

**HORSESHOE BAT SPECIES RECORDED IN THE MANGROVE
ECOSYSTEM OF THE CAT BA NATIONAL PARK,
NORTHERN VIETNAM**

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ABSTRACT

Cat Ba National Park is the core zone of the Cat Ba Archipelago Biosphere Reserve. It contains quite diverse and unique ecosystems including 776 ha of mangrove forest. Although bats of the park were included in many publications, none were recorded from the mangrove ecosystem. We recently conducted field surveys through the wetland areas of the park and recorded three horseshoe bat species: Marshall's horseshoe bat (*Rhinolophus marshalli*), Pearson's horseshoe bat (*Rhinolophus pearsonii*), and the least horseshoe bat (*R. pusillus*). Of these, *R. pearsonii* is the most common species. We here provide morphological and acoustic features of each species with notes on the importance of the mangrove forest in the park for bat research and conservation.

Keywords: Echolocation, island, Mammalia, morphology, wetlands.

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INTRODUCTION

Horseshoe bat is the common name of every extant species of the family Rhinolophidae. To date, Vietnam is home to at least 20 species of horseshoe bats (Thanh et al., 2017). Of these, 5 species are known from Cat Ba National Park (Furey et al., 2002; Can et al., 2008; Thong et al., 2007; Thong, 2008; Thong & Furey, 2008; Thong, 2011; Abramov & Kruskop, 2012; Thong, 2012; Kruskop, 2013; Thong, 2014a; Thong et al., 2016 and Thong et al., 2020).

Cat Ba National Park is located in Hai Phong City, northern Vietnam. It is the core zone of the Cat Ba archipelago, one of the best known localities in Vietnam for unique karst landscapes and high biodiversity values (Dat et al., 2018). The first record of bats from the park was by Bourret (1942a) who described a new subspecies, *Hipposideros larvatus alongensis*. Subsequently, “*alongensis*” was reclassified and regarded as a distinct species endemic to Vietnam (Topal, 1975; Thong, 2011; Thong et al., 2012b). Subsequently, bats in the park were recorded in a series of other papers (Bourret, 1942b; Topal, 1993; Canh et al., 1997; Borissenko & Kruskop, 2003; Thong et al., 2008; Thong et al., 2011; Thong et al., 2012a,c; Thong, 2013; Thong et al., 2014b; Nga & Tung, 2018 and Yuzefovich et al., 2021). The park contains a wide range of ecosystems: tropical humid forests, wetlands, mangroves, caves, and others. Its mangrove is important for biodiversity but is still poorly studied (Furey et al., 2002; Dat et al., 2018). Nevertheless, mangrove of the park had not received attention from bat specialists by 2014. Over the past five years, we conducted a series of surveys on bats in the park and its surroundings. As a part of our survey results, we reported herewith the first record of bats in the mangrove ecosystem of the park.

MATERIALS AND METHODS

Bat capture and morphological examination

Field surveys were carried out through mangrove areas between October 2015 and August 2019 in Gia Luan and Phu Long

Communes, Cat Ba Island, Cat Ba National Park. Bats were captured using hand nets and mist nets of different sizes (3.0 m [height] × 6.0-20.0 m [length]) opened from 17:00 hour to 22:30 hour. Each captured bat was removed carefully from the nets and placed individually in a cotton bag. The following external measurements were taken using a digital caliper to the nearest 0.1 mm: FA, forearm length-from the extremity of the elbow to the extremity of the carpus with the wings folded; EH, ear height-length of ear conch; EW, ear width-the greatest width of ear conch. All captured bats were released at the netting site after taking morphometric data and photos for identification. The details of the methods and measurements are described in Thong et al. (2012a,b) and illustrated in Bates and Harrison (1997) and Csorba et al. (2003). Reproductive status and age were assessed following Racey (2009) and Brunet-Rossinni and Wilkinson (2009), respectively.

