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BATS OF LY SON ARCHIPELAGO, CENTRAL VIETNAM

Vu Dinh Thong
Institute of Ecology and Biological Resources,
Vietnam Academy of Science and Technology

Abstract. Ly Son is a small but important archipelago of Vietnam. It contains different ecosystems ranging from urbanized to natural vegetation. However, little was known about bats and the general biodiversity of this archipelago. In August 2017 and May 2022, the author conducted a series of bat surveys throughout the archipelago. Bats were captured using mist nets and harp traps. Echolocation calls were recorded using the PCTape system at every netting and trapping site and inside a flight tent. Recorded calls were analyzed using the Selena software. Results from the survey confirmed that the Ly Son archipelago is home to two bat species belonging to two genera, two families: Pteropodidae (*Cynopterus sphinx*) and Vespertilionidae (*Myotis muricola*). Of these two species, *C. sphinx* was very common while *M. muricola* was rarely recorded in the archipelago. Remarkably, the echolocation signal duration of *M. muricola* is in a range of 2.6-5.2 milliseconds which is longer than descriptions in previous publications.

Keywords: biodiversity, Chiroptera, echolocation, island, Myotis.

1. Introduction

Ly Son is one of the most important archipelagoes of Vietnam in different aspects including history, culture, and nature conservation. It is located in the north-eastern Quang Ngai province of Vietnam, about 28.0 kilometers from the mainland [1]. This small archipelago comprises three natural islands, namely Dao Lon, Dao Be, and Mu Cu, with a total area of approximately 10 square kilometers [1]. Since 2010, Dao Lon and Mu Cu have been connected by a long artificial breakwater forming a haven for fishing boats. The topography of the islands includes caves, rather flat land areas, and five hills with vegetation ranging from cultivated fields, plantations, and natural forests (Figure 1). The caves and other ecosystems of the archipelago appear to be home to many plant and animal species. However, the general biodiversity of Ly Son was poorly studied. Before the present study, 60 taxa of soft corals were recorded from the islands [1]. Records of bats from this archipelago were just included in Viet et al. [2, 3]. In August 2017 and May 2022, the author conducted two bat surveys throughout the terrestrial ecosystems in

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Contact Vu Dinh Thong, e-mail address: thongvudinh@gmail.com

three islands in the Ly Son archipelago. All captured bats were identified according to their morphology and echolocation calls. This paper provides morphological and acoustic features of bats recorded from the islands over the surveys.

Figure 1. A landscape view of various habitats in Ly Son archipelago

2. Content

2.1. Bat capture and morphometric measurements

The surveys were conducted following Thong et al. [4-6]. Bats were captured and handled following guidelines recommended by the American Society of Mammalogists [7, 8]. Two four-bank harp traps [9] and six mist nets of 6.0 m (height) × 9.0-12.0 m (length), mesh size 16 × 16 mm, were set up under the canopy of fruit trees and natural vegetation. Thirty-six individuals of two species were captured over the surveys: *C. sphinx* (15 males and 17 females) and *M. muricola* (one male and three females). Of which, five males and nine females of *C. sphinx* were juvenile while the remaining individuals are adults and in an unproductive period. 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; TIB, tibia length-from the knee joint to the ankle; HF, hind-foot length from of the extremity of the heel behind the os calcis to the extremity of the longest digit, excluding the hairs or claws; T, tail length from the tip of the tail to its base adjacent to the body. The above measurements were illustrated in Bates and Harrison [10] and Csorba et al. [11]. Reproductive status and age were assessed following Racey [12] and Brunet-Rossini and Wilkinson [13]. To reduce the influence of age variations in morphological features, juveniles were excluded from analyses. Identification of captured bats was based on a comparison with materials from other areas in Vietnam including Cuc Phuong and Cat Ba National Parks.

