Invasion risk assessment of Chinese mitten crab in Japan

［課程博士・論文博士共通］

博士学位論文内容要旨
Abstract

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論文題目 Title	Invasion risk assessment of Chinese mitten crab in Japan チュウゴクモクズガニの日本への侵入リスクに関する研究		

The Chinese mitten crab *Eriocheir sinensis* (H. Milne Edwards, 1853), is an important aquaculture species natively distributed in eastern Asia. This species, however, has been regarded as a notorious invasive alien species outside its native range and successfully established populations in some European countries and North America. The invasion of Chinese mitten crab has caused substantial ecological and economic damage in recipient ecosystems. For instance, *E. sinensis* may compete with or predate on native species; more recently, this species was found to be a carrier of the crayfish plague pathogen and might infect native crayfish species. Chinese mitten crab is a catadromous species, which grows in rivers and migrates to estuarine environment for reproduction. This complex life cycle makes it difficult for people to understand its population dynamics and develop effective eradication strategies. *E. sinensis* has also been designated as an invasive species in Japan and two adult specimens were recently found in Tokyo Bay. Despite this fact, live Chinese mitten crabs are imported from China to Japan for human consumption every year. In 2017, about 87 tons of *E. sinensis* were imported to Japan with a value of approximately 320 million JPY. This invasive species is believed to have negative impact on Japanese ecosystems, such as competition with or predation on native species; thus far, however, no study has been performed to explore the potential ecological impact of *E. sinensis* on native Japanese species, especially on its congener Japanese mitten crab *Eriocheir japonica*. The objectives of this study were to analyze the population dynamics of Chinese mitten crab by a matrix population model approach and examine its possible interactions with native *E. japonica* under laboratory conditions.

In the first chapter, I constructed a periodic matrix population model for *E. sinensis* based on published information about its life history. The life cycle of this species was divided into two seasons: summer and winter and each season contained three stages. Transition probabilities during summer and winter were estimated based on previous studies. An elasticity analysis was performed to identify the most import parameters in regulating population growth of Chinese mitten crab. Model simulation results suggested that population growth of *E. sinensis* in suitable habitat would be larger than 1 and reproductive values of this species increased with developmental stage. The results of elasticity analysis suggested that water temperature and mortality rate during larval development contribute most to population growth. Therefore, the larval stage is the most critical in the life history of Chinese mitten crab and the estuarine environment deserves more attention when evaluating its future invasion risk because this is the habitat in which larvae occur. The modeling also suggested that considerable long-term efforts are required to eradicate this pest once it becomes established, which highlights the importance of taking control measures at the early stages of invasion.

In the second chapter, I examined shelter competition between invasive *E. sinensis* and native *E. japonica* under laboratory conditions. Only male individuals were used to eliminate the effect of sex differences. Shelter competition trials were conducted in pairs of one adult native and one adult invasive crab in different size combinations. A resident-intruder model was used in this experiment and interactions between the two opponents were registered by a drive recorder. Crab behaviour frequency and fight duration were analyzed. My

results suggested competition between the two species was size-dependent: *E. japonica* always successfully defended shelter when competing with size-matched or slightly larger *E. sinensis*; *E. sinensis* only evicted *E. japonica* from shelter when its size was 1.1 times larger than that of *E. japonica*. The two species exhibited different behavioural patterns: compared with *E. sinensis*, *E. japonica* frequently displayed positive behaviour (approach, walking leg contact, chela contact) and seldomly displayed negative behaviour (retreat). Fight duration reached maximum when two opponents had a similar probability of wining. My results highlight the important role of strong native competitors in controlling invasion success, and invasive *E. sinensis* may be unlikely to exclude native *E. japonica* from its habitat by direct competition for shelter.

In the third chapter, I investigated the potential predatory impacts of invasive *E. sinensis* on native *E. japonica*. To achieve this goal, I first studied the cannibalism patterns in native *E. japonica* and then compared cannibalism with the intensity of predation by invasive *E. sinensis* on juvenile *E. japonica*. In cannibalism experiments, I examined the possibility of cannibalism in intermolt *E. japonica* in relation to predator–prey size difference, predator sex, prey density, and presence of alternative food and shelter under laboratory conditions. Predator crabs were starved for 48 h and then exposed to smaller conspecifics as prey for 24 h, after which the number of dead/injured prey was recorded. My results indicated that *E. japonica* cannibalizes conspecifics when the relative size difference between cannibal and victim becomes large. Males were more cannibalistic than females. The presence of alternative food and shelter effectively mitigated cannibalism. Based on these results, I hypothesize that the segregated distribution pattern of *E. japonica* along river courses may be an evolutionary adaptation to reduce intraspecific predation. In cannibalism and predation comparison experiment, adults of the two species were regarded as predators and they were fed before experiment. Each trial contained one predator and five juvenile *E. japonica*. The results suggested no significant difference was detected among treatments and all predators predated intensively on juvenile *E. japonica*.

Finally, the invasion risk of Chinese mitten crab in Japan was discussed on the basis of current results. In Japan, there are limited suitable estuarine environments for the larvae of *E. sinensis*. Around these estuaries, native Japanese mitten crab populations are already distributed. This competitively superior native species may act as a form of biotic resistance and prevent the establishment of invasive *E. sinensis* in Japan. But we should be cautious that invasive *E. sinensis* may adversely influence native *E. japonica* populations in other ways, such as pathogen transmission and hybridization. Further studies are required to address these issues. Several management strategies are proposed to control Chinese mitten crab in Japan. Strict management measures should be taken to prevent the escape of live *E. sinensis* from food market. In addition, appropriate ballast water management strategies should be developed to prevent the further introduction of larvae of this pest via ballast water discharge.