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 (Tran 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-Rossin 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 manrove 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 *Rhinolophus cf. pusillus* and *R. cf. subbadius*. However, Kruskop (2013) indicated that these two forms belong to a single species, *Rhinolophus 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 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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**REFERENCES**

Abramov A. V., Kruskop S. V., 2012. The mammal fauna of Cat Ba Island, northern Vietnam. *Russ. J. Theriol.*, 11: 57–72.

Bates P. J. J., Bumrungsri S., Csorba G., Mao X. G., 2019. *Rhinolophus pearsonii*. The IUCN Red List of Threatened Species 2019: e.T19559A21993105. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T19559A21993105.en

Bates P. J. J., Harrison D. L., 1997. *Bats of the Indian Subcontinent*; Harrison Zoological Museum: Sevenoaks, UK: 1–258.

Borissenko A. V., Kruskop S. V., 2003. Bats of Vietnam and Adjacent Territories: an identification manual; Joint Russian-Vietnamese Science and Technological Tropical Centre, Moscow and Hanoi, Russia and Vietnam, 2003: 1–212.

Bourret R., 1942a. “Sur quelques petits Mammifères du Tonkin et du Laos”, *Comptes rendus du Conseil de Recherches Scientifiques de l’Indochine 2ème semestre*: 27–30.

Bourret R., 1942b. “Les mammifères de la collection du Laboratoire de Zoologie de l’École Supérieure des Sciences”, Université Indochinoise, Hanoi, Vietnam, 44 p.

Brunet-Rossinini A. K., Wilkinson G. S., 2009. Methods for age estimation and the study of senescence in bats. In: *Ecological and behavioral methods for the study of bats*, Kunz T.H., Parsons S. (eds.), Johns Hopkins University Press, Baltimore, Maryland: 315–325.

Can D. N., Endo H., Son N. T., Oshida T., Canh L. X., Phuong D. H., Lunde D. P., Kawada S. I., Hayashida A., Sasaki M., 2008. Checklist of wild mammal species of Vietnam; Kyoto University, Japan, and Institute of Ecology and Biological Resources, Vietnam, 2008: 68–182.

Canh L. X., Sung C. V., Lee S. D., 1997. Mammal resources of Cat Ba and surrounding areas in Vietnam. In Ecosystem and biodiversity of Cat Ba National Park and Ha Long Bay, Vietnam: Annals of Nature Conservation, The Korean National Council for Conservation of Nature, Korea, and Institute of Ecology and Biological Resources, Vietnam, Volume 12: 147–159.

Csorba G., Ujheley P., Thomas N., 2003. *Horseshoe Bats of the World (Chiroptera: Rhinolophidae)*, Alana Books, Shropshire, United Kingdom: 1–160.
Dat P., Yoshino K., Kaida, N., 2018. Monitoring mangrove forest changes in Cat Ba Biosphere Reserve using ALOS PALSAR Imagery and a GIS-based support vector machine Algorithm. Advances and Applications in Geospatial Technology and Earth Resources: 103–118.

Fukui, D. 2019. Rhinolophus pusillus. The IUCN Red List of Threatened Species 2019: e.T85707059A21994916. http://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T85707059A21994916.en

Furey, N., Canh L. X., Fanning E., 2002. Cat Ba National Park: Biodiversity Survey 1999; Society for Environmental Exploration; UK and Institute of Ecology and Biological Resources; Frontier Vietnam Environmental Research Report 20: 18–30.

Kruskop S. V., 2013. Bats of Vietnam: Checklist and an identification manual. Moscow, Russia, 299 p.

Nga C. T. T, Tung N. S., 2018. Biodiversity research and conservation in Cat Ba National Park with updated records from recent field surveys. J. Viet. Env., 9: 285–290.

Racey P. A., 2009. Reproductive assessment in bats. In: Ecological and behavioral methods for the study of bats; Kunz T. H., Parsons S. (eds.), Johns Hopkins University Press, Baltimore, Maryland: 249–264.

Thanh H. T., Son N. T., Sang N. V., Thai D. N., Hoang N. H., Tu V. T., Huan N. X., Thong V. D. 2017. Diversity, taxonomy and conservation status of horseshoe bats (Chiroptera: Rhinolophidae) in Vietnam. Tap chi Sinh hoc, 39(2): 161–171.

Thong V. D., Furey M. N., 2008. The bat fauna of Cat Ba Biosphere. Tap chi Sinh hoc, 30: 73–77.

