Rapid Communication

Current distribution of American bullfrog *Rana catesbeiana* Shaw, 1802 in the Republic of Korea

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Abstract

American bullfrog *Rana catesbeiana* Shaw, 1802 (= *Lithobates catesbeianus*) is one of the world's most problematic amphibians. In both 1957 and 1973, the species was introduced to the Republic of Korea, in order to be bred as a food resource. However, after breeding efforts failed, the breeders illegally released the frogs into the wild. Now, about 50 years later, the species is distributed throughout the nation. The aim of our study was to document the distribution of *R. catesbeiana* throughout the Republic of Korea by analyzing several nationwide surveys. The species was reported to occur at 2,716 sites, mainly along the southern and western coasts, but was rarely distributed in the northern part of Korea or along the eastern coast. Further studies are needed to elucidate the effect of *R. catesbeiana* on the native ecosystems.

Key words: introduced species, non-native species, amphibian, East Asia, South Korea

Introduction

The American bullfrog *Rana catesbeiana* Shaw, 1802 (= *Lithobates catesbeianus*) is one of the world's most widespread amphibian species (Lowe et al. 2000). The species is native to the United States, Canada, and Mexico. However, it has been introduced to many countries in Asia, Europe, and the Americas (Stumpel 1992; IUCN 2015; Laufer et al. 2018), where it threatens native species through competition (Moyle 1973), predation (Gobel et al. 2019), and spread of disease (Laufer et al. 2018; Yap et al. 2018). Adult *R. catesbeiana* grow to over 150 mm (Schroeder and Baskett 1968; Xuan et al. 2010) and usually produce more than 20,000 eggs per clutch. This species showed high dispersal ability, which the record of longest move-distance was 1,363 m (Ingram and Raney 1943; Schwalbe and Rosen 1999; Smith and Green 2005). The species is an opportunistic predator that eats a variety of smaller organisms such as frogs, insects, and even small turtles (Lee 2010; Schwalbe and Rosen 1988; Park et al. 2018). Therefore, the ecological and physical traits of *R. catesbeiana* allow it to successfully compete with endemic species.

In 1957, *Rana catesbeiana* was first introduced to the Jin-hae area of the Republic of Korea with the aim of increasing the income of farm households and providing an additional food resource for human populations (Oh and Hong 2007). In 1973, the species was also imported from Japan and was sold to farmers all over the country, including Jeju Island, which is the most southern part of the Korean peninsula (Oh and Hong 2007). Unfortunately, the introduction of the species failed to generate sufficient income, and as the species value as food decreased, because of changes in eating habits, many farmers illegally released the frogs into the wild. As a result, the species is now distributed over a considerably large area (Jang and Suh 2010; Kim 2010).

In order to better understand the global distribution of the species, the aim of the present study was to document the distribution of *R. catesbeiana* throughout the Republic of Korea. The study was based on the findings of national surveys. Observing the distribution of the species 50 years after its first introduction will provide an important basis for future studies of migration and diffusion in the Republic of Korea.

Materials

To determine the distribution of *Rana catesbeiana* throughout the Republic of Korea, data were collected from the results of several official nation-wide surveys, including the National Survey of Natural Resources from 2006 to 2012, the National Wetland Center Report from 2011 to 2017 and the National Institute of Ecology from 2015 to 2017 (Supplementary material Tables S1, S2). The surveys focused on the distribution of amphibians in Korea, and all surveys were conducted by experts on amphibians.

Results

The occurrence of *Rana catesbeiana* was recorded at 2,716 sites (Figure 1) and was mainly distributed along the western and southern coasts including large and small islands and in several inland areas. In contrast, the species was generally absent in the northern part (northernmost: 38.25100°N) of Korea and along the eastern coast (easternmost: 129.46973°E) (Figure 1).

Discussion

The data collected from the national surveys indicated that *Rana catesbeiana* is widely distributed in the Republic of Korea, including large and small islands, about 50 years after its initial introduction. In particular, humans introduced the species to be used as food resource in Jeju island (Oh and Hong 2007). However, there is no official record that the species was introduced to other islands, and we presumed that the species might be introduced by non-natural ways, because the islands are isolated by sea.

