

別紙 4

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主 論 文 の 要 旨

論文題目

Multiple stressors on anurans: effects of spatial and local factors in Aichi Prefecture, central Japan

(カエル類への複合的ストレス：愛知県における空間及び局所要因の影響)

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論 文 内 容 の 要 旨

This dissertation clarifies the interspecific differences in the distribution of anurans (frogs) in central Aichi Prefecture, that of influential environmental variables, and that of susceptibility to human activity using Generalized Linear Models (GLMs), thereby proposing fundamentals and methods to protect frogs. This dissertation is organized five chapters.

In chapter 1, I reviewed the research progress on the population decline of amphibians in the world. Then the characteristic in Japan was discussed. Many species of frogs use paddy fields as breeding sites. In these years, land consolidation of paddy field, urbanization, and loss of wetland condition by abandonment of cultivation threaten frogs. These stressors must have combined effects, and the extent of the effect varies by environment and species. However, previous studies have rarely compared species differences in the effects of multiple spatial scales. Thus, the main objectives of this dissertation are: (1) to clarify the distribution

and population status of frogs in the study regions; (2) to examine the linkages between the distribution of frogs and environmental stressors, and (3) to separate the effects of spatial and local factors; (4) to clarify how the midsummer drainage and drainage system modernization impact on the tadpoles. I listed the target species and study area of the present study. Finally, the framework for this dissertation was provided.

In chapter 2, I examined the breeding distribution of three frog species, *Rana japonica*, *Rana ornativentris*, and *Bufo japonicus formosus*, along the ecological gradient from urban to mountain areas. Amphibian declines are caused by multiple stressors at spatial and local levels, resulting in habitat loss, fragmentation, splits, and degradation. However, the combined effects of different spatial scales on the amphibian declines are unknown. During early spring, the breeding season of these species, only a few paddy fields are filled with water. Such hydrological conditions in the non-flooded season may influence the spawning of these three species. The number of egg masses, and spatial and local variables were collected at 124 sites in Toyota City, Okazaki City, and Shitara Town, central Japan. The variables that explain the number of egg masses were examined by GLM. The best model that has the lowest value of the Akaike Information Criteria (AIC) was obtained using spatial variables at a 500-m-radius buffer for all three species. The number of egg masses increased by increasing forest area in all three species. However, other variables affect differently for three species. The egg-mass number of *R. japonica* was positively affected by elevation difference and negatively by elevation. That of *R. ornativentris* was positively affected by the abandoned paddy-field. That of *B. japonicus formosus* was positively affected by the residential region with much vegetation area and negatively by elevation difference. At the local scale, the water area affected positively, and the percentage of concrete revetment affected negatively in all three species.

These results clarified the differences of the suitable habitats among three species, as well as the use of concrete revetment on banks of paddy fields, had substantial adverse effects on the breeding of these species.

In chapter 3, I examined the spatial and local factors that affect the distributions of *Rhacophorus schlegelii* and *Rhacophorus arboreus*, along the ecological gradient ranging from paddy-dominated plains to forest-dominated mountains (located in Toyota, Okazaki, and Shinshiro). These two species belong to the same genus and lay their eggs in foam nests. However, their distributions are different. The effects of the factors on the distribution of two tree-frogs were investigated using GLMs. The best models evaluated by AIC were obtained at 250-m-radius buffer for *R. schlegelii* and 500-m-radius buffer for *R. arboreus*. The forest area affected positively for both two species. The elevation difference affected positively, and the total road density affected negatively on the distribution of *R. schlegelii*. *R. arboreus* was affected positively by elevation and paddy-field area. *R. schlegelii* was recorded significantly more frequent in the paddy fields than ponds ($P = 0.0278$), whereas *R. arboreus* was recorded almost the same proportion between paddy fields and ponds ($P = 0.4176$). At the local level, *R. schlegelii* displayed positive relationships with the presence of trees and the proportion of embankment vegetation.

These results clarified differences in the environmental conditions needed for two species. Because *R. schlegelii* is distributed in the urbanized area of lower elevation, it requires trees on the local scale and be suffered from the overcrowded road. On the other hand, *R. arboreus* is distributed in the mountainous area where the water body is scarce and is affected by the presence of paddy fields

In chapter 4, I focused on the tadpole of *R. arboreus* that breeds in summer. Impacts of midsummer drainage and drainage system modernization on tadpoles of this species were

investigated by field surveys, which were conducted in paddy fields in Toyota City. The results showed that the tadpole survival was negatively affected by the midsummer drainage and intermediate-style drainage system.

In chapter 5, I discussed the main results and summarized the conclusions. This study shows a clear relationship between the distribution of five frog species and the environment variables with landscape and local scales. The most influential spatial scale was 250-m-radius for *R. schlegelii* and 500-m-radius for the other four species. This means that environmental conditions at least 1000 m area should be considered to protect these species. This conclusion is supported by previous studies that pointed out that isolation of habitats results in the decline and extinction of frogs. At the local scale, the percentage of concrete revetment affected negatively in four species other than *R. arboreus* that lay their eggs on a tree, and *R. arboreus* was susceptible to the water control in paddy fields. We should pay more attention to interspecies differences in susceptibility to human activities.