2.2. Echolocation recordings and analyses

Echolocation calls were recorded using the PCTape system (480 kHz, 16 bit) in natural habitats and when each captured bat was released after taking measurements and photographs for identification. Batman software, which displays color sonograms of the detected echolocation signals in real-time, was used to obtain high-quality sound sequences. A selected sound sequence of 2.44 seconds with a good signal-to-noise ratio was analyzed using the Selena software (both PCTape and Selena are custom-made at the University of Tuebingen, Germany). Signals were displayed as sonograms with an FFT (Fast Fourier Transformation) of 256, Hann-window, and zero-padding to measure the following call parameters: initial frequency (Fi), terminal frequency (Ft), pulse duration (PD), and inter-pulse interval (IPI). All parameters were measured from the first harmonic.

2.3. Results

Morphological features of the captured fruit bats fit the diagnoses of *C. sphinx*: margins of each pinna and fingers are whitish; the posterior margin of each pinna is curved and thinner than the anterior one; the pelage is soft and dark brown; nostrils are tubular and open slightly outwards (Figure 2). The external tail of adult individuals is well protruded. Their FA and EH are in ranges of 65.9-71.5 mm and 19.0-22.4 mm, respectively (Table 1). External characteristics of the echolocating bats fit the diagnoses of *M. muricola* (Figure 3). Their FA and EH are short with an average of 352 mm (34.2-35.8 mm) and 11.9 mm (11.5-12.4 mm), respectively (Table 1). The dorsal pelage is dark grey and the ventral one is whitish.

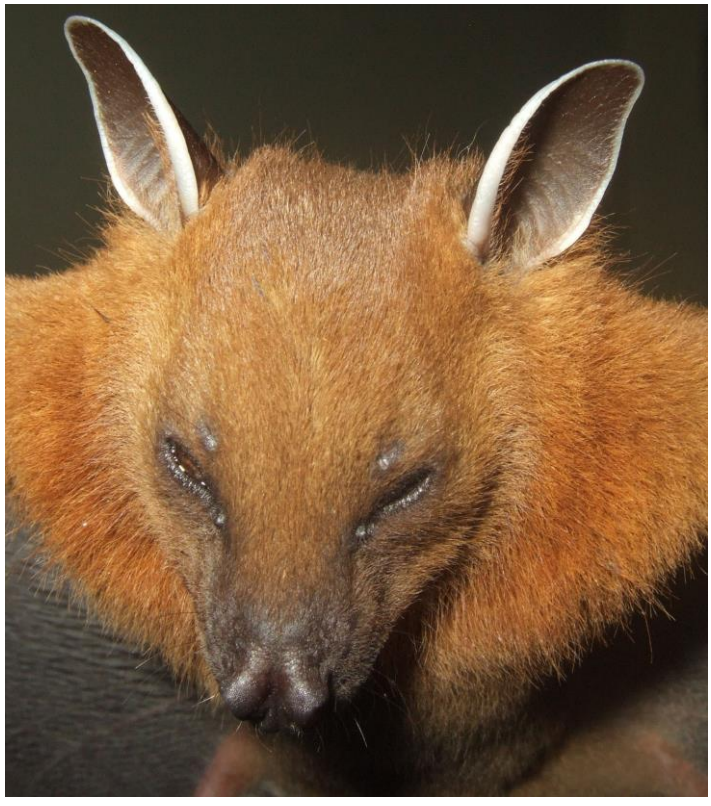

Figure 2. Frontal view of Cynopterus sphinx from Ly Son archipelago

Figure 3. Frontolateral view of Myotis muricola from Ly Son archipelago

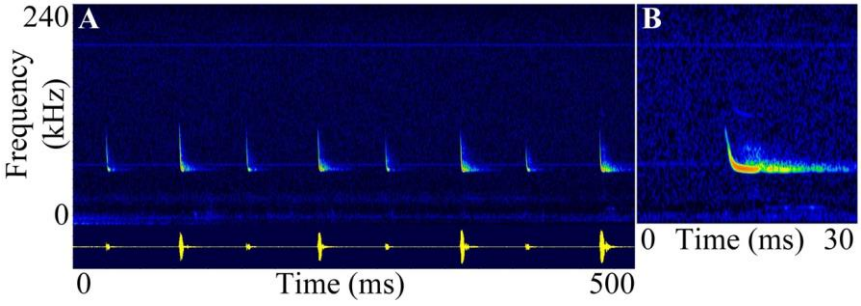

Figure 4. Sonograms and oscillograms of a signal sequence lasting 500 milliseconds (A) and close-up views of a single echolocation signal (B) of Myotis muricola from Ly Son archipelago