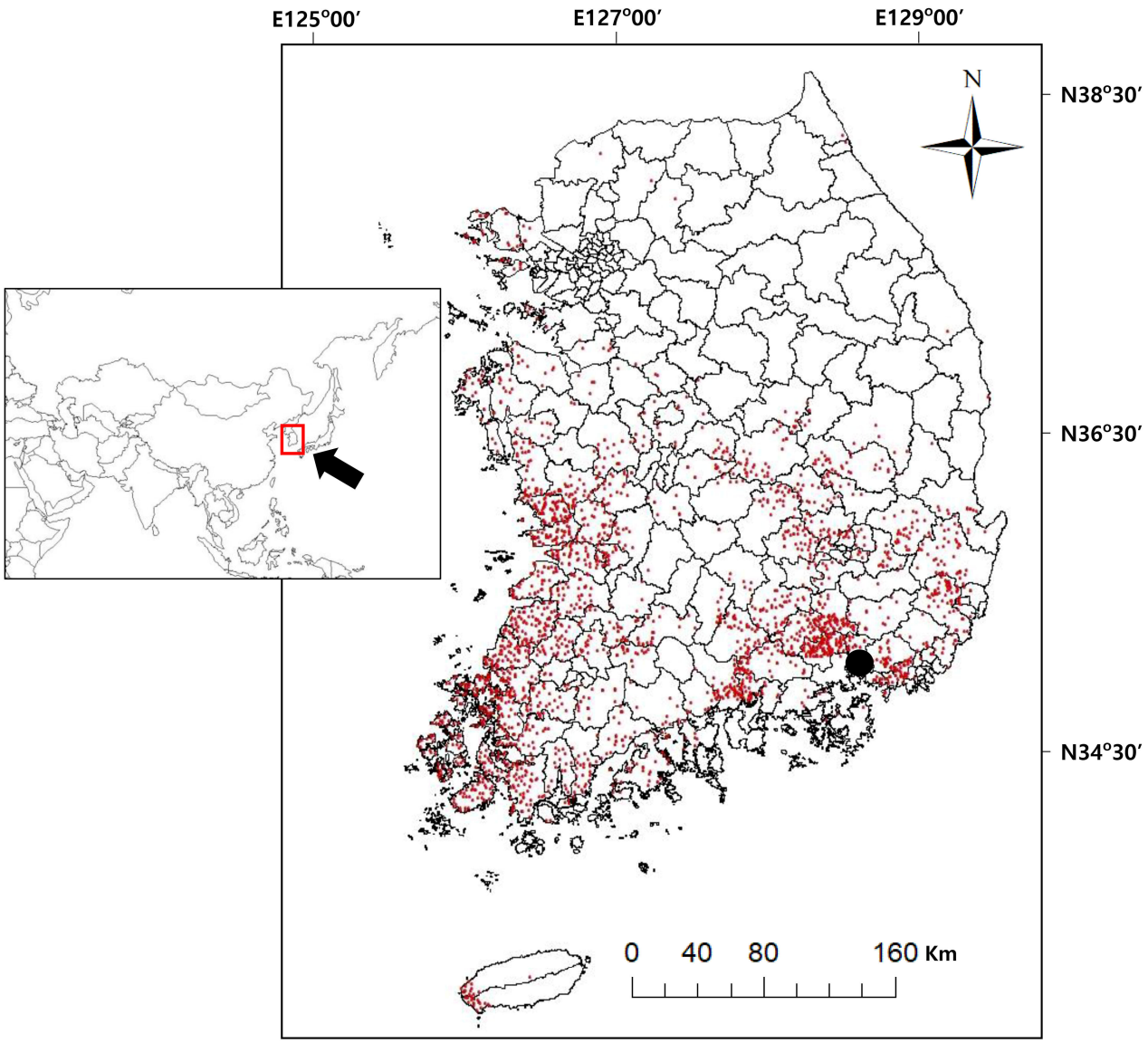

Figure 1. Distribution of *Rana catesbeiana* in the Republic of Korea. Red spots indicate confirmed occurrences. The black circle indicates the location to which the species was first imported in 1957. For details see Supplementary material Tables S1, S2.

Therefore, to understand the spread of non-native species, it is important to track how *R. catesbeiana* spread into the islands.

The introduction of *R. catesbeiana* to Korea has also contributed to the spread of disease to endemic species. Until recently, the most serious disease for amphibians has been chytridiomycosis, which is caused by *Batrachochytrium dendrobatidis*, and *R. catesbeiana* is known to serve as both a host and mediator (Daszak et al. 2004; Garner et al. 2006). In Korea, *B. dendrobatidis* has been isolated from the skin of several amphibians, including *R. catesbeiana* (Jeong et al. 2010). Although the effect of *B. dendrobatidis* to amphibians in North East Asia has been debated, *R. catesbeiana* can transmit the fungus to the endangered species *Dryophyts suweonensis* (Borzée et al. 2017). In addition to disease, a variety of endemic species have become food sources for *R. catesbeiana*, including the endangered species *Mauremys reevesii* (Lee 2010; Park et al. 2018).

The temperature of Korea is predicted to rise by about 5.5 °C in the near future (2071–2100; Boo et al. 2006). This climate change will also affect the distribution of *R. catesbeiana*. Thus, it is necessary to use species distribution models to investigate the effects of climate change on the migration and spread of *R. catesbeiana* (Yap et al. 2018; Koo et al. 2019).

It is difficult to evaluate and predict the effect by *R. catesbeiana* to the domestic ecosystem and species because we have only the distribution data of the species. Therefore, further studies such as food resources, relationship or competition with native species must be followed.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Distribution data for *Rana catesbeiana* in the Republic of Korea.
Table S2. References to Tabe S1.

This material is available as part of online article from:
http://www.reabic.net/journals/bir/2019/Supplements/BIR_2019_Kang_etal_SupplementaryTables.xlsx