学位論文内容の要旨

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学 位 論 文 題 目

Life history of Pacific rainbow smelt *Osmerus dentex* in Funka Bay, Japan
（噴火湾におけるキュウリウオ *Osmerus dentex* の生活史）

I. Introduction

Pacific rainbow smelt *Osmerus dentex* is one of the Osmeridae fishes distributed around Hokkaido Island, northern Japan. Recently, the natural resources of important commercial species of the family such as shishamo *Spirinchus lanceolatus* and capelin *Mallotus villosus* have been reported to decrease due to overfishing and destruction in living environment. The understanding about the biological and ecological features of *O. dentex* is needed not only to fulfilling lacks in the knowledges of the Osmeridae, but also for sustainable resource management of this this species, as well as the other species in the family. This thesis aims to clarify the growth process, feeding habits, and early survival process of *O. dentex* with ecological approaches for suitable fisheries management and future seed release.

II. Materials and methods

O. dentex were collected from T/S *Ushio-maru* (179 tons) of Faculty of Fisheries, Hokkaido University with two types of otter trawl nets in Funka Bay from December 2015 to May 2021. In addition, scoop net sampling was carried out at the mouth of the Yamazaki River in late April and mid-May in 2019. Samples were measured body sizes, sexed, weighed liver and gonads, and removed stomachs, scales, and otoliths. The reliability in age determination between scale and sagittal otolith was compared by evaluating the precision among three independent readers based on the percentage of agreement (PA), coefficient of variation (CV), and average percentage of error (APE). The growth models of fish were fitted with the Gompertz, logistic, von Bertalanffy, and Richard's growth equations; and the best fitted growth model was selected by using r^2 and AIC values. Feeding habit of *O. dentex* was assessed by analyzing the stomach content. The experiments were conducted to evaluate the effects of different temperatures (8, 10, 12 and 14°C) and salinities (0, 8, 16, 24 and 32) on hatching success and embryonic period of *O. dentex*. The experiment to evaluate the effects of different salinities (0, 8, 16, and 24) on the survival rate and the growth of *O. dentex* larvae until 15 days after hatchings (DAH) was also conducted.

III. Results and discussion

Annual increment on otolith was verified for growth analysis for *O. dentex* because otolith ageing was founded more reliable than scale ageing with less error among readers. The Gompertz growth equation was judged as the best fit model

for growth curves of *O. dentex* by r^2 and *AIC* values, however, there was little difference in goodness of fit among Gompertz, logistic, von Bertalanffy, and Richard's growth equations. The maximum age and body size of *O. dentex* in Funka Bay and the mouth part of the Yamazaki River were generally lower than those of *O. dentex* collected in the Beaufort Sea off Alaska, Norton Sound, and southeastern Chukchi Sea in the Arctic Ocean form other studies. The growth rate in Funka Bay was higher than other areas. The difference might be caused by latitudinal effects, food availability, and photoperiod between areas.

Ontogenetic shift in diet was detected in *O. dentex* in Funka Bay and the mouth part of the Yamazaki River. The smaller sized *O. dentex* (< 156 mm SL and 184 mm TL) fed mainly on Decapoda Natantia, Mysidacea, and Amphipoda Gammaridea, and the larger sized one (≥ 157 mm SL) fed mainly on Pisces (fishes such as Japanese anchovy *Engraulis japonicus,* walleye pollock *Gadus chalcogrammus* juveniles, and other three demersal fish juveniles). High percentages of empty stomachs in *O. dentex* in Funka Bay and the Yamazaki River (73% and 88% in the frequency of vacant stomachs, respectively) during spawning period (April-May) were presumed to be caused by low prey requirement during spawning season, the low abundance of walleye pollock juveniles in the environment and the fact that Japanese anchovy was not distributed at all in the low water temperature environment.

Embryos of *O. dentex* were successfully hatched at the temperature range of 8-14°C, and the salinity range of 0-16 but not in 32. The incubation period of embryos was affected by temperature (14-31 days at 8-14°C), but not by salinity in 0-24. The biological zero degree at which embryogenesis ceases was estimated to be 3.4°C, and the cumulative temperature unit was calculated to be 220 ± 25.6 day·°C. Early stage of *O. dentex* larvae of 15 days after hatching (DAH) obtained highest survival rate at rearing in 0-16 salinities, and the highest growth rates showed at 8 and 16. The osmoregulation organ systems in early larval stages might be still not sufficiently developed to encounter osmoregulatory stress in a high salinity environment, and hence, cause mortality. It is suggested that an acclimation in *O. dentex* larvae is necessary for survival the larvae into brackish water (may be into estuary and coastal area) until 15 DAH at least.

The noticeable characteristic of *O. dentex* is larger body size than the other five species of Osmeridae distributed around Hokkaido, and the maximum size of *O. dentex* is 1.5–2 fold larger than the others. With the regarding to the feeding habits, *O. dentex* is the only species that fed mainly on fishes, and this feature is probably the reason causing the prominent size of *O. dentex*. It is interesting that *O. dentex* is mostly absent or rare in the western and northern sides of Hokkaido. Funka Bay has a maximum depth of 98 m and a greater area of shallow water (70 m or less) than other water areas in Hokkaido, and this geographical feature may be suitable for *O. dentex*.