Table 1. Selected external measurements (in mm) of specimens collected during the present study

Species	n	FA	EH	TIB	HF
Cynopterus sphinx	18	69.7 ± 1.9 65.9 - 71.5	20.6 ± 0.9 19.0 - 22.4	27.1 ± 0.9 25.2 - 28.7	14.9 ± 1.2 13.1 - 16.5
Myotis muricola	4	35.2 ± 0.7 34.2 - 35.8	11.9 ± 0.4 11.5 - 12.4	16.2 ± 0.6 15.5 - 16.9	6.8 ± 0.5 6.2 - 7.2

Values are given as mean ± standard deviation, and ranges.
Acronyms are defined in the section "Materials and Methods".

Of the two bat species currently known from the Ly Son archipelago, *M. muricola* is the only species using echolocation calls. A sound sequence recorded in natural vegetation with good signals-to-noise ratio was analyzed. The sequence exhibits a search phase comprising 39 downward frequency-modulated calls. PD of each call varied between 2.6 and 5.2 milliseconds (Figure 4). Fi, Ft, and IPI of the calls are in the range of 74.7-110.4 kHz, 53.5-56.4 kHz, and 53.9-95.5, respectively.

2.4. Discussion

Kruskop (2013) recorded three species of *Cynopterus* from Vietnam: *C. brachyotis*, *C. Horsfieldii*, and *C. Sphinx* [14]. Of these, *C. brachyotis* is distinguishable from the two others by smaller body size and ear shape [15, 16]. *Cynopterus horsfieldii* and *C. sphinx* are almost indistinguishable in external features [15, 16]. The former is only distinguishable from the latter by cranial characteristics with ridges or cusps on occlusal surfaces of the second and third lower molars [14, 17, 18]. However, the taxonomic status of all three species of *Cyopterus* from Vietnam is still under discussion and requires an intensive review in both morphology and genetics.

Morphological characteristics of the captured *M. muricola* individuals are almost similar to descriptions in previous publications except for their pelage color [14, 19] (Figure 3). The dorsal and ventral pelages of this species were described as "clove brown to dark brown with the roosts dark brown to black" and "mid-to buffy brown hair tips and very dark roots" [19]. The dorsal and ventral pelages all 4 captured individuals of *M. muricola* from the Ly Son archipelago are dark grey and whitish, respectively. Vietnam is known as the native country to a species complex of *M. muricola* with a large variation in external features. Extensive research throughout the known distributional range of the species with a combination of data in all morphology, echolocation, and genetics is clearly required for confirmation of the species taxonomy from Vietnam and surrounding countries.

Before the present study, the echolocation of *M. muricola* was poorly documented. The first data on the echolocation of this species from Vietnam was included in Furey et al. [20]. Another record of the species echolocation from Malaysia was also described by Yoon and Park [21]. Of the four sound parameters, the PD of the calls from Ly Son is remarkably different from that the mainland of Vietnam and Malaysia (Table 2). It is also remarkable that Fi and Ft of the Malaysian bat also differ remarkably from those of Vietnamese origin in both mainland and island ecosystems. The above difference would be explained by different recording situations and habitats or intraspecific variations. The calls described in previous publications were recorded in hand-released situations [20, 21]. The calls from Ly Son were recorded when a bat was foraging in natural habitats (Figure 4). On the other hand, as mentioned above, *M. muricola* is a species complex and the echolocation parameters could be diagnostic of cryptic taxa.

Cynopterus sphinx and *M. muricola* are not listed in the current Red Data Book of Vietnam. They are regarded as widespread and common species and listed as "Least Concern" in the current IUCN Red List of Threatened Species [22, 23]. *Cynopterus sphinx* has been recorded from different habitats ranging from urban and rural landscapes to secondary and primary forests in almost all provinces of the country [14, 24]. Within the Ly Son archipelago, this species was also commonly recorded at every study site, including gardens and plantation areas.

