MAMMAL SURVEY IN SONG HINH PROTECTED FOREST, PHU YEN PROVINCE, VIETNAM

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1. INTRODUCTION

Song Hinh Protected Forest is situated in the Song Hinh District of Phu Yen Province in the South-Central Coastal region of Vietnam. The major forested districts in Phu Yen Province are Dong Xuan, Son Hoa, and Song Hinh. The main forest types include tropical humidity rain evergreen broad leaf closed forest and tropical moist semi-evergreen broad leaf closed forests of natural forests. There is limited information on animal biodiversity in Phu Yen Province, including Song Hinh Protected Forest. Despite the close proximity to the relatively well-studied Khanh Hoa and Dak Lak provinces, the mammal fauna of the Phu Yen Province is rather poorly studied, and the published information on the mammals of Song Hinh District is practically absent.

Short-term studies on Song Hinh mammals were conducted in 2021 as part of scientific activity the Joint Vietnam-Russia Tropical Science and Technology Research Centre, which aims to study Vietnamese biodiversity. Due to some objectives, the territory of the protected area was studied unevenly and thus our results cannot be considered final, and the diversity of local small mammals was not revealed entirely. Nonetheless, since there were no other direct studies of small mammals in Song Hinh District and adjacent territories, the publication of our results still seems to be reliable.

2. MATERIALS AND METHODS

Studied area. Our studies were held on 9-16 January 2021 and 10-15 June 2021. The fieldworks were carried out in a forested area located south of the Hinh River Reservoir. Base camp located at 12°49'38"N, 108°59'58"E. The different biotopes at distances of 1-6 km from the base camp were surveyed - lowland poly dominant mixed tropical evergreen forest, the forest along small streams, at an elevation of 200-500 m asl.

Bat survey. - Standard techniques and equipment were used to observe and capture bats. Observations were carried out at night using electric lamps and a narrow-band heterodyne ultrasonic bat detector [1]; D-230 (Pettersson Elektronik AB) was used. For vital trapping, we used monofilament mist nets 4.5×11 and 3.5×9 meters in size, put on fiberglass folding poles across supposed flying paths of animals; and a mobile trap with a net 2.5×2.5 meters, mounted on five-meter carbon fiber rods (Osprey R5000) [2 - 4]. Those methods were used separately or simultaneously, according to local conditions. Direct work (observations and trapping), as a rule, began from the moment of the animal's emergence (about 17.45-18.00 PM; by this time, the nets had already been put in selected places) and continued until 22-24 PM, adjusted for weather conditions and distance to the campsite.

From the captured animals, standard external measurements were taken (head and body length, tail length, hind foot length, ear and tragus/antitragus lengths, forearm length, body mass), which were necessary for the subsequent clarification of identification; most of captured animals were photographed on digital camera. External parasites were collected, mainly parasitic flies of the families Streblidae and Nycterebiidae, which were then fixed in 70% ethanol. All of the above manipulations were carried out without causing damage to the animals.

Non-volant small mammals survey. - Different types of traps were used as follows: 1) large (12×12×25 cm) cage live-traps and snap-traps, each with a bait of raisin and a foam-rubber piece saturated with vegetable oil and honey, cage live-traps were set on the ground as well as on the tree branches (1-3 m above the ground); 2) pitfall traps, i.e., plastic baskets (40×30 cm), buried flush with the ground surface, with two plastic fences (0.5 m length); metal mole-traps Talpex, which were set in the mole channels.

Camera-traps Browning BTC-5HDP were set near forest trails and along banks of small streams. Additional information was obtained during night and day-time excursions.

The standard external body measurements (body mass, head and body length, tail length, hind foot length and ear length; for bats, also tragus/antitragus length and forearm length) were taken. Given the existence of taxonomic problems, individual specimens (from 1 to 3 of each species) were sacrificed and collected for further study, following methods approved in the Animal Care and Use Guidelines of the American Society of Mammalogists [5]. Tissue samples for genetic studies were taken from fresh specimens and stored in 96% ethanol. Voucher specimens are kept at the Zoological Museum, Moscow State University (Moscow, Russia) and the Zoological Institute, Russian Academy of Sciences (Saint Petersburg, Russia).

3. RESULTS AND DISCUSSION

The data obtained from collected specimens, direct observations in the field, and camera-trap records show that the known small mammal fauna of the Song Hinh Protected Forest consists of at least 34 species.

