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Surveys of bats (Mammalia, Chiroptera) in the Tay Con Linh Mountains, Vietnam

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ABSTRACT. The article summarizes the results of two surveys of the bat fauna of the Tay Con Linh mountain range in northern Vietnam (Ha Giang Province) on the border with China. Previously published data on these mountains showed the presence of a rich and unique fauna of rodents and, especially, insectivores, but information about chiropterans for this territory has so far been fragmentary. Surveys carried out in March 2017 and April 2023 at altitudes ranging from 570 to 2300 m asl identified at least 30 bat species from four families. Some of the species found are known in Indochina from isolated records and were first discovered in Ha Giang Province. The bat fauna of Tay Con Linh includes both widespread, ecologically flexible species (e.g., *Cynopterus sphinx*, *Rhinolophus affinis*), as well as species of the Indo-Himalayan fauna that penetrate into the territory of Vietnam along mountain ranges (e.g., *Mirostrellus joffrei*), species which distribution patterns are not clear due to extremely fragmented ranges (e.g., *Rhinolophus siamensis*, *Hipposideros khaokhouayensis*, *Arielulus* cf. *circumdatus*), and at least one Palearctic species (*Myotis altarium*). At the same time, due to the absence of karstic caves on the massif, there are no species obligately associated with karst, and petrophilic species are generally few in number. Most of widespread species are confined to low and medium elevations. On the contrary, a number of species (*Harpiola isodon*, *Murina chrysochaetes*, *M. huttoni*, *Myotis altarium*, *Arielulus* cf. *circumdatus*, *Mirostrellus joffrei*) were found only at altitudes of 1700 m asl and higher. It is noteworthy that these species are also known from the more western provinces of northern Vietnam, which suggests that the Red River (Hong Ha) valley does not play any significant role as an isolating barrier for bats.

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Изучение рукокрылых (Mammalia, Chiroptera) в горном массиве Тэйконлинь, Вьетнам

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РЕЗЮМЕ. В статье обобщены результаты двух исследований фауны рукокрылых в горном массиве Тэйконлинь на севере Вьетнама (провинция Хазянг) на границе с Китаем. Ранее опубликованные данные об этих горах показали наличие богатой и уникальной фауны грызунов и, особенно, насекомоядных, однако сведения о рукокрылых для этой территории в настоящее время носят отрывочный характер. Исследования, проведенные в марте 2017 года и апреле 2023 года на высоте от 570 до 2300 м над уровнем моря, выявили на Тэйконлине присутствие не менее 30 видов летучих мышей из четырех семейств. Некоторые из обнаруженных видов известны в Индокитае по единичным находкам и впервые указаны для провинции Хазянг. Фауна летучих мышей Тэйконлиня включает как широко распространенные, экологически пластичные виды (например, *Cynopterus sphinx*, *Rhinolophus affinis*), так и виды индо-гималайской фауны, проникающие на территорию Вьетнама по горным хребтам (например, *Mirostrellus joffrei*), виды, характер распространения которых не ясен из-за чрезвычайно фрагментированных ареалов (например, *Rhinolophus siamensis*, *Hipposideros khaokhouayensis*, *Arielulus* cf. *circumdatus*), и по крайней мере один палеарктический вид (*Myotis altarium*). В то же время из-за отсутствия карстовых пещер на массиве отсутствуют виды, облигатно связанные с карстом, а петрофильные виды, как правило, немногочисленны. Большинство широко распространенных видов приурочено к низким и средним высотам. Напротив, ряд видов (*Harpiola isodon*, *Murina chrysochaetes*, *M. huttoni*, *Myotis altarium*, *Arielulus* cf. *circumdatus*, *Mirostrellus joffrei*) обнаружены только на высотах 1700 м над уровнем моря и более. Примечательно, что эти виды известны и из более западных провинций Северного Вьетнама, что позволяет предположить, что долина реки Хонгха не играет существенной роли в качестве изолирующего барьера для рукокрылых.

КЛЮЧЕВЫЕ СЛОВА: рукокрылые, новые находки, зоогеография, Северный Вьетнам, провинция Хазанг, крылановые, листоносы, подковоносы, кожановые.