Myotis muricola was rarely recorded over the surveys in Ly Son island. Several previous publications contain unclear records of this species from Vietnam. It was included in a distributional map that covers the whole of Vietnam [25]. The first records of this species were confirmed from Vietnam based on an examination of 6 specimens from Pu Mat National Park [19]. The species is currently regarded as a widespread and common species in Vietnam and throughout its known distributional range in Southeast Asia [2, 3, 14, 23, 24, 26, 27]. Within the Ly Son archipelago, this species was only detected and captured in the remaining natural vegetation in a small colony.

3. Conclusions

Ly Son archipelago is home to at least two bat species, belonging to two genera, and two families: *C. sphinx* and *M. muricola*. Among the two recorded species, *C. sphinx* was very common while *M. muricola* was uncommon in the archipelago. Morphological characteristics of the captured bats of *C. sphinx* and *M. muricola* are almost similar to previous descriptions from other areas of respective species. Echolocation calls of *M. muricola* is different from those in previous publications.

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REFERENCES

[1] Ben, H.X., Dautova, T.N. 2010. Soft corals (Octocorallia: Alcyonacea) in Ly Son islands, Central Vietnam. *Vietnamese Journal of Marin Science and Technology*, Vol. 10, No. 4, pp. 39-49.

[2] Viet, N.V., Loi, D.N., Khoi, L.V., Thong, V.D. 2017. Diversity and distribution of bat species of *Pipistrellus* and *Myotis* (Chiroptera: Vespertilionidae) from Vietnam. Proceedings of the 7th National Scientific Conference on Ecology and Biological Resources. Natural Science and Technic Publishing House, pp. 253-258.

[3] Viet, N.V., Loi, D.N., Thong, V.D. 2018. New records in morphology and echolocation of *Myotis altarium* and *Myotis muricola* (Mammalia: Chiroptera: Vespertilionidae) from Vietnam. Proceedings of the 3rd National Scientific

Conference on Biological Research and Teaching in Vietnam, Natural Science and Technic Publishing House, Hanoi, pp. 278-283.

[4] Thong, V.D., Puechmaille, S.J., Denzinger, A., Bates, P.J.J., Dietz, C., Csorba, G., Soisook, P., Teeling, E.C., Matsumura, S., Furey, N., Schnitzler, H.U. 2012. Systematics of the Hipposideros turpis complex and a description of a new subspecies from Vietnam. *Mammal Review*, Vol. 42, No. 2, pp. 166-192.

[5] Thong, V.D., Puechmaille, S.J., Denzinger, A., Dietz, C., Csorba, G., Bates, P.J.J., Teeling, E.C., Schnitzler, H.U. 2012. A new species of Hipposideros (Chiroptera: Hipposideridae) from Vietnam. *Journal of Mammalogy*, Vol. 93, No. 1, pp. 1-11.

[6] Thong, V.D., Mao, X., Csorba, G., Bates, P.J.J., Ruedi, M., Viet, N.V., Loi, D.N., Nha, P.V., Chachula, O., Tuan, T.A., Son, N.T., Fukui, D., Tu, V.T., Saikia, U. 2018. First records of Myotis altarium (Chiroptera: Vespertilionidae) from India and Vietnam. *Mammal Study*, Vol. 43, pp. 67-73.

[7] Sikes, R.S., Gannon, W.L., 2011. The Animal Care and Use Committee of the American Society of Mammalogists. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. *J. Mammal*., Vol 92, pp. 235-253.

[8] Sikes, R.S., Animal Care and Use Committee of the American Society of Mammalogists, 2016. Guidelines of the American Society of Mammalogists for the use of wild mammals in research and education. *J. Mammal*., Vol. 97, pp. 663-688.

[9] Francis, C. M. 1989. A Comparison of Mist Nets and Two Designs of Harp Traps for Capturing Bats. *Journal of Mammalogy*, Vol. 70, No. 4, pp. 865-870.

