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学 位 論 文 要 旨

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題目: An Ecological Study of Caves in Western Japan,
with Special Reference to Their Ecosystem Structures
（西日本の洞窟の生態学的研究、特にそれらの生態系構造について）

Recently, the researches on the cave ecosystem has progressed associated with steady development of biospeleology. These studies are mainly conducted in some continental limestone caves in Europe and North America, while not active yet in other regions of the world including Japan. Cave ecosystems should provide an excellent model for some ecological principles due to its simplicity. To progress the cave ecosystem ecology, I have studied some Japanease caves, mainly a small lava cave, Ryûkei-dô Cave in Shimane Prefecture.

In Chapter 1, I describe the results of monitoring for 30 months in Ryûkei-dô Cave dealt with three populations of representative cave animals, Symphyla, collembolan, and amphipod. Relationships between the annual fluctuations of animal densities and those of environmental factors were analyzed by multiple regressions. Responses to environmental factors were different in each population showing heterogeneity. The fluctuation of Symphyla showed a high correlation with epigean air temperature, while other two were found throughout year with slight seasonal changes. Although the change in population density of collembolan did not show any trend, but that of amphipod increased when ambient water was cooler with increased nutrients.

In Chapter 2, among heterogeneous cave animals, lifecycle trends in one representative species were pursued to understand biology of cave animals. A population of the cave beetles, *Trechiama yokoyamai*, was studied using mark-recapture method in Oni-no-Iwaya Cave (a limestone cave in Taisyaku-kyo, Japan). They revealed an evident microhabitat shift within the cave; distributed the entire cave in summer, while aggregated in some limited areas in winter, despite that population density was nearly stable, 0.3-0.6 individuals/m^2 throughout

the year. The males were less mobile than females, and tended to stay near the aggregation sites even in active seasons. Due to the sexual difference in mobility, sex ratio could not be determined precisely, changed by season between 0.25-0.43 in male ratio. Tenerals appeared once a year, during September to January with a peak in October. From teneral ratio in adult population, the longevity of the beetle estimated to be a few years. The beetle preferred wet and mid temperature zone, and found often in water. Although food habit is still unclear, the local abundance of the beetles suggested that they depended on bat guano and that they cohabited with actinomycete colonies.

In Chapter 3, carbon cycle of an ecosystem was evaluated in aforementioned Ryûkei-dô Cave. Total organic carbons in each components of the ecosystem were determined, distinguishing microbial carbon and the others. The extremely poor animal community was observed in the cave. A relatively large amount of stocks despite of very small flows were recognized. Almost all of input carbon was derived from dripping water (20 g-C/month), and the carbon was partly deposited on wall (5.2 Kg-C), and in floor mud (116 Kg-C). Pool water retained 6.5 g-C in monthly average. Microflora amounted to be 0.8 Kg-C on wall, most of which was Actinomycete, and 0.7 Kg-C in floor mud consisting of various bacteria. Animals contained only carbon of 1 mg order in monthly average. Dynamics of organic carbon and nitrogen in ambient strata above Ryûkei-dô Cave were also pursued as described in Additional note 1, in which rapid decrease of organic nitrogen was disclosed.

To estimate trophic links within ecosystems, stable isotope ratios of carbon and nitrogen were analyzed as for species in Ryûkei-dô Cave and Oni-no-Iwaya Cave (Additional note 2). All four cave ecosystems so far analyzed stable isotope ratios in the world including the present two revealed the occurrence of two nutritive bases in the cave ecosystems. Troglobiotic nutritive base consisted of chemoautotrophs and/or Actinomycetes with -35‰ in $\delta^{13}C$ ratio. Another troglophilious one was debris of epigeal-origin organic matters with -25 to -20‰ in $\delta^{13}C$ ratio. The cave animal communities were formed on either/both nutritive base(s), respectively, with components being common/uncommon species between the two bases. A hypothesis is proposed to interpret the variation in cave ecosystems, as a chronological succession mainly associated with gradual increase of troglophilious nutritive base.