Introduction

The mammalian fauna and, in particular, bat fauna of the Vietnamese Ha Giang province has not been sufficiently studied. This fully applies to the Tay Con Linh mountain range, the location and elevation difference of which suggest the existence of a rich and distinctive mammalian fauna, including species that are not common for Vietnam. The latter is confirmed by a 2003 study (Lunde *et al.*, 2003), during which several unique finds of small mammals were made at Tay Con Linh, in particular, the Chinese mole species *Scaptonyx fusicauda* Milne-Edwards, 1872 and a new shrew species *Chodsigoa caovansunga* Lunde, Musser et Son, 2003, which has phylogenetic connections with the fauna of the eastern macroslopes of Tibet-Qinghai Plateau (Chen *et al.*, 2017). That survey though technically covering all small mammals, was particularly focused on rodents and insectivores, and only three bat species were reported in it, all from the family Pteropodidae: *Cynopterus sphinx* (Vahl, 1797), *Rousettus leschenaultii* (Desmarest, 1820) and *Sphaerias blanfordi* (Thomas, 1891). All three species are widespread across Vietnam and Southeast Asia in general (Kruskop, 2013; Francis, 2019) and do not represent any specific findings for the region. Later, Dang *et al*. (2004) mention two species of insectivorous chiropterans in the list of Tay Con Linh mammals: *Hipposideros armiger* (Hodgson, 1835) and *Pipistrellus* sp.

Second survey on Tay Con Linh small mammals was conducted by Institute of Ecology and Biological Resources (Hanoi) in March, 2017. Besides other groups, it was for the first time also focused on bats. Its results were published in detail concerning particularly shrews, Soricidae (Saito *et al.*, 2021). However, this survey revealed the second Vietnamese record of *Myotis altarium* Thomas, 1911, a mouse-eared bat distributed mainly in the mountains of central China (Vu *et al.*, 2018), which is in good agreement with the above faunal assumptions. Another bat species found there which record was already described in details was Joffre's pipistrelle, *Mirostrellus joffrei* (Thomas, 1915) (Görföl *et al.*, 2020). This bat was found on Tay Con Linh in an association with eight other species (including aforementioned *M. altarium*), but no details were published concerning records of these species. On the whole, it can be stated that there are rare and even intriguing faunal elements among bats of Tay Con Linh, but the existing published materials cannot exhaust even the background composition of the local chiropteran fauna, especially taking into account its location near zoogeographical boundaries and the large altitude gradient.

The next short-term survey on Tay Con Linh with main focus on Chiroptera was conducted in April, 2023 as part of fieldwork of the Joint Vietnam-Russian Tropical Science and Technology Research Center. The territory of the protected area due to some objectives was