[10] Bates, P.J.J., Harrison, D.L. 1997. *Bats of the Indian Subcontinent*. Harrison Zoological Museum, Sevenoaks, Kent, United Kingdom.

[11] Csorba, G., Ujhelyi, P., Thomas, N. 2003. *Horseshoe Bats of the World (Chiroptera: Rhinolophidae).* Alana Books, Shropshire, United Kingdom.

[12] Racey, P.A. 2009. *Reproductive assessment of bats, in Kunz and Parsons: Ecological and Behavioural Methods for the Study of Bats*, 2nd Edition, The John Hopkins University Press.

[13] Brunet-Rossinni, A. K., Wilkinson, G.S. 2009. *Methods for age estimation and the study of senescence in bats*. In: Kunz T. and Parsons S. (Eds): *Ecological and Behavioural Methods for the Study of Bats*, 2nd Edition: The John Hopkins University Press, p. 315-325.

[14] Kruskop, S.V. 2013. *Bats of Vietnam: checklist and an identification manual*. Joint Russian-Vietnamese Science and Technological Tropical Centre, Moscow, Russia.

[15] Francis, C. M. 2008. *A field guide to the mammals of Southeast Asia*. New Holland Publishers Ltd, UK.

[16] Thong, C.D, Denzinger, A., Long, V., Sang, N.V., Huyen, N.T.T., Thien, N.H., Luong, N.K., Tuan, L.Q., Ha, N.M., Luong, N.T., Schnitzler, H.-U. 2022. Importance of Mangroves for Bat Research and Conservation: A Case Study from Vietnam with Notes on Echolocation of Myotis hasselti. Diversity Vol. 14, No. 4, pp. 258. https://doi.org/10.3390/d14040258.

[17] Lekagul, B. and J.A. McNeely. 1988. *Mammals of Thailand*. Association for the Conservation of Wildlife, Bangkok, Thailand.

[18] Thong, V.D. 2014. Taxonomy and ecology of Cynopterus horsfieldi (Chiroptera: Pteropodidae) from Vietnam. Proceedings of the First International VAST-BAS Conference, pp. 329-334.

[19] Bates, P.J.J., Hendrichsen, D.K., Walston, J.L., Hayes, B. 1999. A review of the mouse-eared bats (Chiroptera: Vespertilionidae: Myotis) from Vietnam with significant new records. *Acta Chiropterologica*, 1, pp. 47-74.

[20] Furey, N.M., Mackie, I.J., Racey, P.A. 2009. The role of ultrasonic bat detectors in improving inventory and monitoring in Vietnamese karst bat assemblages. *Current Zoology*, Vol. 55, No. 5, pp. 327-341.

[21] Yoon, K. B., Park, Y.C. 2016. Echolocation Call Structure and Intensity of the Malaysian *Myotis muricola* (Chiroptera: Vespertilionidae). *Journal of Forest and Environmental Science*, Vol. 32, No. 1, pp. 99-102.

[22] Bates, P., Bumrungsri, S., Molur, S., Srinivasulu, C. 2019. *Cynopterus sphinx*. The IUCN Red List of Threatened Species 2019: e.T6106A22113656. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T6106A22113656.en. Accessed on 16 March 2022.

[23] Srinivasulu, C., Srinivasulu, B. 2019. *Myotis muricola*. The IUCN Red List of Threatened Species 2019: e.T85537578A22065403. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T85537578A22065403.en. Accessed on 16 March 2022.

[24] Hendrichsen, D.K., Bates, P.J.J., Hayes, B.D., Walston, J.L. 2001. Recent records of bats (Mammalia: Chiroptera) from Vietnam with six species new to the country. *Myotis*, 39, pp. 35-122.

[25] Corbet, G. B., Hill, J.E. 1992. *The mammals of the Indomalayan region*. Oxford University Press, Oxford, United Kingdom.

[26] 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, Russia.

[27] Loi, D.N., Thong, V.D. 2017. First records of bats (Mammalia: Chiroptera) from Muong Phang Cultural and Historical Site, Dien Bien province, Northeastern Vietnam. *Vietnamese Journal of Biology*, Vol. 39, No. 3, pp. 396-402.