

Shrews (Mammalia: Eulipotyphla: Soricidae) from Mt. Tay Con Linh, Ha Giang Province, northeast Vietnam

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Abstract We collected soricid shrews of the order Eulipotyphla from March 15 to 27, 2017 on Mt. Tay Con Linh, Ha Giang Province, northeast Vietnam, to investigate species composition and changes over the past 16 years. A total of 35 individuals of the family Soricidae, comprising five genera and the following seven species, were obtained: *Anourosorex squamipes*, *Blarinella quadraticauda*, *Chimarrogale himalayica*, *Chodsigoa caovansunga*, *Chodsigoa hoffmanni*, *Crocidura dracula*, and *Crocidura wuchihensis*. These are the first records of *Anourosorex squamipes* and *Chimarrogale himalayica* in Ha Giang Province. There was no evidence of the presence in this study, of the soricid shrew *Crocidura attenuata* or the talpid mole *Scaptonyx fusicauda*, two eulipotyphlan species that were previously recorded. Logging and an expanded plantation of the Chinese cardamom (*Lanxangia tsaoko*) were observed along the trails. Four individuals from three species were collected in the plantation area, while thirty-one individuals from six species were collected in habitats similar to those reported previously. The Chinese cardamom plantation and logging might have affected the habitat and distribution of the terrestrial shrew species.

Key words : biodiversity, distribution, shrews, northeast Vietnam.

Introduction

The Vietnam–China frontier area is an important region in terms of the biogeographic distribution of the mammalian order Eulipotyphla. The mountainous areas in northern Vietnam are interesting in zoogeography (Fooden, 1996; Le *et al.*, 2015) and host a number of eulipotyphlan

species distributed in subtropical–tropical regions, such as *Crocidura attenuata*, *Neotetracus sinensis*, and *Chimarrogale himalayica* (Abramov *et al.*, 2013, 2017), as well as several species with stronger affinities to the fauna of southwestern China than to the rest of Vietnam, such as *Mogera latouchei*, *Anourosorex squamipes*, *Blarinella quadraticauda*, and *Scaptonyx fusicauda* (Sterling and Hurley, 2005; Abramov *et al.*, 2013). Furthermore, one shrew species,

Chodsigoa caovansunga, was originally described from Mt. Tay Con Linh in Ha Giang Province, northeast Vietnam, and has a limited distribution at the frontier on secluded mountains (Lunde *et al.*, 2003; He *et al.*, 2012). These mountains are currently under threat due to human encroachment of habitats, and the native fauna is disappearing (Sterling and Hurley, 2005). Artificial habitat modification is generally thought to affect species diversity and the distribution of animals, but there are few reports on eulipotyphlan species inhabiting the mountains of northern Vietnam.

In this study, we surveyed eulipotyphlan species, especially soricid shrews, on Mt. Tay Con Linh, Ha Giang Province, northeast Vietnam. The diversity and habitat of Eulipotyphla on this mountain was previously reported in Lunde *et al.* (2003) based on the survey in 2001; we attempted to update the species composition on Mt. Tay Con Linh and to note any changes in composition, as well as discuss the species diversity of soricid shrews in the mountains of northern Vietnam.

Materials and Methods

Study area

On Mt. Tay Con Linh (22°46'24"N, 104°48'40"E; Fig. 1A), shrew trapping was con-

ducted from March 15 to 27, 2017 at nine trapping sites set on trails ranging from 1100 to 2100 m in elevation (Fig. 1B). This mountain area is a protected national forest with a highest peak of 2427 m and no previous flooding, fires, or invasive alien species have been recorded. Although logging and Chinese cardamom (*Lanxangia tsaoko*) plantation were not reported in Lunde *et al.* (2003), such activities were ongoing during our survey along the trails extending to the higher-elevation site (2100 m). Following the information from local people, plantation started in around 1995. The plantation area was still limited under 1500 m in elevation in 2001 when Lunde *et al.* (2003) made survey (Nguyen Truong Son, personal observation), while the plantation area has become larger and expanded into higher elevation by our survey in 2017. The air, ground, and water temperature ranges during our survey were measured at 1300 and 1850 m (minimum–maximum): air = 9.5–18.6°C, ground = 14.9–17.2°C, and water = 13.7–14.2°C at 1300 m; air = 14.1–17.2°C, ground = 12.6–14.2°C, and water = 13.2–13.4°C at 1850 m. The peripheral vegetation along trails was as follows.

1100–1200 m. Subtropical forest with an estimated canopy height of 20–25 m; the understory of the subtropical forest was covered by shrubs, saplings, hollow bamboo, and woody lianas.