Recording and analysis of echolocation calls

Echolocation calls were recorded inside a flight-tent (5.0 m [length] × 5.0 m [width] × 3.0 m [height]) using the PCTape system at a sampling rate of 480 kHz. Batman software was used to select high quality sound sequences before recording. Recorded calls were analysed using Selena software to measure the constant frequency of the second harmonic (CF2) of each call. We displayed the calls as colour spectrograms with durations of 60 milliseconds, a frequency range between 20–120 kHz (FFT 512) and used the cursor to determine the frequency of the CF-component. The PCTape system, Batman and Selena softwares are custom-made by the University of Tübingen, Germany.

RESULTS AND DISCUSSION

Fourteen individuals belonging to three horseshoe bat species (6 adult females of *Rhinolophus marshalli*, 5 adult females and 1 adult male of *R. pearsonii* and 2 lactating female *R. pusillus*) were captured over the surveys in the mangrove areas of the Cat Ba National Park. They were all adults and at the

inactive reproduction stage. Among three recorded species, *Rhinolophus marshalli* and *R. pearsonii* were common in the studied mangrove ecosystem, because they were detected and recorded at almost all netting sites throughout the areas in both Gia Luan and Phu Long Communes. On the other hand, *R. pusillus* was detected only once in a netting site in Phu Long Commune. Morphological and acoustic features of each species recorded in mangrove areas are similar to those recorded in other ecosystems of the park.

Rhinolophus marshalli

Marshall's horseshoe bat

Materials examined

Six adult females were captured at Cai Vieng mangrove area on 2nd October 2015, Phu Long Commune, Cat Ba Island. Echolocation calls of this species were commonly detected and recorded throughout the survey transects and netting sites within the mangrove areas.

Morphological measurements and echolocation

External characteristics and measurements of the six captured individuals are similar to respective description in previous publications (Fig. 1a). Their FA, EH and EW are in a range of 45.0–48.6 mm, 23.3–26.8 mm, 16.9–18.3 mm, respectively. The CF2 of this species is in a range of 44.1–45.8 kHz (Fig. 2a).

Historical records and conservation status

Rhinolophus marshalli is a common horseshoe bat species with records in almost all caves and habitats in Cat Ba Island. Thong et al. (2007) provided the first records of this species in the park with detailed descriptions of morphology and echolocation. Additional records with reference to specimens and related materials were included in Furey (2002), Thong (2011), Abramove & Kruskop (2012), Thong (2012), Kruskop (2013), Thong (2014a) and Thong et al. (2016). These were followed by Thong (2008), Thong & Furey (2008); Can et al. (2008) and Thong et al. (2020). Cat Ba appears as an ideal home to this species with the largest colony up to ca.

30 individuals in a limestone cave in 2007 while “the species has been found as individuals or small groups in the remaining distributional range” worldwide (Thong et al., 2019). Although the known colonies have declined since 2008, it is still listed as “Least Concern” in the current IUCN Red List (Thong et al., 2019).

Rhinolophus pearsonii

Pearson's horseshoe bat

Materials examined

Five adult females and one adult male were captured in the mangrove area in Gia Luan commune. Echolocation call of this species were also commonly detected and recorded throughout the survey transects and netting sites.

Morphological measurements and echolocation

External characteristics and measurements of the captured individuals are also similar to descriptions of this species in previous publications (Fig. 1b). Their FA, EH and EW are in a range of 49.0–53.4 mm, 21.5–25.0 mm, 17.0–17.5 mm, respectively. The CF2 of this species is in a range of 53.7–56.1 kHz (Fig. 2b).

Historical records and conservation status

Rhinolophus pearsonii was commonly recorded in different habitats ranging from plantation to primary forests (Thong, 2011; Abramove & Kruskop, 2012). Its records from the park were included in at least six publications with reference to specimens and/or relevant materials (Furey et al., 2002; Thong, 2011; Abramove & Kruskop, 2012; Kruskop, 2013; Thong, 2014a and Thong et al., 2016). These were followed by Can et al. (2008), Thong (2008), Thong & Furey (2008) and Thong et al. (2020). This species has been found as individuals or small groups up to three individuals in Cat Ba Island. Although the known populations in Cat Ba and remaining distributional range have been declining because of ongoing habitat degradation, the species is still listed as “Least Concern” in the current IUCN Red List (Bates et al., 2019).