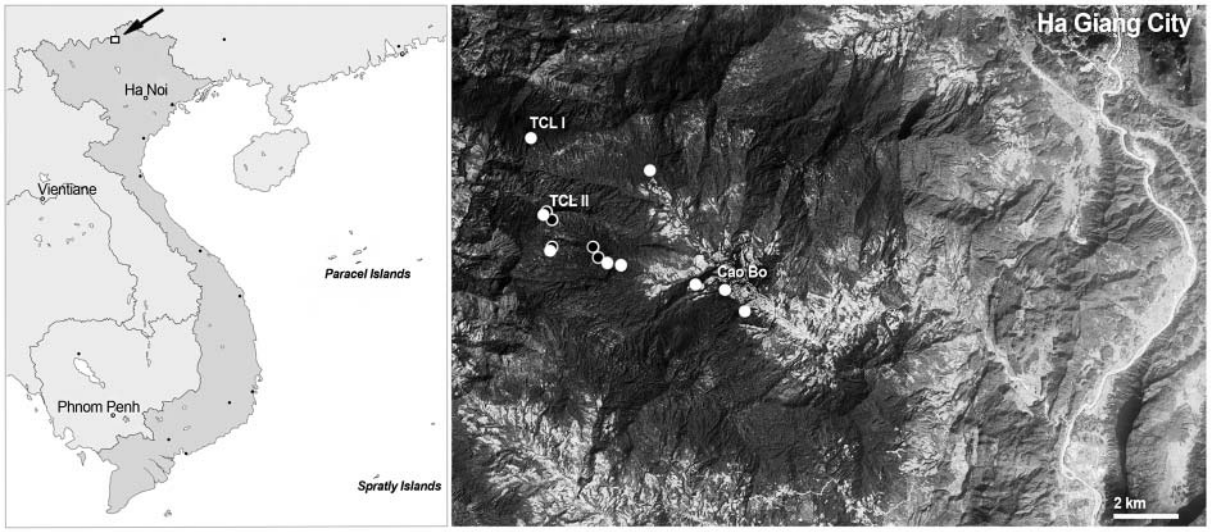

Fig. 1. Position of the Tay Con Linh area within Vietnam (marked by rectangle; left) and main survey points in Tay Con Linh Mountains in March 2017 and April 2023 (black and white dots, respectively; right).

studied unevenly. However, different biotopes, both pristine and man-changed, in the altitude range from ca. 570 to 2300 m asl were observed, and presence of rich chiropteran fauna containing more than twenty species was revealed. Despite being preliminary and possibly incomplete, results of our survey thus expand knowledge about Tay Con Linh bat community in more than three times and contain novel information about some rare and poorly studied species.

In this paper we aimed to provide an overview of the known bat fauna of Tay Con Linh, relying primarily on the 2017 and 2023 surveys. Since such a generalization for bats has not been made previously, this work should serve as both a milestone in the study of the structure and history of the chiropteran fauna of northern Vietnam and a basis for further study of bats in this area.

Material and methods

Study site

The Tay Con Linh mountain massif is situated in the Vietnamese province Ha Giang starting a few km south-west from the provincial capital city (Fig. 1). In 2017 most bat captures were made along the trail to the Tay Con Linh II summit between N 22.7645°, E 104.8304° and N 22.7671°, E 104.8297° and nearby the Tay Con Linh II summit at elevation 1700 m asl (ca. N 22.7767°, E 104.8147°). In 2023, the particular main base for our survey was the Cao Bo Commune (N 22.7556°, E 104.8684°, elevation ca. 580 m asl), located on the inner slope of the valley directed towards the summits of Tay Con Linh. Our work was carried out in the elevation range from 570 to 2300 m asl, including areas nearby summits of Tay Con Linh II (N 22.7739°, E 104.8157°, elevation ca. 1900 m asl) and Tay Con Linh I (N 22.7983°, E 104.8093°, elevation ca. 2290–2300 m asl).

A significant part of the surveyed territory has been anthropogenically modified. Small fragments of the pristine forest habitat remain, interspersed with arable land and secondary vegetation, including tall bamboo. On the slopes, areas of less disturbed forests are present above 1000 m asl; however, at altitudes over 1300 meters, the herbaceous layer is subject to invasion by cultivated *Amomum* sp. (Zingiberaceae). Almost undisturbed pristine forest (cloud-moss forest with trees 15–50 m high) remains near the summit, above 2000 m asl (Fig. 2). At the same time, stream valleys apparently remain less disturbed. It is worth noting that there are large areas of low-trunk bamboo thickets at altitudes of 1900–2200 m asl. Contrary to northward situated Bat Dai Son karstic area (Quan Ba District of Ha Giang Province, ca. N 23.11°, E 104.98°), we have not seen karst in Tay Con Linh which makes this range unattractive for specialized cave-dwelling species. However, piles of granite blocks in stream valleys may provide day roosts for more ecologically flexible petrophilous bats. In general, it can be assumed that the current landscape changes in the studied area may negatively affect the populations of a number of ecologically conservative chiropteran species, but it creates habitats and expands the food supply for more ecologically flexible ones.