Table 1. List of mammal species recorded in the Song Hinh Protected Forest in 2021

No.	Scientific name	When registered		Occurence
		January 2021	June 2021	
Order Soricomorpha				
1	*Crocidura tanakae*	+	+	Confirmed by specimen
2	*Crocidura phanluongi*	+	+	Confirmed by specimen
3	*Euroscaptor parvidens*	+	-	Confirmed by specimen

No.	Scientific name	When registered		Occurence
		January 2021	June 2021	
Order Scandentia				
4	*Tupaia belangeri*	+	+	Confirmed by specimen
5	*Dendrogale murina*	+	+	Confirmed by specimen
Order Rodentia				
6	*Menetes berdmorei*	+	+	Confirmed by specimen
7	*Dremomys rufigenis*	+	+	Confirmed by specimen
8	*Callosciurus erythreus*	+	+	Confirmed by specimen
9	*Olisthomys morrisi*	-	+	Confirmed by specimen
10	*Leopoldamys revertens*	+	+	Confirmed by specimen
11	*Chiromyscus langbianis*	+	-	Confirmed by specimen
12	*Maxomys surifer*	+	+	Confirmed by specimen
13	*Berylmys bowersi*	+	+	Confirmed by specimen
14	*Niviventer tenaster*	+	-	Confirmed by specimen
15	*Niviventer* sp.	+	+	Recorded by photo-trap
Order Carnivora				
16	*Mustela kathiah*	+	-	Recorded by photo-trap
17	*Melogale* sp.	-	+	Recorded by photo-trap
18	*Aonyx cinereus*	-	+	Recorded by photo-trap
Order Chiroptera				
19	*Megaerops niphanae*	-	+	Confirmed by specimen
20	*Rousettus leschenaulti*	-	+	Confirmed by specimen
21	*Rhinolophus affinis*	+	+	Confirmed by specimen
22	*Rhinolophus stheno*	+	-	Confirmed by specimen
23	*Rhinolophus sinicus*	+	+	Confirmed by specimen
24	*Rhinolophus rex*	+	-	Confirmed by specimen
25	*Rhinolophus* cf. *macrotis*	+	-	Confirmed by specimen
26	*Rhinolophus perniger*	+	-	Confirmed by specimen
27	*Rhinolophus pusillus*	+	+	Confirmed by specimen
28	*Hipposideros griffini*	-	+	Confirmed by specimen
29	*Lyroderma lyra*	+	-	Confirmed by specimen
30	*Megaderma spasma*	+	-	Confirmed by specimen
31	*Kerivoula* cf. *hardwickei*	+	-	Confirmed by specimen
32	*Myotis horsfieldii*	-	+	Confirmed by specimen
33	*Myotis alticraniatus*	-	+	Confirmed by specimen
34	*Myotis ancricola*	-	+	Confirmed by specimen

4. KEY SPECIES ACCOUNTS

Order Soricomorpha

Phanluong's shrew - *Crocidura phanluongi* Jenkins, Abramov, Rozhnov et Olsson, 2010

Phanluong's shrew *C. phanluongi* was described on the basis of specimens from Yok Don National Park, Dak Lak Province [6]. The species rank of that form was confirmed by DNA analysis [7]. Besides type locality, Phanluong's shrew is known to occur in the Virachey National Park, north-eastern Cambodia [6] and in the lowlands of southern Vietnam, including the Ma Da Forest in Dong Nai Province and the Bu Gia Map Nature Reserve in Binh Phuoc Province [7 - 9]. The Song Hinh Protected Forest finding is a new locality for Vietnam and the first locality eastward of the Dalat Plateau.

Small-toothed mole - *Euroscaptor parvidens* Miller, 1940

Previously, four - mole species of the genus Euroscaptor have been reported from Vietnam [10 - 12]. The status of small-toothed mole *E. parvidens* was assessed by Kawada et al. [10], and was recently re-evaluated by [12]. These authors listed the mole populations from Dalat Plateau and Kontum Plateau as *E. parvidens*. Recently the populations from southern and central Vietnam have been treated as different species, *E. parvidens* and *E. ngoclinhensis*, accordingly [13].

The Song Hinh locality of *E. parvidens* is the first record of this species for Phu Yen Province. More interestingly, this locality's elevation is just 200 m asl. The only one species of Vietnamese moles *Euroscaptor* spp., *E. subanura*, occurs in low-elevated biotopes, whereas all other species recorded from elevations not less than 800-1000 m.

Order Chiroptera

Chinese horseshoe bat - *Rhinolophus* cf. *sinicus* Andersen, 1905

Horseshoe bats from the "*rouxii*" species group were quite common in Song Khin (second only to *R. affinis* in abundance). Apparently, the majority of medium-sized horseshoe bats hunting 1.5-2 m from the ground along forest roads and paths belonged to this species. According to the sequence of the cytochrome *c* oxidase (*cox*I) gene, specimens from Song Hinh have approximately 97% similarity with *R. thomasi* from central Vietnam (which clearly indicates the correctness of the identification of the species complex). No sequences with a higher similarity have yet been found in online databases. In relatively large size (forearm length 45.7-46.5 mm) and relatively high lancet, specimens from Song Hinh differ from Thomas's horseshoe bats from central and northern Vietnam and formally correspond to the diagnosis of *R. sinicus* [14].