Thong V. D., Tu V. T., Tien P. D., Chu C. W., Senawi. J., Bates P. J. J., Furey N. M., 2007. Echolocation call frequency of Marshall’s horseshoe bat Rhinolophus marshalli from Cat Ba National Park and its current status in Vietnam. Proceedings of the 2nd national scientific conference on ecology and biological resources, Hanoi, Vietnam: 274–277.

Thong V. D., 2008. Bat Conservation at Cat Ba Biosphere Reserve, North-east Vietnam, Conservation Leadership Programme. Available online: www.conservationleadershipprogramme.org (accessed on 19 May 2021).

Thong V. D., 2011. Systematics and echolocation of rhinolophoid bats (Mammalia: Chiroptera) in Vietnam. PhD Thesis, University of Tuebingen, Tuebingen, Germany.

Thong V. D., 2012. New findings and an extensive description of Rhinolophus marshalli Thonglongya, 1973 in Vietnam. HNUE Journal of Science, 57: 3–10.

Thong V. D., 2013. An updated list of leaf-nosed bats (Hipposideridae) from Vietnam and key features of Hipposideros alongensis. Tap chi Sinh hoc, 35: 178–184.

Thong V. D., 2014a. Acoustic identification and taxonomic remarks of horseshoe bats (Chiroptera: rhinolophidae) in Cat Ba National Park, north-eastern Vietnam. Proceedings of the first international VAST-BAS conference: 323–328.

Thong V. D., 2014b. Taxonomy and ecology of Cynopterus horsfieldi (Chiroptera: Pteropodidae) from Vietnam. Proceedings of the first international VAST-BAS conference: 329–334.

Thong V. D., Dietz C., Denzinger A., Bates P. J. J., Furey N. M., Csorba G., Hoye G., Thuy L. D., Schnitzler H. U., 2011. Further records of Murina tiensa from Vietnam with first information on its echolocation calls. Hystrix - Italian Journal of Mammalogy, 22: 129–138.

Thong V. D., Dietz C., Denzinger A., Bates P. J. J., Puechmaille S. J., Callou C., Schnitzler H. U., 2012a. Resolving a
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mammal mystery: the identity of Paracoelops megalotis (Chiroptera: Hipposideridae). Zootaxa, 3505: 75–85.

Thong V. D., Dietz C., Schnitzler H. U., Denzinger A., Furey N. M., Borissenko A., Bates P. J. J., 2008. First record of Hipposideros khaokhouayensis (Chiroptera: Hipposideridae) from Vietnam. HNUE Journal of Science, 53: 138–143.

Thong V. D., Dung D. T., Thanh N. V., 2016. An overview of bat research in Cat Ba Biosphere Reserve with remarks on previous records. Proceedings of the 2nd national scientific conference on biological research and teaching in Vietnam, Da Nang, Vietnam: 737–744.

Thong V. D., Puechmaille S. J., Denginger A., Bates P. J. J., Dietz C., Csorba G., Soisook P., Teeling E. C., Matsumura S., Furey N. M., Schnitzler H. U., 2012b. Systematics of the Hipposideros turpis complex and a description of a new subspecies from Vietnam. Mammal Review, 42: 166–192.

Thong V. D., Puechmaille S. J., Denzinger A., Dietz C., Csorba G., Bates P. J. J., Teeling E. C., Schnitzler H. U., 2012c. A new species of Hipposideros (Chiroptera: Hipposideridae) from Vietnam. Journal of Mammalogy, 93: 1–11.

Thong V. D., Southaphan S., Nha P. V., 2020. The conservation status of bats (Mammalia: Chiroptera) in Cat Ba National Park, Northern Vietnam. HNUE Journal of Science 2020, 65(10): 92–98.

Thong V. D., Thanh H. T., Soisook P., Bates P. J. J., Csorba G., 2019. Rhinolophus marshalli, The IUCN Red List of Threatened Species 2019: e.T19552A21978274. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T19552A21978274.en

Topál G., 1975. “Bacula of some Old World leaf-nosed bats (Rhinolophidae and Hipposideridae, Chiroptera: Mammalia)”, Vertebrata Hungarica, 16: 21–53.

Topál G., 1993. Taxonomic status of Hipposideros larvatus alongensis Bourret, 1942 and the occurrence of H. turpis Bangs, 1901 in Vietnam (Mammalia, Chiroptera). Acta Zoologica Hungarica, 39: 267–288.

Yuzefovich A. P., Artuyushin I. A., Kruskop S. V., 2021. Not the Cryptic Species: Diversity of Hipposideros gentilis (Chiroptera: Hipposideridae) in Indochina. Diversity, 13. https://doi.org/10.3390/d13050218