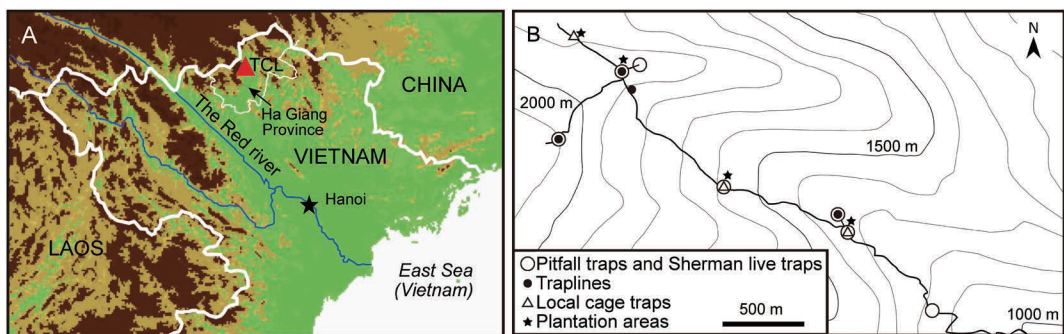


Fig. 1. (A) Map of northern Vietnam with the location of Mt. Tay Con Linh (TCL), Ha Giang Province. This mountain is connected with southern China via a montane region above 1000 m in altitude (dark brown) and is also connected with other mountains in Ha Giang Province above an altitude of 500 m (light brown). (B) Map of Mt. Tay Con Linh showing trapping sites and the type of traps along trails between 1100 and 2100 m in altitude.

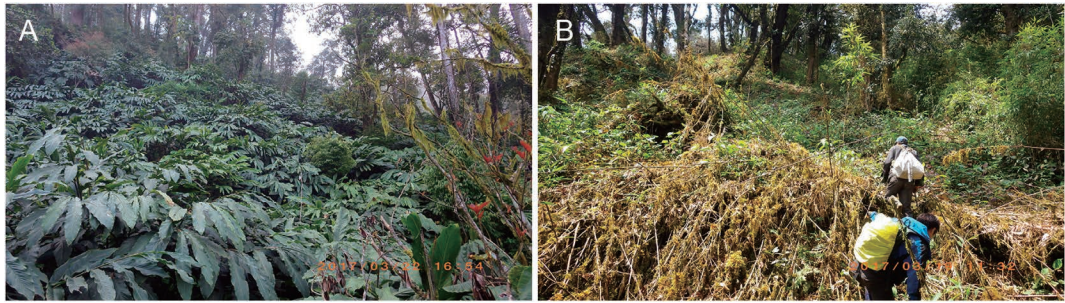


Fig. 2. (A) Habitat at approximately 1600-m altitude on Mt. Tay Con Linh, Ha Giang Province, northeast Vietnam. A plantation of Chinese cardamom (*Lanxangia tsaoko*) occupied the understory (forward) of fragmented subtropical trees (backward). (B) Habitat at approximately 2100-m altitude on Mt. Tay Con Linh. The forest and bamboo shrubs were cut down to prepare for Chinese cardamom plantation (forward) and disturbed forests still remain (backward).

1200–1850 m. Plantation of Chinese cardamom with limited subtropical trees and understory of herbaceous plants (Fig. 2A); the average vegetation height in the plantation was estimated at approximately 1.5–2.0 m; patches of disturbed subtropical forest with understory similar to that below 1200 m remained, with an estimated average canopy height of ~20 m; the trail crossed several small clear streams in the plantation area; stream widths were 0.5–1.5 m and depths were shallower than 0.5 m; the streambed was composed of soil mixtures, rocks, and fallen trees; there were many tadpoles and some aquatic insects, such as larvae of the orders Plecoptera, Diptera, and Odonata.

1850–2100 m. Disturbed forests with an estimated average open canopy height of 10–15 m; the understory was small bamboo; logging was ongoing below the highest trapping site (Fig. 2B); the area northwest of the crossing point of our trails was dominated by a plantation of Chinese cardamom; there were branched clear water streams of 1–3 m in width; the habitats around streams were similar to those described below 1850 m.

Trapping method

A variety of traps, including pitfall traps (plastic cup of height 150 mm × diameter 95 or 115 mm), Sherman live traps (7.5 × 7.5 × 24 cm), and local cage traps (15 × 15 × 25 cm)

were used to collect animals. Traplines of pitfall traps were set with fences made from plastic sheets at four trapping sites (Fig. 1B). Three traplines set above an altitude of 1800 m were set from March 15 to 23, and a trapline set below the 1400 m altitude was set from March 23 to 27. Each trapline was checked every morning during the setting period. Pitfall traps were also set where shrews were likely to occur, such as at the sides of rocks and fallen trees, in dense shrubs, in dry rain channels, and along animal pathways at seven trapping sites (Fig. 1B). Sherman live traps were baited with oatmeal, cat food, or dried fish. Local cage traps were set streamside at three trapping sites (Fig. 1B) with tadpoles captured from the streams as bait. All traps except for pitfall traps in traplines were set for two or three successive nights and checked every morning.

Specimen examination

Specimens were fixed in 10% formalin solution (3.75% formaldehyde) and then preserved in 50% ethanol. Liver samples were preserved in 99% ethanol. Skulls were separated and cleaned. The following standard external measurements were taken using a ruler and digital caliper in the field: total length, tail length, ear length, hindfoot length, and forefoot length. Total length and tail length were measured to the nearest 0.5 mm. Values for head and body length were obtained by subtracting tail length from total length. Tail ratio

(%) was calculated as tail length/head and body length $\times 100\%$. Ear, hindfoot, and forefoot lengths were measured to the nearest 0.01 mm. The body weight was recorded to the nearest 0.1 g. Seven standard cranial and mandibular measurements were taken with digital calipers to the nearest 0.01 mm: condylo-incisive length, braincase breadth, width between upper molars, upper toothrow length, mandibular length (from the most posterior point of the condyle to the tip of the first incisor), mandibular height (at the coronoid process), and lower toothrow length. All specimen identifications were confirmed using both external and skull features. All specimens collected in our survey were deposited at the Department of Vertebrate Zoology, Institute of Ecology and Biological Resources (IEBR), Vietnam Academy of Science and Technology, Hanoi.