Long-eared horseshoe bat - *Rhinolophus* cf. *macrotis* Blyth, 1844

The taxonomy of this species complex is extremely tangled [15 - 17]. It could be assumed that the specimen of the long-eared horseshoe bat caught in Song Hinh belongs to a genetic lineage from southern Vietnam [18], the name and taxonomic status of which are not clear. Further genetic studies are required to elucidate this issue.

Giant horseshoe bat - *Rhinolophus perniger* Hodgson, 1843

An adult female of this species was captured by a mobile trap on the edge of a cow pasture. The animal was seen eating a large katydid. In total, two individuals were observed demonstrating typical perch-hunting behavior: they caught prey, apparently on the ground, attacking it with a throw from a branch in the peripheral part of the tree canopy, from a height of about 3-4 m, after which they returned to the porch. The giant horseshoe bats from Vietnam are now assigned by default to *R. perniger*, species relatively recently separated from *R. luctus* [19]. However, the taxonomy of the "*trifoliatus*" species group is obviously insufficiently studied [20], and the species boundaries within it require clarification.

Griffin's leaf-nosed bat - *Hipposideros griffini* Thong, Puechmaille, Denzinger, Dietz, Csorba, Bates, Teeling et Schnitzler, 2012

This species is the only representative of the Hipposideridae so far found in Song Hinh. Two adult males were captured in nets placed under trees near the forest edge. This large bat is a sibling species of the Himalayan leaf-nosed bat, *H. armiger* [21]. The delimitation between species (both phenotypic and geographical) is still not entirely clear; the status of *H. griffini* is questionable in some cases [22]. As a result, in most works, the authors do not separate them, designating all findings as *H. armiger*.

We have analyzed the available craniometry data for *H. armiger* and related forms using the Principal Component Analysis. The first component fairly reliably separates specimens attributed to *H. griffini* from *H. armiger*, while another taxon, for which species status was once assumed, *H. terasensis* from Taiwan, almost completely overlaps with *H. armiger* in terms of the values of all obtained discriminant functions. The Song Hinh specimen certainly shows a greater resemblance to *H. griffini*. This result supports a separate taxonomic status of Griffin's leaf-nosed bat.

Indian false vampire - *Lyroderma lyra* (E. Geoffroy, 1810)

We caught this species in the Song Hinh only in January. At the same time, one of the captured females was at an early stage of pregnancy. Thus, the birth of this species in the Song Hinh should take place in mid-late February, and by mid-May (the estimated time of mass births in most insectivorous bats), the young should already be relatively independent. Perhaps this has somehow related to the predatory diet of the Indian false vampire, which also includes other bats.

Central Highland whiskered bat - *Myotis ancricola* Kruskop, Borisenko, Dudorova et Artyushin, 2018

The "*nipalensis*" species group has recently been designated as a separate taxon and has a patchy distribution from Nepal to Vietnam [23, 24]. The species of this group remain among the least studied myotines in Asia, being known from a very limited number of findings. Morphometric analysis of an adult male captured over the river in the Song Hinh showed that with a probability of 0.96 it belongs to *M. ancricola*, which was previously known by the few records in Gia Lai and Kon Tum provinces and the adjacent territory of Laos [23]. Thus, our find is only the fifth for this species, and expands its known range to the south by about 190 km, indirectly indicating faunal links between the Song Hinh Forest and the Gia Lai - Kontum plateaus.

Order Scandentia

Northern smooth-tailed tree-shrew - *Dendrogale murina* (Schlegel et Müller, 1843)

This small-sized tree-shrew appears to be patchily distributed from eastern Thailand through Cambodia and south-eastern Laos to southern and central Vietnam [25]. The biology and species range of *D. murina* are relatively poorly known. This is the first record of this species for the Phu Yen Province. All recent checklists did not mention this area for the species range [25 - 27].

In the Song Hinh, this species was recorded by photo-trap in scrub along a small stream and a few times are seen by us in growth aside a forest road.

Order Rodentia

Northern Temminck's flying squirrel - *Olisthomys morrisi* (Carter, 1942)

The small flying squirrel was caught on 12 June 2021 in a mist net set for catching bats at the edge of a disturbed primary forest, at elevation 245 m asl. Morphologically, the Song Hinh specimen fits well in the description of the so-called "northern" *Petinomys setosus*, which is known from northern Myanmar and northern Thailand [28, 29] and likely from Laos [30]. This is the first record of this taxon for Vietnam. Further molecular and morphological analyses revealed that this specimen and other "northern" *P. setosus* does not belong to the genus *Petinomys*. The most likely scientific name for the flying squirrel from the Song Hinh should be *Olisthomys morrisi* [31].

