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Small mammal surveys in the region of the Hue City, Central Vietnam

Vu Kim Luong, Bui Tuan Hai*, Hoang Trung Thanh, Ly Ngoc Tu, Masaharu Motokawa, Alexei V. Abramov, Sergei V. Kruskop, Nguyen Vu Khoi & Nguyen Truong Son*

ABSTRACT. Small mammal surveys were conducted within the globally significant Annamite Range of central Vietnam in 2018 and 2023, in three protected areas — Sao la Hue, Phong Dien, and Bac Hai Van nature reserves (NRs). A total of 38 mammal species were recorded during the surveys, with bats (Chiroptera, 57.85%) and rodents (Rodentia, 28.94%) predominating. Species richness varied considerably across the sites, with the Sao la Hue NR being the most diverse (35 species), followed by Phong Dien NR (19 species) and Bac Hai Van NR (12 species). Nine species represent new distributional records for the region, including: *Chimarrogale varennei*, *Crocidura kegoensis*, *Crocidura tanakae*, *Hipposideros gentilis*, *Hipposideros grandis*, *Kerivoula kachinensis*, *Rhinolophus chaseni*, *Rhinolophus microglobosus*, and *Dacnomys millardi*. The study has also confirmed the presence of IUCN-listed species, including the Near Threatened black giant squirrel (*Ratufa bicolor*), as well as VRDB-listed species: the Vulnerable Indian giant flying squirrel (*Petaurista philippensis*) and the particolored flying squirrel (*Hylopetes alboniger*). Some abundant species were found in all three of nature reserves studied, including *Hipposideros grandis*, *H. gentilis*, *Callosciurus erythraeus*, *Tamiops rodolphii*, and *Leopoldamys* cf. *revertens*. The varied species composition of these reserves, which likely reflects differences in their habitat connectivity and ecological conditions, highlights the need for a coordinated landscape-related conservation strategy. This approach should primarily involve creating and maintaining of biological corridors to ensure the long-term conservation of small mammal populations in this biodiversity hotspot.

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Исследования мелких млекопитающих в регионе Хюэ, Центральный Вьетнам

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РЕЗЮМЕ. В 2018 и 2023 гг. были проведены исследования мелких млекопитающих на трёх особо охраняемых территориях — в природных заповедниках Саола Хюэ, Фонг Дьен и Бак Хай Ван, расположенных в Аннамских горах в центральном Вьетнаме. В ходе исследований было отмечено 38 ви-

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дов, среди которых преобладали летучие мыши (Chiroptera, 57.85%) и грызуны (Rodentia, 28.94%). Видовое разнообразие в исследованных заповедниках значительно различалось; наиболее разнообразным был природный заповедник Саола Хюэ (35 видов), за которым следуют Фонг Дьен (19 видов) и Бак Хай Ван (12 видов). Девять видов представляют собой новые находки для данного региона: *Chimarrogale varennei*, *Crocidura kegoensis*, *Crocidura tanakae*, *Hipposideros gentilis*, *Hipposideros grandis*, *Kerivoula kachinensis*, *Rhinolophus chaseni*, *Rhinolophus microglobosus*, *Dacnomys millardi*. Исследования выявили наличие гигантской белки (*Ratufa bicolor*) — вида, занесённого в список МСОП как находящийся в состоянии, близком к угрожаемому, и видов, включённых в Красную книгу Вьетнама — гигантской летяги (*Petarista philippensis*) и двухцветной летяги (*Hylopetes alboniger*). Некоторые виды были многочисленными во всех трёх исследованных заповедниках: *Hipposideros grandis*, *H. gentillis*, *Callosciurus erythraeus*, *Tamiops rodolphii* и *Leopoldamys* cf. *revertens*. Различный видовой состав в заповедниках, вероятно, отражает различия в местообитаниях и экологических условиях и подчёркивает необходимость скоординированной природоохранной стратегии. Приоритетное внимание необходимо уделять поддержанию биологических коридоров для обеспечения долгосрочного сохранения популяций мелких млекопитающих в этой критической точке биоразнообразия.

КЛЮЧЕВЫЕ СЛОВА: видовое разнообразие, летучие мыши, грызуны, насекомоядные, биологическое разнообразие, Саола Хюэ, Фонг Дьен, Бак Хай Ван.

Introduction

The Annamite Range, which forms the spine of the Indochinese Peninsula, is recognized as one of the world's most critical ecoregions for biodiversity conservation (Olson & Dinerstein, 2002). Harboring one of the mainland Southeast Asia's largest contiguous forest blocks, this region is characterized by an exceptionally high level of endemism and contains numerous key biodiversity areas. The discovery of several large mammal species that were new to science in recent decades, including the saola *Pseudoryx nghetinhensis* and the large-antlered muntjac *Muntiacus vuquangensis*, highlights its global significance (Tordoff *et al*., 2012; Höffner *et al*., 2024).

The region of the Hue City in central Vietnam, situated at the transition between the Northern and Central Truong Son biogeographic regions, represents a particularly vital component of this ecoregion (Höffner *et al*., 2024). While the area is well-known for hosting mammal species of high conservation value, such as the red-shanked douc langur *Pygathrix nemaeus*, Truong Son muntjac *Muntiacus truongsonensis*, Owston's civet *Chrotogale owstoni*, and Annamite striped rabbit *Nesolagus timminsi* (WWF-Vietnam & USAID, 2018), the diversity of small, less conspicuous mammals remains poorly documented. This represents a significant knowledge gap, given that small mammals are integral to ecosystem function and can serve as sensitive indicators of the environmental health.

