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Using ecological barriers for the conservation of frogs along roads

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ABSTRACT

Due to the fragmentation of biological habitats by road construction, a large population of frogs are killed by cars every year when they cross the roads to aquatic areas for spawning. Ecological barriers can guide frogs to the ecological corridor and cross the road without casualties. This study investigated the effectiveness of using ecological barriers in the conservation of native frogs, while barring exotic amphibian, *Polypedates megacephalus*. The height and slope adjustment of ecological barriers were also proposed for references. Samples of *Bufo melanostictus, Rana limnocharis, Rana guentheri*, and *Polypedates megacephalus* were collected to record their weights, body lengths, jump lengths, jump heights, barrier heights, and angles. According to the results on the barrier effect of the barriers, *P. megacephalus* and *R. guentheri* can jump at a distance of 30–40 cm from the barriers. *R. limnocharis* and *B. melanostictus* can jump at a distance of 5–15 cm from the barriers. Regarding the barriers angle for preventing crossing, *R. limnocharis* and *P. megacephalus* have no ability to cling at a 65° angle; *R. guentheri* has no ability to cling at a 90° angle, due to its huge body and lack of suckers. *B. melanostictus* has no ability to cling at a 25° angle, due to its strong toes and small body. The findings can serve as a reference for ecological conservation on amphibians and inhibition of the *P. megacephalus* population.

1. Introduction

Ecological engineering is an engineering practice developed for the conservation of natural environments, in response to human development and economic needs (Bergen et al., 2001). Human development has brought serious harms to many native environments, and changed the species composition, abundance, and biodiversity of the ecosystem (Kim and Byrne, 2006; Stenseth et al., 2002; Dirzo and Raven, 2003; Turner et al., 2004 and Biesmeijer et al., 2006). In order to alleviate the problems, infrastructure must reduce its ecological impact (Kuo, 2006). Many of existing ecological barriers are fixed installations, which are expensive and non-environmentally friendly. Yang (2005) suggested that the design of barriers should have fine wire mesh at the lower part and spacious wire mesh at the upper part, in order to prevent small animals from clinging and climbing.

Elsevier (2012) indicated that the purpose of setting ecological barriers is to prevent wild animals from entering a project area or road. As the public roads separate the animal habitats, ecological barriers can protect the surroundings of the habitat to prevent animals from entering the road or killed by vehicles, as well as to guide the animals to another habitat through the ecological corridor (Liu and Chen, 2008). Lin (2006) pointed out that road networks lead to the fragmentation of the habitat of native species, or even the extinction of the species. In Taiwan's Alishan National Scenic Area, for the safety of tourists, a concrete structure is set along both banks of the creek, which renders the living environment of animals in the fragmented habitat even more difficult (Hou et al., 2010). The competition between land development and ecological conservation in modern cities is an important issue (Yu et al., 2012). Bohemen (1998) and Zhang et al. (2010) mentioned that infrastructure is one of the major causes of the fragmentation of ecological environments. Road construction, noise and traffic disturbances have negative impacts on wildlife, can damage habitats, and even cause mortalities. Fahrig et al. (1995) argued that the increased volume of traffic around the world could indirectly lead to the decline of the amphibious population, in particular, in densely populated areas.

Taiwan's native frogs are anura frogs, which are distributed on various plains and in high-altitude areas (Lue, 2006). Amphibians play an important role in the ecosystem of Taiwan (Lue, 1996; Chen, 2003; Hou et al., 2008). Lue (1996) suggested that different species of amphibians prefer different aquatic qualities at the tadpole stage. Xie (1993) found that *Bufo melanostictus* of Bufonidae have distinctive gender differences, and proactively hug approaching objects to compete for a rare mating opportunity. The average male

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body length is 6 cm, and the average female body length is 7 cm. Chen (2003) stated that the female toad generally produces 4000–5000 eggs in the form of dual gelatinous egg strings. *Rana limnocharis* is widely distributed across Taiwan, in areas of elevation below 1500 m. They prefer to live at marshlands and paddy fields. The average body length of male frog is 4.3 cm, and that of female frog is 5.5 cm (Chen, 2003). Chen (2003) suggested that *Rana guentheri* prefers to live in a secluded area, and is widely distributed in rice paddies, ponds, and marshlands on level grounds and low-elevation hilly areas across Taiwan. The average body length of the male frog is 7 cm, and that of the female frog is 8 cm. It can produce about 3000 eggs each time. Wu et al. (2010) found that the reproduction period of *Polypedates megacephalus* is from March to August. The male and female frogs have significant differences in body shape and color. The SVL of the female *P. megacephalus* is 7.4 ± 0.9 cm and weight is 32.6 ± 9.1 g, which are both larger than the male frog at 5.0 ± 0.3 cm and 9.8 ± 3.6 g, respectively. Yang (2012) stated that most of the habitats of *P. megacephalus* are man-made environments, such as gardens, orchards, and parks of elevation below 570 m. In 2006, an exotic species was found proliferating in potted plants in Tianwei Township, Changhua County. The survival competition and hybrid problems between *P. megacephalus* and other frogs, such as the white-throated tree frog, led to the gradual loss and reduction of native species (Yang, 2012).