In addition, eight skull specimens from three *Chodsigoa hoffmanni* and five *Cho. caovansunga* that were collected from Mt. Tay Con Linh and studied by Lunde *et al.* (2003) were examined for comparisons. These specimens were once registered in the collection of the American Museum of Natural History (AMNH), New York, USA and now are kept at IEBR, Hanoi, while the remaining specimens of the two species by Lunde *et al.* (2003) are still kept in AMNH that we did not examine.

Results

A total of 36 individuals from seven species in the family Soricidae were collected between elevations of 1150 and 2100 m (Table 1): three individuals of *Chodsigoa hoffmanni*, four of *Cho. caovansunga*, two of *Chimarrogale himalayica*, nine of *Anourosorex squamipes*, two of *Blarinella quadraticauda*, seven of *Crocidura dracula*, and nine of *Cr. wuchihensis*. The shrew species captured in the Chinese cardamom plantation area were limited to only four individuals of three species (*Cho. caovansunga*, *Chi. himalayica*, and *B. quadraticauda*), whereas the other individuals were collected from natural habitats.

Family Soricidae Subfamily Soricinae

Chodsigoa hoffmanni Chen *et al.*, 2017

Three specimens were collected on a trap-line in dense bamboo shrubs at an altitude of 2100 m (Table 1). Lunde *et al.* (2003) reported the occurrence of this species at lower elevations (1500–1600 and 1900–2000 m), thus the altitudinal range on Mt. Tay Con Linh is 1500–2100 m. Although this species was reported as *Chodsigoa parca* by Lunde *et al.* (2003), specimens from

Table 1. Eulipotyphlan species from Mt. Tay Con Linh, Ha Giang Province, northeast Vietnam. The numbers of captured individuals are given along with the elevation (between 1100 and 2100 m), as well as the collection elevation by Lunde *et al.* (2003) (denoted by "L"; between 1300 and 2000 m). The elevation of 1700 m was only surveyed by Lunde *et al.* (2003). Asterisks indicate individuals captured in a Chinese cardamom plantation area. **One dead body picked up at 1400 m is included, but it was not included in the altitudinal distribution.

Species	n	Range	Altitude (m)						
			Number of traps (per night: P, pitfall traps; S, Sherman traps; C, cage traps)						
			1100–1200 P18, S28	1300–1400 P20, S13, C5	1500–1600 P30, S45, C2	1700	1800–1900 P48, S10	1900–2000 P80, S10	2000–2100 P23, S14
Family Soricidae									
<i>Chodsigoa hoffmanni</i>	3	1500–2100			L			L	3
<i>Chodsigoa caovansunga</i>	4	1300–2100		1/L	L	L	1/L	1*/L	1
<i>Chimarrogale himalayica</i>	2	1300–1900		1*			1*		
<i>Anourosorex squamipes</i>	9	1300–2100		1			1	3	4
<i>Blarinella quadraticauda</i>	2	1500–1900			1*/L	L	1		
<i>Crocidura dracula</i>	7**	1100–2100	1	2	L		1		2
<i>Crocidura wuchihensis</i>	9	1100–1600	2	7/L	L				
<i>Crocidura attenuata</i>	—	1300–2000		L	L		L	L	
Family Talpidae									
<i>Scaptomyx fuscicauda</i>	—	1300–1400		L					
Total	36		3	12	1		5	4	10

Yunnan Province in China and Mt. Tay Con Linh were subsequently separated and described as a new species, *Cho. hoffmanni*, by Chen *et al.* (2017). *Chodsigoa hoffmanni* is now known only from Mt. Tay Con Linh in Vietnam and Wuliang Shan and Ailao Shan in Yunnan Province in China (He, 2018c).

Chodsigoa caovansunga Lunde *et al.*, 2003

Four specimens were collected between 1300–2100 m in altitude (Table 1). Specimens were collected from dense bamboo shrubs, disturbed forest, and a Chinese cardamom plantation area. The updated altitudinal range on Mt. Tay Con

Linh, including information from Lunde *et al.* (2003), is 1300–2100 m. At 2100 m, this shrew cooccurs with the congeneric *Cho. hoffmanni*. In the external and cranial features (Tables 2 & 3, Figs. 3 & 4), *Cho. caovansunga* is clearly smaller than *Cho. hoffmanni*, thus distinguishing both species from each other. The features and cranium and mandible measurements of these two species were similar to those of specimens examined by Lunde *et al.* (2003) (Table 3). *Chodsigoa caovansunga* was originally described from Mt. Tay Con Linh by Lunde *et al.* (2003) and is currently known to inhabit only Mt. Tay Con Linh in Vietnam and Yunnan Province in China (He, 2018b).

Table 2. External measurements (in mm) of seven soricid shrew species collected from Mt. Tay Con Linh, Ha Giang Province, northeast Vietnam. Mean values and ranges (minimum–maximum) are given in the upper and lower rows, respectively. Raw values are given for *Chimarrogale himalayica* and *Blarinella quadraticauda*, as they were represented by only two individuals each.