In the Hue City region, three nature reserves — Sao la Hue, Phong Dien, and Bac Hai Van — form an important latitudinal green corridor stretching from the Vietnam–Laos border to the sea. These reserves cover a total area of 93355.55 hectares (WWF-Vietnam & USAID, 2018). Despite its rich biodiversity, Vietnam's wildlife faces multiple impacts from climate change, land-use changes, and human socio-economic development pressures (Höffner *et al*., 2024; Nguyen *et al*., 2025); and this area is no exception.

This study presents the first systematic survey of small mammal communities across these three nature reserves. Field surveys were conducted in 2018 and 2023 to assess regional species diversity and compare it with that of neighboring areas. The aim was also to update the data relevant to biodiversity conservation and sustainable development strategies.

Materials and methods

The study sites, which include three natural reserves (NRs) in the region of the Hue City, are shown in Fig. 1. The sampling times and coordinates are given in Table 1.

Table 1. Times and locations of three study areas.

Study site	Times	Sampling localities	
		Latitude	Longitude
Sao la Hue NR	16–24 Mar 2018	16.069	107.5049
		16.0419	107.5324
	21–26 Jun 2023	16.0668	107.5802
Phong Dien NR	29 Mar–03 Apr 2018	16.5321	107.1336
		16.5022	107.1575
		16.4648	107.1717
Bac Hai Van NR	27 Feb–05 Mar 2018	16.2068	107.9303
		16.1939	108.0353
		16.186	108.1186

A variety of traps were used to capture different species of non-volant terrestrial mammals (Fig. 2), including Sherman traps (7 × 7 × 30 cm) and Tomahawk traps (15 × 15 × 45 cm), as well as locally made cages. A total of 1570 trap-nights were conducted. Mole traps were set for 112 trap-nights in areas demonstrating mole activity. Pitfall traps (700 ml plastic cups with a diameter of 9 cm and a height of 15.6 cm) targeting

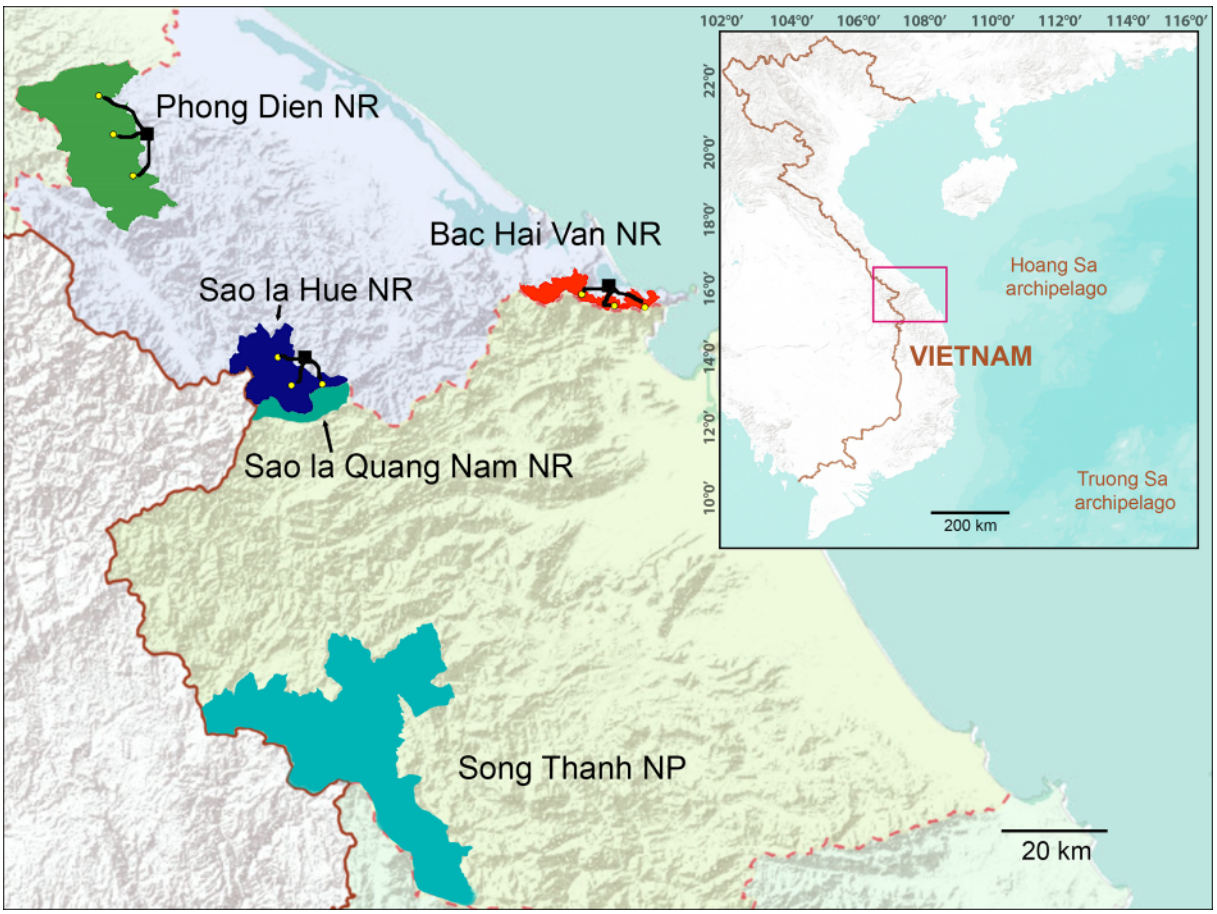

Fig. 1. Location of three nature reserves surveyed. Trails and traplines are in black.

