content of triglyceride did not show significant differences among fish group ( $p > 0.05$ ). However, SBLD fed fish tended to have the lowest plasma TG level. In conclusion, SBL supplementation in DBSFL could not improve growth performance, plasma triglyceride, moreover it decreased lipid retention of the fish.

The results in chapter 4 showed that no statistically significant differences ( $p > 0.05$ ) were found between

the two dietary groups in terms of growth performance during the 6 weeks of feeding. After switching the diet, the fish fed the dry diet in this experiment had significantly lower feeding rates on the 1st and 2nd days of feeding than those fed the moist diet ( $p < 0.05$ ). The approximate time taken by the conger eels to ingest either of the feed was 30 s. In conclusion, we found no significant differences in growth performance resulting from the two dietary treatments of experiment 1, demonstrating that moist or dry diets are equally acceptable to conger eels.

Digestibility is one of the methods to evaluate the quality of ingredients. It is generally determined by two methods such as direct and indirect methods. To evaluate the nutritional quality and examine the effectiveness of direct and indirect methods, this present study was conducted to elucidate the effect of carboxymethylcellulose and wheat gluten on digestibility of Japanese conger eel (*Conger myriaster*) using direct and indirect methods.

The results in chapter 5 showed that the feces from fish fed WG 5% remained firm shape in the water and easily collected by siphon but that from WG 3% fed fish collapsed some parts, and that of CMC 5% fed fish was completely disconnected and became a powdered shape. The average apparent digestibility of dry matter by the indirect method as in the range of 42.4 to 66.1. The values of WG 3% and 5% were significantly higher than CMC 3% and 5%. The average apparent digestibility of dry matter by the direct method was in the range of 71.2 to 78.2, and there were no significant differences among the treatment. It was concluded from DM digestibility determined by a direct method that WG 3% and 5% is a better binder to diet for Anago compared to CMC 3% and 5%. The result from indicator (chromic oxide) determination in the feces revealed that the gap between the values from the two methods was due to the leaching of chromic oxide in the indirect method from feces rather than incomplete fecal retrieval in the direct method. Thus, the direct method can be applicable for digestibility study in Anguilliform.