Species	n	Body weight (in gram)	Head and body length (mm)	Tail length (mm)	Tail ratio (%)	Ear length (mm)	Hindfoot length (mm)	Forefoot length (mm)
<i>Chodsigoa hoffmanni</i>	3	10.7 9.3–13.1	78.0 74.0–84.0	77.0 72.0–86.0	98.6 96.1–102.4	8.16 7.68–8.60	15.89 15.16–16.94	10.32 10.26–10.40
<i>Chodsigoa caovansunga</i>	4	5.5 5.3–5.7	68.5 68.0–69.5	65.4 60.0–69.5	95.4 88.2–101.5	9.23 8.35–9.99	14.34 13.48–14.87	9.19 8.69–9.69
<i>Chimarrogale himalayica</i>	2	35.1, 31.3	125.0, 121.0	96.0, 82.0	76.8, 67.8	8.05, 11.88	21.81, 20.40	12.96, 13.33
<i>Anourosorex squamipes</i>	9	22.0 15.8–26.5	104.9 97.0–111.5	9.9 8.5–11.5	9.4 8.3–11.3	8.02 6.84–8.85	14.19 13.81–14.45	10.66 9.51–11.78
<i>Blarinella quadraticauda</i>	2	4.7, 5.5	73.5, 76.0	34.5, 32.0	46.9, 42.1	4.46, 669	10.94, 11.87	9.72, 9.01
<i>Crociodura dracula</i>	6	10.7 7.7–12.3	82.8 68.0–90.0	54.9 50.0–60.0	66.7 61.7–77.2	9.22 6.96–10.37	13.76 12.99–14.45	9.43 8.54–10.35
<i>Crociodura wuchihensis</i>	9	5.3 3.3–7.2	63.0 56.0–70.5	40.7 33.0–46.5	64.5 57.0–71.4	8.24 5.81–9.56	11.16 10.26–12.48	7.02 6.15–7.91

Table 3. Cranial and mandibular measurements (in mm) of seven soricid shrew species collected from Mt. Tay Con Linh, Ha Giang Province, northeast Vietnam. Mean values and ranges (minimum–maximum) are given in the upper and lower rows, respectively. Raw values are given for *Chimarrogale himalayica* and *Blarinella quadraticauda*, as they were represented by only two individuals each. For comparative and identification purposes, several specimens of *Chodsigoa hoffmanni* and *Cho. caovansunga* from Lunde *et al.* (2003) were also examined and measured.

Species		Condylar-incisive length	Braincase breadth	Width between upper molars	Upper toothrow length	Mandibular length	Mandibular height	Lower toothrow length
<i>Chodsigoa hoffmanni</i>	3	19.37 19.01–19.76	9.30 9.09–9.65	5.15 4.89–5.41	8.57 8.46–8.71	12.16 11.95–12.51	4.26 4.12–4.34	7.55 7.46–7.66
Lunde <i>et al.</i> (2003)'s	3	19.04 18.94–19.15	9.06 8.88–9.18	5.12 5.08–5.18	8.44 8.31–8.52	11.87 11.79–11.92	4.17 4.05–4.28	7.40 7.21–7.51
<i>Chodsigoa caovansunga</i>	4	17.77 17.45–18.20	8.56 8.29–8.88	5.01 4.89–5.10	7.88 7.74–8.05	11.19 11.03–11.39	3.83 3.54–4.09	7.31 7.23–7.40
Lunde <i>et al.</i> (2003)'s	5	17.60 17.28–17.95	8.43 8.25–8.51	4.95 4.72–5.14	7.75 7.53–7.91	10.87 10.57–11.10	3.96 3.72–4.25	7.04 6.93–7.25
<i>Chimarrogale himalayica</i>	2	27.83, 26.55	13.74, 13.30	8.55, 8.03	12.63, 11.79	17.75, 16.86	6.50, 6.31	11.45, 10.79
<i>Anourosorex squamipes</i>	9	24.79 24.22–25.31	13.96 13.66–14.28	7.49 7.04–7.73	10.88 10.60–11.54	16.55 15.97–16.91	7.08 6.77–7.35	10.40 10.22–10.68
<i>Blarinella quadraticauda</i>	2	19.91, 20.47	9.13, 9.02	5.15, 5.02	9.01, 9.15	12.40, 12.60	4.62, 4.59	8.27, 8.30
<i>Crociodura dracula</i>	7	20.66 20.29–21.08	9.26 9.00–9.52	6.21 5.90–6.61	9.30 8.85–9.98	12.98 12.70–13.21	4.84 4.51–4.96	8.27 8.16–8.32
<i>Crociodura wuchihensis</i>	9	16.17 14.68–17.09	7.64 7.16–8.02	5.21 4.34–7.91	7.00 6.78–7.30	9.84 9.55–10.33	3.77 3.67–4.00	6.41 6.23–6.77



Fig. 3. External features of (A) *Chodsigoa hoffmanni* (IEBR Motokawa-675), (B) *Chodsigoa caovansunga* (IEBR Motokawa-681), (C) *Chimarrogale himalayica* (IEBR Motokawa-715), (D) *Anourosorex squamipes* (IEBR Motokawa-685), (E) *Blarinella quadraticauda* (IEBR Motokawa-697), (F) *Crocidura dracula* (IEBR Motokawa-649), and (G) *Crocidura wuchihensis* (IEBR Motokawa-708). Scale bars: 50 mm.