shrews were used for 995 trap-nights. Bats were captured using ground-level mist nets and four-bank harp traps (Willig *et al*., 2009). The total capture effort was 4665 m²·net-hours for mist nets and 1708 m²·net-hours for harp traps. These devices were typically operated from approximately 17:30 to 22:00 or 23:00 and were checked at 20-minute intervals. The traps were placed along trails, forest edges, streams, and cave entrances to maximize detection. All the sampling involving animal capture and handling adhered to the Animal Care and Use Guidelines of the American Society of Mammalogists (Sikes *et al.*, 2016). Direct visual encounter surveys were conducted during the daytime (109.5 hours in total) and nighttime (94.5 hours in total) to supplement the trapping data and record species activity patterns. Binoculars and a camera equipped with a 500 mm telephoto zoom lens were used to spot and photograph animals.

Field surveys were conducted in three protected areas of the Hue City between 2018 and 2023, including the Sao la Hue NR, Phong Dien NR, and Bac Hai Van NR. The total sampling effort varied slightly between sites. In the Sao la Hue NR, small-mammal surveys were carried out twice, from 16–24 March 2018 and from 21–26 June 2023 The combined effort included 80 hours of daytime observations, 2550 m²·net-hours, 1114 hours of harp trapping, 62 trap nights using mole traps, and 1295 trap nights using Sherman, cage, and pitfall traps. Night observations totalled 48 hours. In the Phong Dien NR, the survey was conducted from 29 March to 4 April 2018. This comprised 17.5 hours of daytime observations, 576 m²·net-hours, 216 hours of harp trapping, 24 trap nights using mole traps, and 480 trap nights using Sherman, cage, and pitfall traps, with 30.5 hours of night observations. In the Bac Hai Van NR, the fieldwork took place from 27 February to 5 March 2018. This included 12 hours of daytime observations, 1539 m²·net-hours, 378 hours of harp trapping, 26 trap nights using mole traps, and 750 trap nights using Sherman, cage, and pitfall traps, with 16 hours of night observations.

The captured individuals were photographed, and standard external measurements (in 0.1 mm) were taken directly in the field. These included head-body length (HB), tail length (TL), hind-foot length (HF), ear length (E), forefoot length (FF, for moles), and forearm length (FA, for bats). The specimens were preserved in 70% ethanol, while liver samples were preserved sepa-

Fig. 2. Traps used in the surveys. A — Sherman trap, B — pitfall trap, C — cage trap, D — mist net, E — harp trap, F — mole trap.

rately in 99% ethanol. All voucher specimens were deposited at the Institute of Biology, Vietnam Academy of Science and Technology. Taxonomic identification was based on Csorba *et al*. (2003), Kruskop (2013), Wilson *et al*. (2016, 2017), Wilson & Mittermeier (2018, 2019), and Francis (2019), as well as other relevant species descriptions. The conservation status of the small mammals studied was evaluated according to the IUCN Red List (version 2025-1) and the most recent edition of the Vietnam Red Data Book (VRDB, 2024).

A faunal similarity between the three surveyed nature reserves and two adjacent protected areas (Song Thanh National Park (NP) and Sao la Quang Nam NR, Da Nang City) was assessed using the Sørensen–Dice similarity index (Cs). This index measures the overlap in species composition based on presence-absence data. All pairwise comparisons were computed using statistical software PAST v. 5.2 (Hammer *et al.,* 2001).

Results

In 2018 and 2023, a total of 157 specimens were collected, including two tree shrews, 14 squirrels, 26 rats, 21 shrews, two moles, and 92 bats. Based on these specimens and direct field observations, we recorded 38 species of small mammals belonging to ten families and four orders from the three nature reserves in the region of the Hue City (Table 2).

Several species were found in the study area for the first time. In the Sao la Hue NR, the ranges of *Chimarrogale varennei*, *Crocidura kegoensis*, *Crocidura tanakae*, *Hipposideros gentilis*, *Kerivoula kachinensis*, *Rhinolophus chaseni*, and *Dacnomys millardi* were extended. *Rhinolophus lepidus* was newly recorded in the Phong Dien NR, *Hipposideros grandis* was first documented in both the Phong Dien and Bac Hai Van NRs and *Rhinolophus microglobosus* was newly recorded from Sao la Hue and Phong Dien NRs. These results also include the first records of the species listed on the IUCN Red List. Notably, *Ratufa bicolor* has been assessed as Near Threatened (NT).

A comparison of the present survey data from the Sao la Hue, Phong Dien, and Bac Hai Van NRSs with published data from the Song Thanh NP and the Sao La Quang Nam NR in Da Nang City (Ly *et al*., 2019) revealed that Song Thanh NP had the highest small mammal diversity, with a total of 56 species. The Sao La Hue NR was second with 35 species, followed by the Sao la Quang Nam NR (34 species) and the Phong Dien NR (19 species). The Bac Hai Van NR showed the lowest diversity, with only 12 species recorded.