4. CONCLUSION

Tropical forests throughout Southeast Asia, including Vietnam, are greatly endangered. Compared with the hard-to-access montane tropical forests in the high-elevated Dalat and Kontum plateaus, evergreen tropical forests in lowland and foothill areas of the southern coastal region of Vietnam are more endangered; most areas of lowland tropical forest are already destroyed due to logging and other human activities. According to recent data the land cover of Phu Yen Province has

changed tremendously in the last decade. In the period of 2010-2015, the area of natural forests and grasslands, shrubs, and bare lands reduced rapidly and replaced with an increase in the area of planted forest cover and trees and industrial and crops. From 2015 to 2020, the coating volatility decreased significantly.

Despite of their accessibility, the many remaining patches of tropical lowland and foothill forests, such as the Song Hinh Protected Forest, could cradle still unknown biodiversity, which makes the need for biological exploration in this region even more urgent.

During our studies in the Song Hinh Protected Forest, we found at least 34 species of small mammals. Despite the fact that the Song Hinh is located near the relatively well-studied Khanh Hoa Province, its fauna and the fauna of Phu Yen Province as a whole have so far remained surprisingly poorly studied. It was all the more intriguing to discover in this forest a rich community of small mammals, and, in particular, bats. Despite the fact that the territory under survey bears traces of human transformation, we did not find some faunal "markers" of secondary communities, such as *Cynopterus sphinx* and *Myotis muricola*.

Some finds raise the question of faunal relationships between the mammals of the Song Hinh Forest and other parts of Indochina. Geographically, one would assume the closest links with the Dalat Plateau, but such recorded species as *Myotis ancricola* and the remarkable *Olisthomys morrisi* suggest other connections. This question can be further answered by a genetic study and comparison of such species with a pronounced phylogeographic structure as *Euroscaptor parvidens*, *Crocidura tanakae*, *Chiromyscus langbianis*, *Rhinolophus affinis*, *Rhinolophus* cf. *pusillus*, *Myotis alticraniatus* and others.

The results of the present study confirm wealth and diversity of small mammals in the studied area. Undoubtedly, the Song Hinh Protected Forest is worth having higher conservation status, like a Nature Reserve.

However, it should be noted that our inventory of the small mammalian fauna of the Song Hinh is far from complete. Our surveys were very short and restricted to the studied area. Also, it can be expected that the mammalian distribution and occurrence will vary significantly depending on the season. Song Hinh is located in the tropical monsoon climate, hot and humid, influenced by the sea. The climate is divided into two distinct seasons: the rainy season from September to December and the dry season from January to August, the boundaries of seasons vary slightly. Fieldwork in January of 2021 was done in the rainy season. Some species recorded during this period (*Euroscaptor parvidens*, *Megaderma spasma*, *Lyroderma lyra*, *Rhinolophus perniger*, *Rhinolophus rex*, and others) were not recorded during the dry season in June of the same year.

Additional surveys in the Song Hinh Protected Forest during other seasons and in other parts of the protected area are needed to adequately estimate the mammal diversity here.

Acknowledgements: *We are grateful to the Joint Vietnam-Russia Tropical Science and Technology Research Centre, Phu Yen Provincial People's Committee, and Song Hinh Protection Forest Management Board for supporting the authors in the process of data collection and field survey in Phu Yen Province. We would like to express our thanks to heads of expeditions A.N. Kuznetsov and Hoi Nguyen Dang for the organization of the field studies. We are thankful to A.N. Kuznetsov, S.P. Kuznetsova, N.A. Poyarkov, P.V. Yuschenko, E.S. Popov for their kind help and scientific assistance during the field works. The study was performed in line with the stated themes of scientific work of the Zoological Museum of Moscow State University (No. 121032300105-0) and the Zoological Institute of the Russian Academy of Sciences (No. 1021051302486-9).*

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SUMMARY

Rapid field surveys of mammals in the Song Hinh Protected Forest (Phu Yen Province, Vietnam) were conducted in January and June 2021. Thirty-four small mammals were recorded based on field observations and on morphological and/or molecular evidence: two Scandentia species, three Eulipotyphla species, three Carnivora species, 10 Rodentia species and 16 Chiroptera species. The results of the present study confirm the wealth and diversity of small mammals in the studied area. Undoubtedly, Song Hinh Protected Forest is worth having higher conservation status, like a Nature Reserve.

Keywords: *Small mammals, new records, Song Hinh forest, Phu Yen province.*

Nhận bài ngày 31 tháng 7 năm 2022
Phản biện xong ngày 21 tháng 10 năm 2022
Hoàn thiện ngày 02 tháng 11 năm 2022

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