***Chimarrogale himalayica* (Gray, 1842)**

Two specimens were collected in local cage traps set at two trapping sites at altitudes of 1300–1400 m and 1800–1900 m (Table 1). Both specimens were collected along a stream beside the plantation of Chinese cardamom. This is the first record of *Chi. himalayica* from Mt. Tay Con

Linh, as well as from Ha Giang Province. *Chimarrogale himalayica* is distributed in the southern Himalayas, southwestern China, northern Myanmar, Laos, and northern Vietnam (Abramov *et al.*, 2017; He, 2018d).

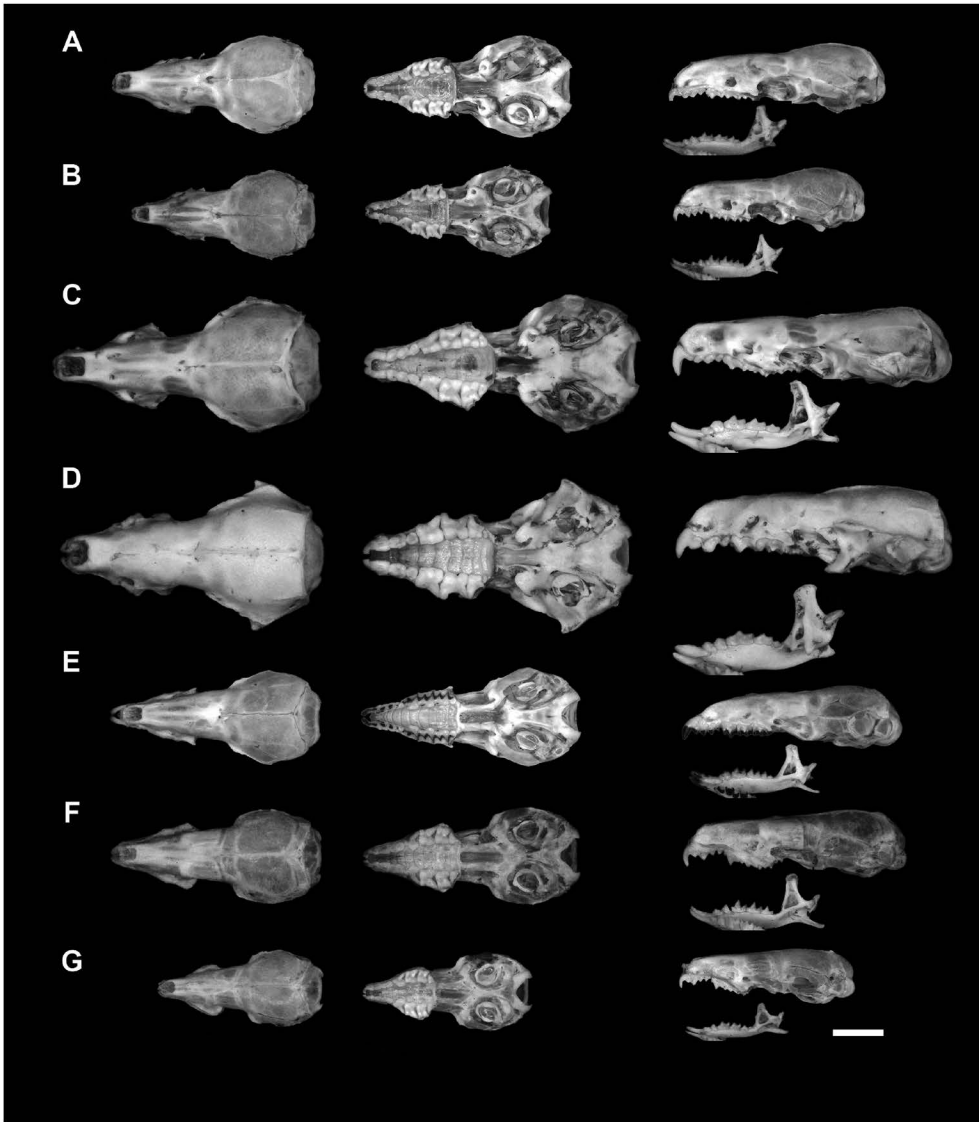


Fig. 4. Skulls (dorsal view, ventral view, left lateral view of cranium, and right lingual view of mandible) of (A) *Chodsigoa hoffmanni* (IEBR Motokawa-675), (B) *Chodsigoa caovansunga* (IEBR Motokawa-681), (C) *Chimarrogale himalayica* (IEBR Motokawa-715), (D) *Anourosorex squamipes* (IEBR Motokawa-685), (E) *Blarinella quadratacauda* (IEBR Motokawa-697), (F) *Crocidura dracula* (IEBR Motokawa-649), and (G) *Crocidura wuchihensis* (IEBR Motokawa-708). Scale bars: 5 mm.