Analysis of the Sørensen–Dice similarity index revealed distinct patterns of faunal overlap among the five protected areas (Table 3). The highest similarity values (Cs = 0.64) were observed between the Sao la Hue NR and Sao la Quang Nam NR, as well as between the Sao la Quang Nam NR and Song Thanh NP, indicating strong faunal affinities among these adjacent sites. A slightly lower value was recorded between the Sao la Hue NR and Song Thanh NP (Cs = 0.62), while the similarity be-

Table 2. Small mammals recorded in five nature reserves of Central Vietnam. Nature reserves: (SLH — Sao la Hue, PD — Phong Dien, BHV — Bac Hai Van, SLQ — Sao la Quang Nam, ST — Song Thanh). S — specimen collected, O — species observed.

No.	Species	This study			Ly *et al*., 2019		Comments
		SLH	PD	BHV	SLQ	ST	
1	*Dendrogale murina*	–	–	–	–	O	IUCN: LC
2	*Tupaia belangeri*	O	O	S	S+O	S+O	IUCN: LC
3	*Galeopterus variegatus*	–	–	–	O	O	IUCN: LC
4	*Chimarrogale varennei*	S	–	–	O	–	New record for the region of the Hue City IUCN: Not Evaluated
5	*Crocidura kegoensis*	S	–	–	–	S	New record for the region of the Hue City. Ly *et al*. (2019) listed this species as *C. zaitsevi* IUCN: LC
6	*Crocidura tanakae*	S	–	–	–	S	New record for the region of the Hue City IUCN: LC
7	*Euroscaptor ngoclinhensis*	S	–	–	S	S	Ly *et al*. (2019) listed this species as *E. parvidens* IUCN: Not Evaluated
8	*Alionoctula coromandra*	S	–	–	S	–	IUCN: LC
9	*Alionoctula javanicus*	–	–	–	–	S	IUCN: LC
10	*Cynopterus sphinx*	S	–	S	S	S	IUCN: LC
11	*Hipposideros armiger*	–	–	–	S	–	IUCN: LC
12	*Hipposideros cineraceus*	S	–	–	–	S	IUCN: LC
13	*Hipposideros galeritus*	–	–	–	–	S	IUCN: LC
14	*Hipposideros gentilis*	S	–	–	S	S	New record for the region of the Hue City. IUCN: LC
15	*Hipposideros grandis*	–	S	S	S	S	New record for the region of the Hue City. IUCN: LC
16	*Hipposideros poutensis*	S	–	S	–	–	IUCN: Not Evaluated
17	*Hypsugo pulveratus*	S	–	–	–	–	IUCN: LC
18	*Kerivoula dongduongana*	S	S	–	S	S	IUCN: LC
19	*Kerivoula kachinensis*	S	–	–	–	S	New record for the region of the Hue City. IUCN: LC
20	*Kerivoula titania*	S	S	–	–	S	IUCN: LC
21	*Macroglossus sobrinus*	–	–	–	S	S	IUCN: LC
22	*Megaderma spasma*	–	–	–	S	S	IUCN: LC
23	*Megaerops niphanae*	–	–	–	–	S	IUCN: LC
24	*Miniopterus pusillus*	–	–	–	–	S	IUCN: LC
25	*Murina cyclotis*	–	–	–	–	S	IUCN: LC
26	*Murina feae*	S	S	–	–	S	IUCN: LC
27	*Murina fionae*	–	–	–	–	S	IUCN: LC
28	*Myotis ater*	–	–	–	–	S	IUCN: LC
29	*Myotis horsfieldii*	–	–	–	–	S	IUCN: LC
30	*Rhinolophus affinis*	S	S	–	S	S	IUCN: LC
31	*Rhinolophus chaseni*	S	–	–	–	–	New record for the region of the Hue City. IUCN: Not Evaluated
32	*Rhinolophus lepidus*	–	S	–	–	S	IUCN: LC
33	*Rhinolophus macrotis*	–	–	–	–	S	IUCN: LC

Table 2 (*continue*)

No.	Species	This study			Ly *et al*., 2019		Comments
		SLH	PD	BHV	SLQ	ST	
34	*Rhinolophus malayanus*	–	–	–	–	S	IUCN: LC
35	*Rhinolophus microglobosus*	S	S	–	S	S	New record for the region of the Hue City. IUCN: LC
36	*Rhinolophus pearsonii*	–	–	–	S	S	IUCN: LC
37	*Rhinolophus perniger*	S	S	–	–	S	Ly *et al*. (2019) listed this species as *Rhinolophus luctus*. IUCN: LC
38	*Rhinolophus pusillus*	S	–	–	S	S	IUCN: LC
39	*Rhizomys pruinosus*	S	O	O	O	O	IUCN: LC
40	*Rousettus leschenaulti*	–	–	–	–	S	IUCN: NT
41	*Scotomanes ornatus*	S	–	–	S	–	IUCN: LC, VRDB (2024): EN
42	*Sphaerias blanfordi*	–	S	–	S	–	IUCN: LC
43	*Tylonycteris fulvida*	S	S	–	–	S	IUCN: Not Evaluated
44	*Tylonycteris malayana*	S	–	–	S	S	IUCN: Not Evaluated
45	*Callosciurus erythraeus*	S	O	S	S+O	S+O	Common species. IUCN: LC
46	*Callosciurus inornatus*	–	–	–	–	S	IUCN: LC
47	*Dremomys rufigenis*	O	O	S	S+O	S+O	IUCN: LC
48	*Menetes berdmorei*	–	–	–	S+O	S	IUCN: LC
49	*Mus musculus*	–	–	–	–	S	IUCN: Not Evaluated
50	*Hylopetes alboniger*	O	O	O	O	O	IUCN: LC, VRDB (2024): VU
51	*Petaurista philippensis*	O	O	–	O	O	IUCN: LC, VRDB (2024): VU
52	*Ratufa bicolor*	O	O	O	O	O	IUCN: NT
53	*Tamiops rodolphii*	O	O	O	S+O	S+O	IUCN: LC
54	*Berylmys bowersi*	–	–	–	S	S	IUCN: LC
55	*Dacnomys millardi*	S	–	–	S	S	New record for the region of the Hue City
56	*Leopodamys* cf. *revertens*	S	S	S	S	S	Common species
57	*Maxomys surifer*	S	–	–	S	S	IUCN: LC
58	*Niviventer fulvesens*	S	–	S	–	–	IUCN: Not Evaluated
59	*Niviventer huang*	–	–	–	–	S	IUCN: Not Evaluated
60	*Suncus murinus*	–	–	–	S	S	IUCN: LC
61	*Rattus exulans*	S	–	–	–	S	IUCN: LC
62	*Rattus nitidus*	–	–	–	–	S	IUCN: LC
63	*Rattus tanezumi*	–	–	–	–	S	IUCN: LC
64	*Atherurus macrourus*	–	–	–	O	O	IUCN: LC
65	*Hystrix brachyura*	–	–	–	O	O	IUCN: LC
Total		**35**	**19**	**12**	**34**	**56**	