Survey methods

Observations were carried out in the dark using electric lanterns and an ultrasound bat detector D230 (Pettersson Elektronik AB) and Echo Meter Touch 2. For bat trapping, monofilament mist nets 2×12, 2.5×10, 4×11, 3.5×9 and 3.5×8 meters in size with 16 mm mesh were used and put in places of the supposed flight paths of animals on fiberglass folding poles. In 2017, also a 4-layer 1.8×1.8 m harp trap was used aside with the

mist nets. In 2023, mist nets were used together with a mobile trap with a 2.5×2.5 m net, fixed on five-meter carbon fiber rods ("flap-trap"). The work itself (observations and trapping), as a rule, began from the moment of the animals emergence (about 17.50–18.00 p.m.) and continued until 22.00–24.00 p.m., adjusted for weather conditions. In total, sampling effort in 2017 was ca. 4200 m^2 net-hours in twelve capture nights, and in 2023 it was ca. 5780 m^2 net-hours in ten capture nights (not counting use of the "flap-trap").

Permission for field surveys in Tay Con Linh Protected Area was granted by the People's Committee of Ha Giang Province, Vietnam (#695/SNgV-LS, 13 December, 2016 and # 182/SNgV-LS of 03.04.2023).

Bats were captured and handled in the field following guidelines approved by the American Society of Mammalogists (Sikes *et al.*, 2016). Captured individuals were kept in individual fabric bags until the next day after capture. Each captured bat was identified, examined to determine sex and reproductive condition; most of them were weighed, measured externally, and photographed. Standard external measurements were taken in the field: body mass (M), head and body length (L), tail length (C), hind foot length (without claws; Pl), ear length (A) and forearm length (FA). External parasites were collected; mainly parasitic flies of the families Streblidae and Nycteribiidae, which were then fixed in 70% ethanol. Selected specimens (from 1 to 4 for each species) were collected for further laboratory study (totally preserved in 70% ethanol); tissue samples for the DNA analysis were fixed in 95% ethanol. All the voucher specimens are now preserving in the Institute of Ecology and Biological Resources, VAST, Hanoi, Vietnam (IEBR), and Zoological Museum of the Moscow State University, Moscow, Russia (ZMMU).

For certain specimens, which could be hardly identified based on morphological traits (in particular in case of *Pipistrellus* species), mitochondrial DNA was sequenced and analyzed. For this purpose, total DNA was extracted from ethanol preserved muscle samples using standard protocol of proteinase K digestion, phenol-chloroform deproteinization and isopropanol precipitation (Sambrook *et al.*, 1989). The cytochrome *b* gene (*cytb*; 1026 bp) was amplified with primers previously used by us for *Pipistrellus* species; for details of genetic analysis see Kruskop *et al*. (2018) and Yuzefovich *et al*. (2021). Preliminary genetic identification was conducted with the use of BLAST (https://blast.ncbi.nlm.

Fig. 2. Selected habitats of Tay Con Linh: moss pristine forest at an elevation of about 2300 m asl (a, c), and boulders in the stream bed at about 1000 m asl. Photos by A. Yuzefovich.

nih.gov/Blast.cgi). Maximum likelihood (ML) analysis (Nguyen, Schmidt *et al.*, 2015) with 10000 replicates of ultrafast bootstrap (Hoang *et al.*, 2018) was performed with the software IQ-TREE v.1.6.12. Alignment of *cytb* was partitioned into three codon positions; the best-fitting substitution models were determined using the ModelFinder implementation in IQ-TREE. Best-fit models according to BIC (Bayesian Information Criterion) were: TNe+G4: 1st position, HKY+F+I: 2nd position, TN+F+I: 3rd position.

Results

About thirty bat species were identified during our survey, representing four chiropteran families: Pteropodidae, Hipposideridae, Rhinolophidae and Vespertilionidae. Of these species, only five duplicate earlier published records, thus six times increasing the known bat fauna of Tay Con Linh. Accordingly, the actuals bat list in the observing area includes 27 species. It should be noted, however, that two species on our list were examined at the time of capture, but due to certain circumstances were not measured, photographed, or genotyped; one another species is included in the list based on an observation and photograph of a specimen in the wild.

Family Pteropodidae

The occurrence of three species from this family has been confirmed, including one that was not previously recorded for the territory. In our surveys we did not capture or observe one of the species, previously reported by Lunde *et al.* (2003) — *Rousettus leschnaulii*.