***Anourosorex squamipes* Milne-Edwards, 1872**

Nine specimens were collected at altitudes of 1300–2100 m (Table 1). All specimens were collected from dense bamboo shrubs in disturbed forest. This species comprised 25% of the total shrew captures. This is the first record of *A.*

squamipes from Mt. Tay Con Linh, as well as from Ha Giang Province. *Anourosorex squamipes* is distributed in central and southern China, northern and eastern Myanmar, northern Laos, northern Vietnam, and northern Thailand (He, 2018a).

***Blarinella quadraticauda* Milne-Edwards, 1872**

Two specimens were collected from two trapping sites set at altitudes of 1500–1600 m and 1800–1900 m (Table 1). The specimens were collected from disturbed forest and the Chinese cardamom plantation. This species was formerly classified as *B. griselda* but is now regarded as *B. quadraticauda* (Bannikova *et al.*, 2019) after taxonomic revisions of the genus *Blarinella* (He *et al.*, 2018; Bannikova *et al.*, 2019). Lunde *et al.* (2003) reported *B. griselda* from 1500–1600 m and 1700 m, thus the altitudinal range on Mt. Tay Con Linh is regarded as 1500–1900 m. *Blarinella quadraticauda* is distributed in central and southwestern China and northern Vietnam (Bannikova *et al.*, 2019).

Subfamily Crocidurinae***Crocidura dracula* Thomas, 1912**

Six specimens were collected from altitudes of 1100–2100 m (Table 1). Specimens were collected from dense bamboo shrubs, disturbed forest, and the remaining subtropical forest. In addition, a dead body (IEBR Motokawa-696) was picked up on a trail at around 1400 m. This species' altitudinal range on Mt. Tay Con Linh is the widest among eulipotyphlan species at 1100–2100 m. *Crocidura dracula* is distributed in central and southcentral China, northern Laos, northern Vietnam, and northern Myanmar (He, 2018e).

***Crocidura wuchihensis* Wang, 1966**

Nine specimens were collected from altitudes of 1100–1400 m (Table 1). Including the information from Lunde *et al.* (2003), who reported ranges of 1300–1400 m and 1500–1600 m, the altitudinal range on Mt. Tay Con Linh is regarded as 1100–1600 m, with no records above 1700 m. *Crocidura wuchihensis* is distributed on Hainan Island and in Guangxi Province in southern China, and northern and central Vietnam (He, 2018g).

Discussion

Lunde *et al.* (2003) reported seven species of Eulipotyphla from Mt. Tay Con Linh: *Chodsigoa parca* (now *Cho. hoffmanni*, following Chen *et al.* [2017]), *Cho. caovansunga*, *Blarinella griselda* (now *B. quadraticauda*, following Bannikova *et al.* [2019]), *Crocidura fuliginosa* (now *Cr. dracula*, following Bannikova *et al.* [2011]), *Cr. attenuata*, and *Cr. wuchihensis* of Soricidae, and *Scaptonyx fusicauda* of Talpidae. Two species reported in Lunde *et al.* (2003), *Cr. attenuata* and *S. fusicauda*, were not collected during our survey.

Blarinella quadraticauda and *Cho. caovansunga* were captured in the Chinese cardamom plantation. In a previous study in China, *Cho. caovansunga* was reported to occur in a banana plantation (He *et al.*, 2012). These findings suggest that this species is less susceptible to habitat change. *Chodsigoa hoffmanni* was captured in habitats with a bamboo shrub understory in both our survey and in that of Lunde *et al.* (2003). Shrew species are believed to be threatened by habitat loss, degradation, and fragmentation (Molur *et al.*, 2005). In our study, a total of 33 individuals of six species from the family Soricidae were collected from traps set on the ground. Among these, only two individuals of two species were collected in the Chinese cardamom plantation area. This suggests that the Chinese cardamom plantation and logging affected the habitat and distribution of the terrestrial shrew species in different way depending on each species.

Scaptonyx fusicauda Milne-Edwards, 1872, a shrew mole species from the family Talpidae, was not captured in this study, even though this subfossorial species could be collected by pitfall traps and Sherman traps in Vietnam and China (Lunde *et al.*, 2003; Motokawa, unpublished data). *Scaptonyx fusicauda* is now known from central and southcentral China, northern Myanmar, and northern Vietnam (Kryštufek and Motokawa, 2018). Only one specimen of *S. fusicauda* have been reported from Vietnam, at an altitude

of 1300m on Mt. Tay Con Linh representing the southeasternmost range of the species (Lunde *et al.*, 2003; Abramov *et al.*, 2013). Further surveys are expected to clarify the distribution range of *S. fusicauda* on Mt. Tay Con Linh or mountains in northern Vietnam.

By contrast, our specimens represent the first records of *Anourosorex squamipes* and *Chimarrogale himalayica* from Mt. Tay Con Linh, Ha Giang Province, Vietnam. In Vietnam, *A. squamipes* has been found on mountains in three northern provinces, Lao Cai, Cao Bang, and Son La (Abramov *et al.*, 2013), although the record from Son La Province is based only on a faunal report without voucher specimens (Dang *et al.*, 2012). Mt. Tay Con Linh in Ha Giang Province and the other reported localities are all mountains connected to montane regions of southern China.