Table 3. The Sørensen–Dice index compares the similarity between five protected areas.

	Sao la Hue	Phong Dien	Bac Hai Van	Sao la Quang Nam	Song Thanh
Sao la Hue	1				
Phong Dien	0.59	1			
Bac Hai Van	0.47	0.58	1		
Sao la Quang Nam	0.64	0.53	0.43	1	
Song Thanh	0.62	0.48	0.29	0.64	1

tween the Sao la Hue NR and Phong Dien NR remained relatively high (Cs = 0.59).

Overall, the inland protected areas (Sao la Hue NR, Phong Dien NR, Sao la Quang Nam NR, and Song Thanh NP) exhibited a moderate faunal similarity, with index values ranging from 0.48 to 0.64. By contrast, the Bac Hai Van NR was found to be the most faunistically distinct site. It demonstrated only a low to moderate similarity with the other reserves, with index values ranging from 0.29 to 0.58. The lowest overlap was recorded between the Bac Hai Van NR and Song Thanh NP (Cs = 0.29), which highlights the unique species composition of this coastal reserve compared to the inland corridor.

Key species recorded from three protected areas

Family Tupaiidae

Tupaia belangeri (Wagner, 1841)

Morphology (*n*=2): HB = 180–185, TL = 150–180, HF= 40–43, E = 15.

This is a widespread and common species in Vietnam (Francis, 2019). During our surveys, a total of six individuals were recorded. Two individuals were collected in the Bac Hai Van NR at an altitude of 450 m a.s.l., within primary forest areas. Four individuals were observed in the Sao la Hue NR and Phong Dien NR, but no specimens were collected at these sites.

Family Soricidae

Crocidura tanakae Kuroda, 1938

Morphology (*n*=11): HB = 77–85, TL = 47–57, HF = 12.2–13.4, E = 8.2–9.5.

This species is widely distributed across the northern to southern Annamite regions in Vietnam, as well as in Khammuan and Phongsali provinces in Laos (Clayton, 2016, Abramov *et al*., 2013, 2021). During the present survey, both Sherman traps and pitfall traps were used to capture shrews. However, the specimens of *C. tanakae* were collected exclusively using pitfall traps at the elevations of around 800 m a.s.l. A total of 11 specimens were collected, all of which were from the Sao la Hue NR.

Crocidura kegoensis Lunde, Musser et Ziegler, 2004

Morphology (*n*=5): HB = 48–52.5, TL = 33.5–40, HF = 9.4–10.4, E = 4.8–5.1.

Until now, this small shrew, which is only found in the Hue City region, was identified as *Crocidura zaitsevi*. However, Bannikova *et al*. (2023) reclassified *C. zaitsevi* as a synonym of *C. kegoensis*. This species has a wide distribution across southern and central Vietnam (Abramov *et al*., 2013; Bannikova *et al*., 2023). Abramov (2021) also suggested that *C. kegoensis* may occur in Laos. In 2018, five specimens of *C. kegoensis* were collected in the Sao la Hue NR using pitfall traps at elevations ranging from 797 to 965 m a.s.l.

Fig. 3. *Chimarrogale varennei*. Photographed by Bui Tuan Hai.

Chimarrogale varennei Thomas, 1927

Morphology (*n* = 4): HB = 94–108, TL = 87.5–88, HF = 21.8–22.4, E = 5.0–6.8.

This species (Fig. 3) is widespread, ranging from the former Quang Binh Province to Lam Dong Province (Abramov *et al*., 2017; Bui *et al*., 2023). Ly *et al*. (2019) also recorded this species near the border between the Sao la Hue NR and Sao la Quang Nam NR. During the present survey, four specimens of Varenne's water shrew were collected in the Sao la Hue NR along streams at elevations ranging from 450 to 620 m a.s.l., using local cage traps baited with crabs. This study suggests that cage traps are more effective than pitfall traps (large buckets) with drift fences for capturing *Chimarrogale*.