Figure 1. Frontolateral view of horseshoe bat species from mangrove ecosystem of Cat Ba National Park: *Rhinolophus marshalli* (a), *R. pearsonii* (b) and *R. pusillus* (c)

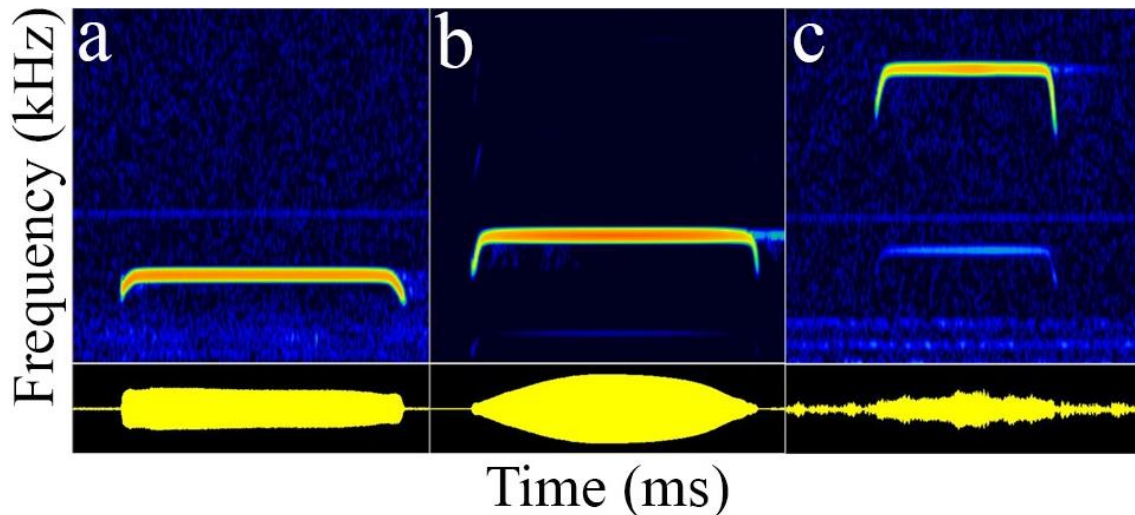


Figure 2. Echolocation calls of horseshoe bat species from mangrove ecosystem of Cat Ba National Park: *Rhinolophus marshalli* (a), *R. pearsonii* (b) and *R. pusillus* (c)

Rhinolophus pusillus

Least horseshoe bat

Materials examined

Two lactating females were captured on 26 June 2019 at Cai Vieng mangrove area, Phu Long Commune, Cat Ba Island. Echolocation calls of this species were also rarely detected and recorded in the mangrove area studied over the surveys.

Morphological measurements and echolocation

The connecting process of the each captured individual is rather pointed and

somewhat bent forward. In general, external characteristics and measurements of the two captured individuals are also similar to descriptions of this species in previous publications (Fig. 1c). Their FA, EH and EW are in a range of 34.0–36.8 mm, 15.0–16.8 mm, 11.5–12.0 mm, respectively. The CF2 of this species is in a range of 108.6–109.0 kHz (Fig. 2c).

Historical records and conservation status

The Least horseshoe bat is uncommon in Cat Ba National Park. Its records with reference to specimens and/or relevant

materials were included in Furey et al. (2002), Thong (2011), Abramove & Kruskop (2012), Kruskop (2013), Thong (2014a) and Thong et al. (2016). Abramove & Kruskop (2012) described two different morphological forms from Cat Ba Island and provisionally regarded them as *Rhinolohus* cf. *pusillus* and *R.* cf. *subbadius*. However, Kruskop (2013) indicated that these two forms belong to a single species, *Rhinolohus pusillus*. This species was also listed in four other documents (Can et al., 2008; Thong, 2008; Thong & Furey, 2008 and Thong et al., 2020). To date, *Rhinolophus pusillus* in Vietnam and surrounding countries is still regarded as a species complex. Further investigations are required to resolve its taxonomic status. The species is listed as “Least Concern” in the current IUCN Red List because its known populations are likely stable (Fukui, 2019). It is also listed as an “uncommon” species in Cat Ba National Park (Thong et al., 2020).

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