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Designation of amphibian corridor referring to the frog's climbing ability

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ABSTRACT

In this study, we measured the body weight, body length, jump height, jump length, and climbing abilities of three species of frogs indigenous to Taiwan. The results were used to design an amphibian corridor suitable for amphibian mobility. Twenty specimens for each of the three species, *Rana adenopleura*,*Rana latouchii*, and *Kurixalus idiootocus*, were collected for testing. Their climbing ability on different matrix angles, materials, temperatures, and humidity were tested. The results showed that the jump height and jump length of the three frog species were in a descending order of *R. adenopleura* > *R. latouchii* > *K. idiootocus*. When tested in different climatic environments and climbing matrices, female frogs of all three species showed better climbing ability than that of male frogs. Generally speaking, the influence of climatic conditions on climbing ability was in a descending order of high temperature and high humidity > high temperature and low humidity > low temperature and high humidity > low temperature and low humidity. The steeper the matrix slope, the lower the climbing ability. The findings can provide useful reference for researchers of amphibian corridors in the future.

1. Introduction

Urban development and natural conservation in cities are competing issues (Yu et al., 2012). An ecological corridor is a type of ecological engineering, which aims to reduce the continuous disappearance of biological existence, reproduction, and migration, as resulted from the interference of human activities (Chen, 2011). The damages of environments due to human-induced overdevelopment have changed the biodiversity, abundance, and composition of the ecosystem (Kim and Byrne, 2006; Stenseth et al., 2002; Dirzo and Raven, 2003; Turner et al., 2004; Biesmeijer et al., 2006; Bin et al., 2014; Deyong et al., 2012). Alan et al. (2012) indicated that the ecological corridor could enhance biodiversity, but man-made facilities still affect habitat fragmentation. Transportation, road construction, and noise have negative impacts on environments, such as the road-kills of animals on the road, pollution in natural habitats, and population extinction (Bohemen, 1998; Zhang et al., 2010; Lin, 2006). Fahrig et al. (1995) argued that the globally increased traffic volume might indirectly reduce the amphibian population, especially in densely populated regions. In Taiwan's Alishan National Scenic Area, the concrete riverbanks for tourist safety have indeed fragmented the habitats of the organisms (Hou et al., 2010). Chen (2003) and Wang (2006) indicated that habitat fragmentation is one of the major causes of regional population extinction, thus, effective ecological corridors should be set to relieve this situation. Wang (2009) stressed the importance of enhancing urban greening and biodiversity, as well as building ecological corridors. Bergen et al. (2001) defined ecological engineering as an engineering mode that is developed in response to man-made development for the purpose of environmental protection. Therefore, the design of infrastructures should aim to mitigate the environmental impacts (Kuo, 2006). Ecological corridors are designed to guide organisms to safely move to another habitat, and prevent them from entering into hazardous areas, such construction sites or roads (Chang et al., 2013; Elsevier, 2012; Liu and Chen, 2008). On the same principle, the fish ladder helps fish migrate, thus alleviating the large dam barrier effect on the migration rate of fish (Adam et al., 2012; Christos and John, 2012; Peter and Giuseppe, 2012).

The amphibians play an important role in Taiwan's ecosystem (Lue, 1996; Hou et al., 2008). Yang (1999) found that *Rana adenopleura* is widely distributed in mountainous swamps and still water areas below 2000 m across Taiwan, especially in areas with flourishing hydrophyte. The difference between male and female frogs is slight. The average body length of male frogs is 6.5 cm,

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while that of female frogs is 6.5 cm. Yang (2010) and Xu (1991) reported that *Rana latouchii* is widely distributed over Taiwan's plains and mountainous areas of medium and low elevations, in stagnant pools with aquatic plants, and ditches and streams with slow flow. They also inhabit cities, and breed all year round. The difference between male and female is slight. The average body length of male frogs is 4.5 cm, and that of female frogs is 5.5 cm. According to Yang (1999), *Kurixalus idiootocus* is widely distributed in mountainous areas at medium and low elevations in the west of Taiwan.

Hou et al. (2010) and Chang et al. (2011) proposed the method for measuring the body weight, body length, and toe surface area of amphibians. Green and Carson (1988) used a tensiometer to measure the climbing ability of frogs on a glass matrix. Zhang (1989) used an electronic weighing scale to gauge body weight of *K. idiootocus*, and used a vernier caliper to measure its straightened body length. Hou et al. (2008) measured the jump height of frogs by coiling several 1 mm thick cardboards into paper tubes with an inner diameter of 5 cm and height of 5–20 cm, and placing the paper tubes at vertical intervals of 1 cm. *K. idiootocus* was placed in different tubes, and stimulated by Chinese silvergrass to jump. To measure the jump length, Hou et al. (2009a) placed *K. idiootocus* in a fixed position on a flat plate larger than 100 × 100 cm, and averaged five times of jump length. The results of this study provides useful information for the slope of the amphibious corridor based on the frogs climbing ability and provides landscape, architecture and ecological engineers to for construction and designation.