Family Talpidae

Euroscaptor ngoclinhensis Zemlemerova, Bannikova, Lebedev, Rozhnov et Abramov, 2016

Morphology (*n* = 2): HB = 121–123, TL = 14.4–15.0, HF = 16.2–16.9, FF = 18.1–18.7.

The Ngoc Linh mole was originally described by Zemlemerova *et al*. (2016) as a subspecies of *Euroscaptor parvidens*. However, based on a distinct skull morphology and multivariate statistical analyses, Bui *et al*. (2020) elevated its status to that of a full species. During our surveys, three specimens were collected from the Sao la Hue NR (one in 2018 and two in 2023). The 2018 specimen, collected at an altitude of 956 m a.s.l., was previously identified by Bui *et al*. (2020) as *E. parvidens*. However, the present study confirms, based on both morphology and molecular data, that all three specimens represent *E. ngoclinhensis*, marking the first record of this species in the region of the Hue City.

Family Sciuridae

Petaurista philippensis (Elliot, 1839)

The giant flying squirrel is sporadically distributed across most forest areas of Vietnam, from the northern mountainous regions to the Central Highlands and the southeast regions (Wilson & Mittermeier, 2018). This species is arboreal and nocturnal. During the present survey, several individuals were photographed near the Cha Lenh Ranger Station in the Sao la Hue NR at an altitude of 541 m a.s.l., in the Phong Dien NR at an altitude of 620 m a.s.l. and in Bac Hai Van at an altitude of 518 m a.s.l.

Dremomys rufigenis Blanford, 1878

Morphology (*n*=4): HB = 190–200, TL = 140–170, HF = 44–44.5, E = 23.2–24.5.

This species is widespread in Vietnam (Balakirev *et al*., 2022). A total of nine individuals were recorded in the surveyed area, including four specimens that were trapped and five that were observed in the wild. This species is distributed at elevations ranging from 400 to 800 m a.s.l. Unlike *Callosciurus erythraeus*, *D. rufigenis* is primarily active on the ground when feeding and only occasionally moves to the canopy. Field observations suggest that this species is relatively common in the area and appears to have a large population. Two individuals were observed in the Sao la Hue NR at an altitude of 450 m a.s.l., three individuals were observed in the Phong Dien NR at an altitude of 421 m a.s.l., and four specimens were collected from the Bac Hai Van NR (620 m a.s.l.).

Fig. 4. *Ratufa bicolor*. Photographed by Le Manh Hung.

Ratufa bicolor (Sparrman, 1778)

Ratufa bicolor (Fig. 4) is scattered throughout old-growth and good primary forests across entire Vietnam, from the northern mountainous provinces to the south-east region, including Central Vietnam and the Central Highlands, (Duckworth & Hedges, 2016). It generally inhabits tall trees and is active during the day, especially in the early morning and late afternoon. During the 2018 survey, four individuals were observed: two in the Sao la Hue NR in the late afternoon and at an altitude of 541 m a.s.l., and two in the Phong Dien and Bac Hai Van NRs in the early morning at the altitude of 797 m and 956 m a.s.l., respectively.

Hylopetes alboniger (Hodgson, 1836)

The particolored flying squirrel has a wide distribution across Southeast Asia, including Vietnam (Thorington *et al*., 2012). During the current field survey, an individual was observed alive in the evening in the Sao la Hue NR. In addition to this direct observation, local residents captured another squirrel and presented it to our team.

Tamiops rodolphii (Edwards, 1867)

In Vietnam, this species (Fig. 5) is found south of the Song Ca River (Nghe An Province), where it is said to have a high population density. It is primarily active in the canopy, where it feeds on bark and young leaves, as well as occasionally feeding on ground-dwelling insects. During the present survey, six individuals were observed in various habitats, including natural and timber forests with medium- to small-sized trees, in all three nature reserves. Three individuals were recorded in the bamboo forest of the Sao la Hue NR, primarily at elevations between 500 and 700 m a.s.l.

Fig. 5. *Tamiops rodolphii*. Photographed by Nguyen Truong Son.

Fig. 6. *Maxomys surifer*. Photographed by Nguyen Truong Son.

Family Muridae

Maxomys surifer (Miller, 1900)

Morphology (*n*=2): HB = 175–187, TL = 171–188, HF = 35.7–35.5, E = 23.2–25.1.

This rat (Fig. 6) is a common rodent that is widely distributed throughout forests in Vietnam, from the northern mountains and central regions to the south-east and south-west (Balakirev *et al*., 2017). Despite being considered widespread, only two individuals of this species were recorded during the survey. These were collected from the Sao la Hue NR along a small stream and near the Sao la Hue Ranger Station, at an elevation of approximately 700 m a.s.l.

Leopoldamys cf. *revertens* (Robinson et Kloss, 1922)

Morphology (*n* = 14): HB = 252–282, TL = 270–320, HF = 44.2–46.3, E = 29.5–31.3.

This species (Fig. 7) is widely distributed, ranging from mountain forest habitats in northern Vietnam to lowland areas in southern Vietnam. It has also been recorded in Laos and Thailand (Balakirev *et al*., 2013). It is the most common species in the family Muridae in the three study areas when observed and collected

Fig. 7. *Leopoldamys* cf. *revertens*. Photographed by Nguyen Truong Son.

