論文内容の要旨

論文題目 **Cave ecology in the Philippines, a conservation perspective: linking surface and subsurface ecosystems**
(フィリピンの洞窟における保全的視点からの生態研究：地上生態系と地下生態系の連結)

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Caves in the Philippines are understudied despite the high susceptibility of its environment to human disturbance. This is of particular importance as caves are known to contain unique and poorly understood fauna. The purpose of this study is to explain the importance and dynamics of the underground ecosystem by determining the factors that relate the surface and subsurface ecosystem. The following are the objectives of this study: (1) to know the diversity of cavernicolous crabs in the Philippines; (2) to determine the phylogeny and history of migration of cave animals; (3) to characterize and evaluate the present condition of cave aquatic environment; (4) to understand the trophic dynamics of the cave ecosystem; and (5) to integrate the results in the context of their use in the conservation of caves and their inhabitants.

Caves from 26 islands in the Philippines were intensively investigated. Cavernicolous crabs were collected for taxonomic identification and as model organism for this study. Tissue samples of freshwater crab genus *Sundathelphusa* were isolated for mitochondrial DNA analysis to construct their phylogeny. Ion chromatography was used to analyze major ions from the groundwater while other physico-chemical parameters were measured *in situ* to characterize the quality of the cave aquatic environment. $\delta^{13}C$ and $\delta^{15}N$ stable isotope signatures of various samples of animals and organic materials from freshwater and anchialine caves were analyzed using mass spectrometer to determine the cave's trophic dynamics and sources of nutrients. In addition, human-induced disturbances were also identified and documented from the study sites.

A total of 23 species of crabs in five families representing five genera were identified inhabiting the subterranean habitats (anchialine and freshwater caves), five of them are new. This clearly demonstrated that many cave animals are waiting to be discovered and is more diverse than expected. It also suggests that underground ecosystems are very important refuge, breeding ground and/or habitat of animals.

Mitochondrial DNA sequences of the large subunit rRNA (16S rRNA) revealed multiple colonizations of caves by the *Sundathelphusa* species as well as the phylogenetic relationship within this genus. Its congeners inhabit a wide range of habitats, ranging from epigean to hypogean domain. This clearly suggests that each cave species is unique and endemism is high, and therefore, habitat protection is very important.

Analyses and characterization of the physico-chemical parameters of groundwater revealed high concentrations of nitrite in caves in Panglao, Bohol. This contamination is mainly coming from anthropogenic sources. The high concentration of contaminants in its groundwater could only be attributed to the resort facilities and domestic sources. Groundwater quality from other cave localities were noticeably high and seem to be in excellent condition since they are isolated from human settlements. This strongly suggests that human activities play a very important role in the fate of cave and quality of groundwater ecosystems.

Stable isotope analysis elucidates the diet and trophic levels of species inhabiting the subterranean habitat, both in freshwater and anchialine caves. The $\delta^{13}C$ and $\delta^{15}N$ signatures explained the trophic dynamics and nutrient source in caves. The troglobitic fish, *Caecogobius cryptophthalmus*, is the top predator among the fauna in the freshwater cave, preying on the juveniles and carcasses of the crabs. The bats foraging on the surface habitat supply the nutrients and food at the base of the trophic structure while using the cave as their shelter and breeding ground. For anchialine cave, the false spider crab occupied the top of the trophic level but the stable isotope analysis did not reveal its diet. However the structure of the chelipeds having brush-like setae may suggest that they are feeding on the epilithic biofilm (bacteria) or detritus materials.

Results had clearly suggested a strong link between the surface and the subterranean ecosystems. The rich assemblage of unique cave animals, having limited geographic range and reduced dispersal ability, and the nutrient and chemical pathways are the key elements that connect the two systems. And yet these ecosystems are vulnerable to anthropogenic disturbances.

Further research is highly suggested and recommended to better understand the ecology of caves, document their biodiversity and focus on reducing human threats and surface-level habitat degradation, particularly contaminants that may enter the caves, as well as protection of both above and underground ecosystems.