Capturing water shrew species of the genus *Chimarrogale* generally requires traps to be set streamside because the species is usually found along streams (Abe, 1992; Lunde and Musser, 2002; Lin and Motokawa, 2014). Therefore, we set traps streamside and successfully collected specimens of *Chi. himalayica* on Mt. Tay Con Linh for the first time. This finding adds a new locality to the several previously reported areas in mountains of northern Vietnam (Abramov *et al.*, 2013, 2017). This species is considered rare and the only semi-aquatic species of Eulipotyphla in northern Vietnam.

In Lunde *et al.* (2003), one individual of *Cr. fuliginosa* was reported from an altitude of 1500m, then was reidentified as *Cr. dracula* by Bannikova *et al.* (2011). In our survey, *Cr. dracula* had the widest altitudinal distribution among the collected species (Table 1). On the other hand, there was no evidence of the presence of *Cr. attenuata* in our survey. *Crociodura attenuata* was thought to be widespread in mainland Vietnam (Hutterer, 2005; Jenkins *et al.*, 2009). However, its distribution is restricted to only Mt. Tay Con Linh and Cat Ba Island (Hai Phong Province) after its separation from the cryptic species *Cr. tanakae* (Bannikova *et al.*, 2011; Abramov *et al.*, 2012, 2013; He, 2018f, 2018h; Li *et al.*,

2019).

From this study's results, Mt. Tay Con Linh hosts a high species diversity of soricid shrews of Eulipotyphla in Vietnam, possibly due to the wide altitudinal range available on the high mountain and its geographical location. To evaluate these factors, further studies on eulipotyphlan fauna in mountainous regions of northern Vietnam are needed, as well as comparisons with mountainous localities in southern China, northern Laos, northern Thailand, and northern Myanmar. Such surveys and studies are also desirable for the conservation of terrestrial mammals at the Vietnam–China frontier.

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References

- Abe, H. 1992. Capturing methods of insectivores. Honyurui Kagaku [Mammalian Science], 31: 139–143. (In Japanese)
- Abramov, A. V., A. A. Bannikova and V. V. Rozhnov 2012. White-toothed shrews (Mammalia, Soricomorpha, *Crociodura*) of coastal islands of Vietnam. *ZooKeys*, 207: 37–47.
- Abramov, A. V., D. N. Can, B. T. Ha and N. T. Son 2013. An annotated checklist of the insectivores (Mammalia, Lipotyphla) of Vietnam. *Russian Journal of Theriology*, 12: 57–70.
- Abramov, A. V., A. Bannikova and V. Rozhnov 2017. Revision of *Chimarrogale* (Lipotyphla: Soricidae) from Vietnam with comments on taxonomy and biogeography of Asiatic water shrews. *Zootaxa*, 4232: 216–230.
- Bannikova, A., A. V. Abramov, A. V. Borisenko, V. S. Lebedev and V. V. Rozhnov 2011. Mitochondrial diversity of the white-toothed shrews (Mammalia, Eulipotyphla, *Crociodura*) in Vietnam. *Zootaxa*, 2812: 1–20.
- Bannikova, A. A., P. D. Jenkins, E. N. Solovyeva, S. V. Pavlova, T. B. Demidova, S. A. Simanovsky, B. I. Shetel, V. S. Lebedev, Y. Fang, L. Dalen and A. V. Abramov 2019. Who are you, Griselda? A replacement name for a new genus of the Asiatic short-tailed shrews