Fig. 8. *Rhizomys pruinosus*. Photographed by Nguyen Truong Son.

in various habitats, ranging from waterfalls and bamboo forests to secondary forests and hills. A total of 14 specimens were collected: two individuals from the Sao la Hue NR (752 m a.s.l.), three individuals from the Phong Dien NR (620 m a.s.l.) in 2018, and nine individuals from the Bac Hai Van NR (170–500 m a.s.l.).

Rattus exulans (Peale, 1849)

Morphology (*n* = 4): HB = 123–135, TL = 139–151, HF = 23.3–24.9, E = 16.5–17.8.

The species occurs in all the three NRs, but was only collected from the Sao la Hue NR in 2018, at an elevation of ~700 m a.s.l. Four specimens were captured using local cage traps set up in secondary forests near local households and agricultural fields.

Family Spalacidae

Rhizomys pruinosus Blyth, 1851

Morphology (*n*=2): HB = 320–340, TL = 120–125, HF = 45.9–50.1, E = 18.5–20.9.

Rhizomys pruinosus (Fig. 8) is a widespread and common species in Vietnam (Dang *et al*., 2008; Francis, 2019). It seems to prefer hilly bamboo forests mixed up with scrub and grass (Lunde & Son, 2001). These habitats are common in the areas surveyed, at the altitudes below 700 m a.s.l. During the present survey, individuals were collected from the wild in the Phong Dien NR and were also observed in habitats such as bamboo and secondary forests. One specimen was observed in a local restaurant in A Dot Commune (A Luoi District) of Sao la Hue NR.

Family Vespertilionidae

Murina feae (Thomas, 1891)

Morphology (*n* = 3): HB = 40.3–45.7, TL = 34–34.5, HF = 7.5–8.4, E = 11.3–14.4, FA = 26.5–29.8.

The species (Fig. 9) was initially described as *M. cineracea* and was referred to as such until the discovery of its senior synonym *M. feae* (Francis & Eger, 2012). This tube-nosed bat has been reported in 18 Vietnamese provinces (including the former provinces; Nguyen *et al*., 2015), making it one of the most widespread *Murina* species in the country. An adult female and an adult male were captured in the Sao la Hue NR using mist nets in bamboo forest, and one individual was captured in a ravine with secondary forest in the Phong Dien NR (541 m a.s.l.).

Kerivoula kachinensis Bates, Struebig, Rossiter, Kingston, Sai Sein Lin Oo et Mya Mya, 2004

Morphology (*n* = 3): HB = 48.1–50.9, TL = 58.1–59.5, HF = 9.3–10.1, E = 15.4–15.9, FA = 39.3–39.8.

This is the one of the two largest species of the genus *Kerivoula* recorded in Vietnam (Fig. 10). It was first reported in Chu Mom Ray (Kon Tum) and Muong Muon (Lai Chau) (Vu *et al*., 2006). More recently, it was found in the Pu Huong NR (Nghe An) (Dang *et al*., 2008) and Bu Gia Map (Binh Phuoc) (Kruskop, 2013). During the present survey, three individuals were captured by mist net in a bamboo and small tree forest

Fig. 9. *Murina feae*. Photographed by Nguyen Truong Son.

Fig. 10. *Kerivoula kachinensis*. Photographed by Nguyen Truong Son.

habitat, close to a large stream in the Sao la Hue NR in 2018.

Family Hipposideridae

Hipposideros grandis Allen, 1936

Morphology (*n*=11): HB = 69.03–72.3, TL = 31.3–37.8, HF = 10.9–14.5, E = 22–23, FA = 60.6–61.5.

This bat (Fig. 11) belongs to the "*larvatus*" species group. It was previously treated as conspecific with *H. larvatus* but was then regarded as a distinct species by Thabah *et al*. (2006). This latter view has since been adopted by Smith & Xie (2008), Kruskop (2013), and confirmed in the study conducted by Yuzefovich *et al*. (2022). However, the taxonomic status of this species still requires clarification in order to distinguish it from other taxa in the same species group and to determine its range. The grand leaf-nosed bat inhabits primary to semideciduous forests, as well as disturbed habitats such as orchards. It forages in the vegetation around limestone outcrops and in the forest understory and open spaces of orchards (Wilson & Mittermeier, 2019). During the present surveys, two specimens of *Hipposideros grandis* were captured in the Phong Dien NR (628 m a.s.l.) and nine from the Bac Hai Van NR (170 m a.s.l.). All the specimens were collected using harp traps.

Fig. 11. *Hipposideros grandis*. Photographed by Nguyen Truong Son.

Hipposideros gentilis Andersen, 1911

Morphology (*n*=16): HB = 35.5–36, TL = 28.5–34.5, HF = 6.0–8.1, E = 19.2–23, FA = 40.8–42.5.

Fig. 12. *Hipposideros gentilis*. Photographed by Nguyen Truong Son.

Based on body and bacular morphology, Srinivasulu & Srinivasulu (2018) elevated *H. gentilis* Andersen, 1918 to a species of its own, and proposed that *H. pomona* Andersen, 1918 sensu stricto is confined to southern India, while *H. gentilis* sensu lato is found from north-east India to south-east Asia. Little is known about the habitat and ecology of this species except that it roosts in small colonies of a few individuals in caves and crevices in subterranean habitats (Bates & Harrison 1997; Molur *et al*., 2002). It is a common species (Fig. 12) in the Sao la Hue NR area, with many individuals observed flying over streams. In 2018, 16 individuals were collected at an altitude of 541–620 m a.s.l. To date, this species has not yet been recorded in the Phong Dien and Bac Hai Van NRs.