2. Materials and methods

2.1. Materials

2.1.1. Species selection

R. adenopleura, *R. latouchii*, and *K. idiootocus* are common found in the still water areas of mountainous areas at medium and low altitudes in Taiwan. These three species were selected for this study. *R. adenopleura* and *R. latouchii* were caught in the Taipei Wulai mountain area at longitude 121°564379 East, latitude 24°869492 North. *K. idiootocus* was caught in Yilan Changpi Lake at longitude 121°612202 East, latitude 24°645280 North.

2.1.2. Measuring instruments

The body lengths of the amphibians were measured by a vernier caliper. The measuring range was 100 mm/4″ and size was 118.2184″. The weights of amphibians were measured by an electronic scale in the unit of gram. The precision of the scale was 1/2000 and the size was 215 mm × 150 mm. The tape length was 5 m for measuring the jump length and jump height of amphibians.

2.1.3. Amphibian corridor

In this study, we proposed an amphibian corridor design that can maintain separation between the tourists on the riverbanks and the amphibians in water areas (Fig. 1(a)). The main structure is a steel pipes with a diameter of 3 cm, laid with 2 cm thick coconut fiber mat, and 2 cm thick soil. Hydrophyte is planted on the top, and a hinge is mounted between the bottom and the concrete banks, allowing the corridor angle to be adjustable with the water level (Fig. 1(b)). The latches and the corridor bottom are connected by nylon rope to limit the inclination of the corridor body. When the water level becomes too high in a torrential rain, a nylon rope is pulled and the latches are drawn out, thus automatically disconnecting the corridor from the concrete bank to form a floating island. The latches are restored when the water level resumes after the rain. Our future study will import the complete experimental data into the amphibian corridor design, thereby determining appropriate corridor angles and normalizing stopper length. Well-designed corridor can effectively conserve the migration of the ecological population (Fig. 1(c)).

2.2. Methods

2.2.1. Sampling mode and sample quantity

According to the on-site patch sampling, as proposed by Lue (1996), and according to the sampling mode of Chang et al. (2011) and Yu (1976), 20 samples were collected for each of three species, namely *R. adenopleura*, *R. latouchii*, and *K. idiootocus*. The samples were divided into male and female groups. Each group had 10 samples, totaling 60 samples. The experiment was completed within 14 days, and the frogs were released back to their original habitat.

2.2.2. Body weight and body length

According to Chang (2011) and Chang et al. (2013), the body weights of the frogs were measured by an electronic scale, and the snout–vent length was measured by a vernier caliper.

2.2.3. Jump height and jump length

According to Cadiergues et al. (2000), the frogs were confined to a paper-made space, with a diameter of 10 cm, height of 60 cm, and height scale mark of 1 cm. The frogs were stimulated by Chinese silvergrass to jump, and their jump heights were recorded. To

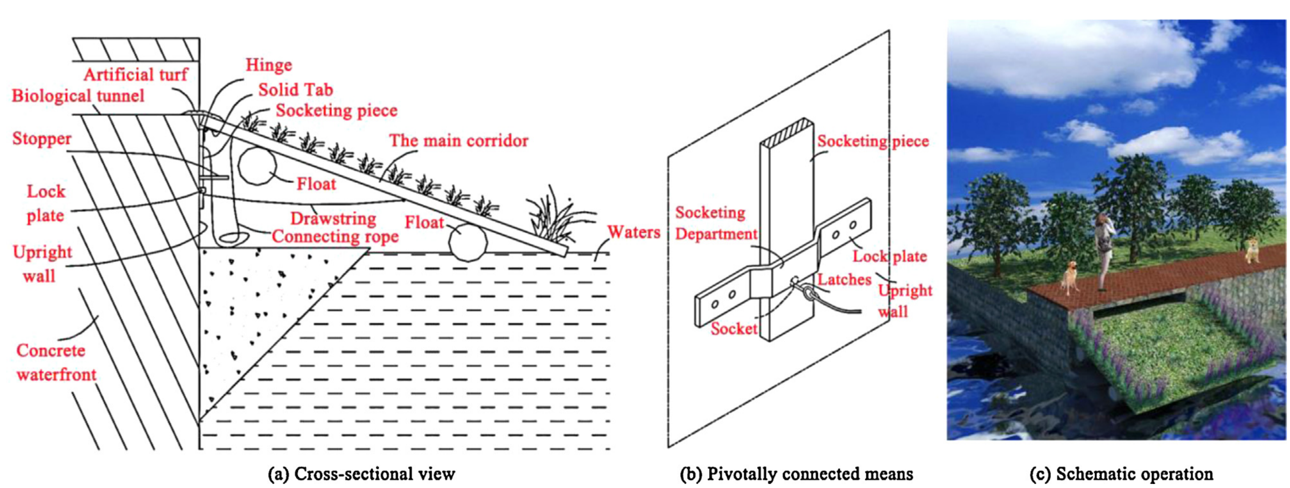

Fig. 1. The structure and material of amphibian corridor.