- (Mammalia, Eulipotyphla, Soricidae): molecular and morphological analyses with the discussion of tribal affinities. *ZooKeys*, 888: 133–158.
- Chen, Z.-Z., K. He, C. Huang, T. Wan, L.-K. Lin, S.-Y. Liu and X.-L. Jiang 2017. Integrative systematic analyses of the genus *Chodsigoa* (Mammalia: Eulipotyphla: Soricidae), with descriptions of new species. *Zoological Journal of the Linnean Society*, 180: 694–713.
- Dang, N. X., N. X. Nghia, N. T. Son and T. H. Hai 2012. Study of mammals diversity in Xuan Nha and Muong Do Nature Reserves, Son La Province, Northwestern Vietnam. *Mammal Study*, 37: 55–62.
- Fooden, J. 1996. Zoogeography of Vietnam primates. *International Journal Primatology*, 17: 845–899.
- He, K. 2018a. Chinese mole shrew *Anourosorex squamipes*. In Wilson, E. D. and Mittermeier, A. R. (eds.): *Handbook of the Mammals of the World, Vol. 8 Insectivores, Sloths and Colugos*, pp. 447. Lynx Edicions, Barcelona.
- He, K. 2018b. Van Sung's brown-toothed shrew *Chodsigoa caovansunga*. In Wilson, E. D. and Mittermeier, A. R. (eds.): *Handbook of the Mammals of the World, Vol. 8 Insectivores, Sloths and Colugos*, p. 453. Lynx Edicions, Barcelona.
- He, K. 2018c. Hoffmann's brown-toothed shrew *Chodsigoa hoffmanni*. In Wilson, E. D. and Mittermeier, A. R. (eds.): *Handbook of the Mammals of the World, Vol. 8 Insectivores, Sloths and Colugos*, pp. 453–454. Lynx Edicions, Barcelona.
- He, K. 2018d. Himalayan water shrew *Chimarrogale himalayica*. In Wilson, E. D. and Mittermeier, A. R. (eds.): *Handbook of the Mammals of the World, Vol. 8 Insectivores, Sloths and Colugos*, p. 455. Lynx Edicions, Barcelona.
- He, K. 2018e. Large white-toothed shrew *Crociodura dracula*. In Wilson, E. D. and Mittermeier, A. R. (eds.): *Handbook of the Mammals of the World, Vol. 8 Insectivores, Sloths and Colugos*, p. 484. Lynx Edicions, Barcelona.
- He, K. 2018f. Asian gray white-toothed shrew *Crociodura attenuata*. In Wilson, E. D. and Mittermeier, A. R. (eds.): *Handbook of the Mammals of the World, Vol. 8 Insectivores, Sloths and Colugos*, pp. 485–486. Lynx Edicions, Barcelona.
- He, K. 2018g. Hainan white-toothed shrew *Crociodura wuchiensis*. In Wilson, E. D. and Mittermeier, A. R. (eds.): *Handbook of the Mammals of the World, Vol. 8 Insectivores, Sloths and Colugos*, p. 486. Lynx Edicions, Barcelona.
- He, K. 2018h. Taiwanese gray white-toothed shrew *Crociodura tanakae*. In Wilson, E. D. and Mittermeier, A. R. (eds.): *Handbook of the Mammals of the World, Vol. 8 Insectivores, Sloths and Colugos*, p. 491. Lynx Edicions, Barcelona.
- He, K., K. Deng and X.-L. Jiang 2012. First record of Van Sung's shrew (*Chodsigoa caovansunga*) in China. *Zoological Research*, 33: 542–544. (In Chinese with English abstract)
- He, K., X. Chen, P. Chen, S.-W. He, F. Chen, X.-L. Jiang and K. L. Campbell 2018. A new genus of Asiatic short-tailed shrew (Soricidae, Eulipotyphla) based on molecular and morphological comparisons. *Zoological Research*, 39: 309–323.
- Hutterer, R. 2005. Order Soricomorpha. In Wilson, D. E. and Reeder, D. M. (eds.): *Mammals Species of the World, A Taxonomic and Geographic Reference, Third edition*. pp. 220–311. The Johns Hopkins University Press, Baltimore.
- Jenkins, P. D., D. P. Lunde and C. B. Moncrieff 2009. Descriptions of new species of *Crociodura* (Soricomorpha: Soricidae) from mainland Southeast Asia, with synopses of previously described species and remarks on biogeography. *Bulletin of the American Museum of Natural History*, 331: 356–405.
- Kryštufek, B. and M. Motokawa 2018. Family Talpidae (moles, desmans, star-nosed moles and shrew moles). In Wilson, E. D. and Mittermeier, A. R. (eds.): *Handbook of the Mammals of the World, Vol. 8 Insectivores, Sloths and Colugos*, pp. 552–619. Lynx Edicions, Barcelona.
- Le, V. K., X. H. Nguyen and T. N. Nguyen 2015. *Zoogeography*. 401 pp. Hanoi National University Publishing House, Hanoi. [In Vietnamese]
- Li, Y., H. Li, M. Motokawa, Y. Wu, M. Harada, H. Sun, X. Mo, J. Wang and Y. Li 2019. A revision of the geographical distributions of the shrews *Crociodura tanakae* and *C. attenuata* based on genetic species identification in the mainland of China. *ZooKeys*, 869: 147–160.
- Lin, L.-K. and M. Motokawa 2014. *Mammals of Taiwan, Volume 1. Soricomorpha*. 89 pp. Center for Tropical Ecology and Biodiversity, Tunghai University, Taichung.
- Lunde, D. P. and G. G. Musser 2002. The capture of the Himalayan water shrew (*Chimarrogale himalayica*) in Vietnam. *Mammal Study*, 27: 137–140.
- Lunde, D. P., G. G. Musser and N. T. Son 2003. A survey of small mammals from Mt. Tay Con Linh II, Vietnam, with the description of a new species of *Chodsigoa* (Insectivora: Soricidae). *Mammal Study*, 28: 31–46.
- Molur, S., C. Srinivasulu, B. Srinivasulu, S. Walker, P. O. Nameer and L. Ravikumar 2005. Status of south Asian non-volant small mammals: conservation assessment and management plan (CAMP) workshop report. 618 pp. Zoo Outreach Organization/CBSG-South Asia, Coimbatore, India.
- Sterling, E. and M. Hurley 2005. Conserving biodiversity in Vietnam: Applying biogeography to conservation research. *Proceedings of the California Academy of Science*, 56: 98–114.

Appendix. Specimens examined.

Chodsigoa hoffmanni: IEBR-Motokawa 674, 675, 683, IEBR-AMNH 274166, 274240, 274286; *Cho. caovansunga*: IEBR-Motokawa 681, 682, 684, 709, IEBR-AMNH 273203, 273206, 274175, 274194, 274238; *Chimarrogale himalayica*: IEBR-Motokawa 686, 715; *Anourosorex squamipes*: IEBR-Motokawa 646, 647, 648, 658, 673, 677, 685, 694, 714; *Blarinella quadraticauda*: IEBR-Motokawa 672, 697; *Crocidura dracula*: IEBR-Motokawa 649, 676, 688, 696, 710, 711, 716; *Cr. wuchihensis*: IEBR-Motokawa 700, 701, 702, 703, 704, 707, 708, 712, 713.