Fig. 13. *Rhinolophus perniger*. Photographed by Nguyen Truong Son.

Fig. 14. *Rhinolophus microglobosus*. Photographed by Nguyen Truong Son.

Family Rhinolophidae

Rhinolophus perniger Hodgson, 1843

Morphology (*n*=2): HB = 81.8–92.2, TL = 51.7–56.7, HF = 16.9–17.6, E = 38.8–39.1, FA = 68.5–72.5.

Previously, this species was classified as *R. luctus* (Kruskop, 2013; Ly *et al.*, 2019), but based on karyological and morphological data, it is now recognized as a distinct species (Volleth *et al*., 2015). The species was initially considered *R. lanosus*, but the name *perniger* has a priority over it (Volleth *et al*., 2017; Burgin, 2019). Two specimens (Fig. 13) were found in the Sao la Hue NR in 2018 at an altitude between 450 m a.s.l. and 552 m a.s.l., but none were found in the other two nature reserves.

Rhinolophus microglobosus Csorba et Jenkins, 1998

Morphology (*n* = 8): HB = 44.1–52.4, TL = 18–19.4, HF = 8.0–8.7, E = 16.4–17.9, FA= 43.5–45.4.

This bat (Fig. 14) was originally described and for a time considered a subspecies of *R. stheno* (Csorba & Jenkins, 1998; Simmons *et al*., 2005). However, based on body size and skull characters (it generally has a smaller size and a higher calling frequency), it was determined to be a distinct species (Soisook *et al*., 2008). Nevertheless, it is sometimes considered conspecific with *R. stheno* sensu stricto. This species was found in all three protected areas with a total of ten specimens recorded. Nine were collected from the Sao la Hue NR and one from the Phong Dien NR. Three specimens were caught by harp traps and seven by mist nets along small, shallow streams.

Discussion

This paper presents the first systematic inventory of small mammals in the Sao la Hue NR, the Phong Dien NR, and the Bac Hai Van NR. It reveals a rich faunal assemblage comprising 38 species. The high species richness, particularly in the Sao la Hue NR (*n* = 35), highlights the critical importance of this region within the Annamite biodiversity hotspot. Com-

pared with the findings of Vu & Tran (2005), eight additional bat species have been documented in the Hue City. The discovery of nine new distributional records (including the first confirmed occurrence of *Euroscaptor ngoclinhensis* in the Hue City region) suggests that the area is significantly under-surveyed and may harbor additional unrecorded species.

Analysis of faunal similarity has revealed a clear biogeographical pattern structured along the inland-to-coastal gradient. The relatively high similarity index between Sao la Hue and Phong Dien (Cs = 0.59) and their moderate to high overlap with adjacent Song Thanh NP and Sao la Quang Nam NR, suggests that these inland protected areas function as a relatively contiguous ecological unit. This connectivity is vital for the persistence of wide-ranging species and the maintenance of regional metapopulations. By contrast, the Bac Hai Van NR emerges as the most faunistically distinct site, exhibiting low to moderate similarity with all the other reserves (Cs = 0.29–0.58). This distinction is likely due to a combination of factors, including its geographical position within a disjunct coastal mountain range, the potential historical isolation, and a greater habitat fragmentation resulting from its proximity to coastal development. The unique species composition of the Bac Hai Van emphasizes its importance as a separate conservation unit, which may harbor locally adapted populations or species assemblages not found further inland. Additionally, it should be noted that the lower diversity observed in the Bac Hai Van NR may be attributed to its small area and the limited research efforts conducted during this study.

From a conservation perspective, it is important to document the species listed in the Vietnam Red Data Book (VRDB, 2024) and the IUCN. The presence of the Near Threatened *Ratufa bicolor* (IUCN) and the Vulnerable *Hylopetes alboniger* (VRDB) in all three reserves, as well as the Vulnerable *Petaurista philippensis* (VRDB) in two reserves, indicates that the forest canopy is intact enough to support these species. This finding alone elevates the conservation priority of the region and provides a strong justification for enhanced habitat protection measures.

While this study provides a solid baseline, there are several limitations that should be noted. Firstly, the survey periods were relatively short and may not have reflected the full extent of seasonal variation in species activity or occurrence. Additionally, some cryptic or trap-shy species may have been undersampled. Future research should involve long-term monitoring and the broader use of non-invasive techniques, such as camera trapping and acoustic monitoring for bats. Genetic analyses should also be incorporated. Molecular data will be particularly important for clarifying the taxonomic status of morphologically similar species and for evaluating the genetic connectivity or isolation among populations within these reserves, especially with regard to the Bac Hai Van distinct fauna.

Conclusion

The present study reports on 38 species of small mammals occurring in three nature reserves in the region of the Hue City: Sao la Hue NR, Phong Dien NR, and Bac Hai Van NR. The species compositions differed among the surveyed reserves, with Sao la Hue and Phong Dien showing the greatest similarity, which is likely to reflect stronger habitat connectivity. Bac Hai Van exhibited the lowest similarity, potentially due to fragmented landscapes and a greater human disturbance. Species of conservation concern were also recorded highlighting the ecological significance of these areas. To ensure the long-term conservation, management should prioritize maintaining forest connectivity, restoring degraded habitats and strengthening protection measures. Together, the three reserves are vital for conserving small mammals in central Vietnam and should be given high priority in regional biodiversity planning.

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