In amphibious biological experiments, Chang et al. (2011) and Hou et al. (2010) proposed methods to measure the weight, body length, and toe surface area of native amphibians. Green and Carson (1988) used a tension meter to measure the clinging ability of frogs on a glass substrate. Zhang (1989) used an electronic weight meter to measure the weight of *Chirixalus idiootocus* in the unit of gram, and measured its body length using a caliper after straightening its body. Hou et al. (2008) measured the jumping height of frogs by rolling a 1 mm cardboard into a paper tube, with an internal diameter of 5 cm and height of 5–20 cm. The paper tubes were of various heights, and at intervals of 1 cm. The *C. idiootocus* was placed inside different tubes and stimulated by miscanthus to jump. The jumping heights were thus measured. The jumping length was measured by placing the frog at a fixed position with a 100×100 cm plane board. Its jumping length was averaged from five jumps (Hou et al., 2009). Emerson and Diehl (1980) used wood, glass, Teflon, and leaves to observe the clinging ability of frogs, and changed the angles in a range of 1–180°. The upper limit of most tree frogs, in terms of clinging ability, is 105–135°. Hanna and Barnes (1991) measured the clinging ability of tree frogs by rotating glass and sandpaper at a speed of 4.8° per second. Bikerman (1971) proposed the relationship equations of relevant factors of the substrate and the frog's clinging ability.

So far, in Taiwan, there is no effective way to use ecological barriers for amphibian conservation or control the dispersion of *P. megacephalus*. This study investigated the effectiveness of using ecological barriers to prevent native frogs from crossing dangerous roads and separate native frogs from hybridizing with *P. megacephalus*. The results may provide an alternative way for ecological conservation instead of constructing major ecological projects or eradicating the exotic frogs.

2. Materials and methods

2.1. Materials

2.1.1. Sampling Species Selection

This study selected samples of *Bufo melanostictus*,*Rana limnocharis*, *Rana guentheri*, and exotic *Polypedates megacephalus* because their habitat is the same. Each species samples are 20, captured in the surrounding area (east longitude 23° 906,682 and north latitude 120° 534,015) of Mingdao University in Pitou Township and Tianwei Eco-leisure Farm (east longitude 23° 870,494 and north latitude 120° 494,721) in Tianwei Township, Changhua County.

2.1.2. Ecological barriers

The ecological barrier was made of aluminum, which is a rustproof and lightweight material (Tsai, 2000). The barrier consists of a supporting bracket, two aluminum frames, and four ball bearing slides. The bracket is 20 cm in length and 1.5 cm in thickness, and affixed in soil. The aluminum frame is 30 cm × 30 cm and 1.5 cm thick. The ball bearing slide is 30 cm in length, 4.4 cm in width, and 1.1 cm in thickness, and the length is adjustable. The three aluminum frames can be tightened by screws to form a drawer-like storage space (Fig. 1), which can be directly used (Fig. 2). When animals are in hibernation, the structure can be stored underground or removed without damaging the ecological environment or the natural landscape (Fig. 3). Both material and size can be changed according to the area. If the mesh or structure is damaged, it can be replaced by new components without changing the entire framework. The ecological barrier is modularized by units, and the left and right sides of the aluminum frame are designed to be linked together. Therefore, the barriers can be arranged and assembled according to the needs of the conservation area.

2.1.3. Measuring instrument and research materials

A Vernier caliper was used to measure the body length of the frog. The measuring range was 100 mm/4″ and the size was 118.2184 inches. The weight of the amphibians was measured using an electronic scale in the unit of grams. The precision was 1/2000, and the size was 215 mm × 150 mm. A tape measure of 5 m in length was used to measure the jump height and jump length of the frogs. A protractor was used to measure the angle of the ecological barriers in order to measure the barrier effectiveness.

2.2. Methods

2.2.1. Sampling method and number of samples

Samples were collected on site using the patch sampling method, as proposed by Lue (1996). Referring to Chang et al. (2011) and Yu (1976), 20 samples were captured. The experiments were completed within 14 days, and the frogs were released to the capturing site, without affecting their behavioral capabilities.

2.2.2. Weight and body length measurement

According to Chang et al. (2011), this study used an electronic scale to measure the weight of the frogs, and a Vernier caliper to measure the body length of the frogs.

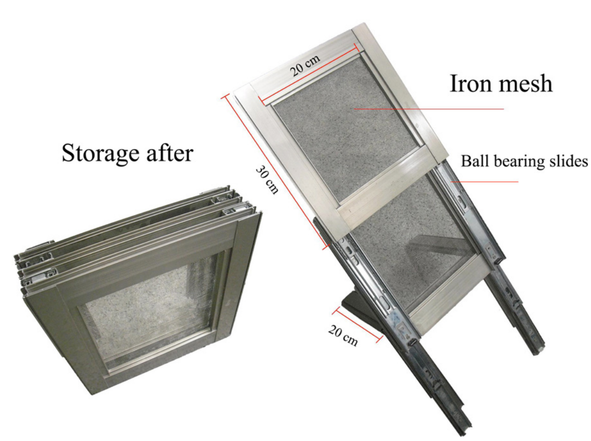

Fig. 1. Eco barriers equipment.