Sphaerias blanfordi (Thomas, 1891) — Tailless fruit bat

This bat was previously reported from Tay Con Linh since one specimen was captured in 2001 at elevation of 1500 m asl (Lunde *et al.*, 2003). In 2017, eight specimens were captured by mist net on the slope of Tay Con Linh II at about 1100 m asl. In 2023, two specimens (both adult males) were mist-netted in disturbed primary forests: one on the slope of Tay Con Linh II ca. 3.5 km NW from Cao Bo at elevation of 1050 m asl (close to the previous place), and another on the valley slope opposite to Cao Bo at elevation of ca. 1180 m asl (N 22.7888°, E 104.8446°). Animals were reproductively inactive.

Voucher specimen: ZMMU S-209693 m.

Cynopterus sphinx (Vahl, 1797) — Indian short-nosed fruit bat

One specimen was captured in 2017 on the slope of Tay Con Linh II at about 1100 m asl. Also, this bat species was once observed visually near the Cao Bo Village at ca 600 m asl in 2023. This is the most common fruit bat species throughout Southeast Asia, and was previously reported from Tay Con Linh (Lunde *et al.*, 2001).

Voucher specimen: IEBR B170322DF-05 m.

Eonycteris spelaea (Dobson, 1871) — Cave fruit bat

One specimen (subadult female) was captured in 2023 in the brook valley in Cao Bo Village (Fig. 3a). Though this fruit bat is not uncommon in Vietnam, the mentioned record of *Eonycteris* is the first one made for Tay Con Linh and, probably, for Ha Giang Province as a whole.

Family Hipposideridae

Hipposideros armiger (Hodgson, 1835) — Himalayan roundleaf bat

This species was previously reported for Tay Con Linh (Dang *et al.*, 2004), though without specifying a particular location. In 2023, we captured this species in the brook valley on the slope of Tay Con Linh II ca. 3.5 km NW from Cao Bo at elevation of 1050 m asl, and on the valley slope opposite to Cao Bo at elevation of ca. 1100 m asl. In the first location several specimens broke the mist net and were released without measuring. All specimens seen in hands were adult females. Two measured specimens had forearm lengths of 93.5 and 94.2 mm, which is quite large for the species and over the size limit of the closely related *H. griffini* (Vu *et al.*, 2012; Kruskop, 2013).

Voucher specimens: ZMMU S-209664 f, ZMMU S-209665 f.

Hipposideros khaokhouayensis Guillen-Servent et Francis, 2006 — Laotian roundleaf bat

In 2017, four specimens (two males and two females) were captured on the slope of Tay Con Linh II at about 1100 m asl and close to the Tay Con Linh II summit at the altitude of approximately 1700 m asl (Fig. 3c). This bat is known to have a highly disruptive distribution, being previously known from the type locality in Laos, from the Cat Ba Island in Halong Bay, and from the Son La Province, Vietnam (Kruskop, 2013; Vu, 2023). Therefore, record in Tay Con Linh is the second confirmed finding of this species in the mainland of Vietnam, in part fulfilling the large existing gap between two previously known locations and suggesting the species' wider distribution in the region.

In 2023, the roundleaf bat of the "*bicolor*" species group was observed in a mist net in heavily disturbed primary forest at an altitude of approximately 1050 m asl. However, during the recovery of other simultaneously captured animals, this specimen was missed. It was preliminary identified as *H. gentilis*, however in light of above mentioned record it also could be *H. khaokhouayensis*, since both species are closely related and similar in morphology.

Voucher specimens: IEBR B170324DF-12 (sex unknown), IEBR B170324DF-14 f, IEBR B170326DF-01 f, IEBR TCL17.4B m.

Coelops frithii Blyth, 1848 — Tailless leaf-nosed bat

In 2017, two individuals (males; Fig. 3b) were captured by a harp trap close to the Tay Con Linh II summit at the altitude of approximately 1700 m asl in the evening time, at 19:10 and 19:42. This bat has a wide but sporadic distribution across Southeast Asia and though being recorded in various biotopes, it is still quite poorly studied (Kruskop, 2013; Huang *et al.*, 2019). In Tay Con Linh, animals were found in association with both high-altitude species such as *Harpiola isodon*, and

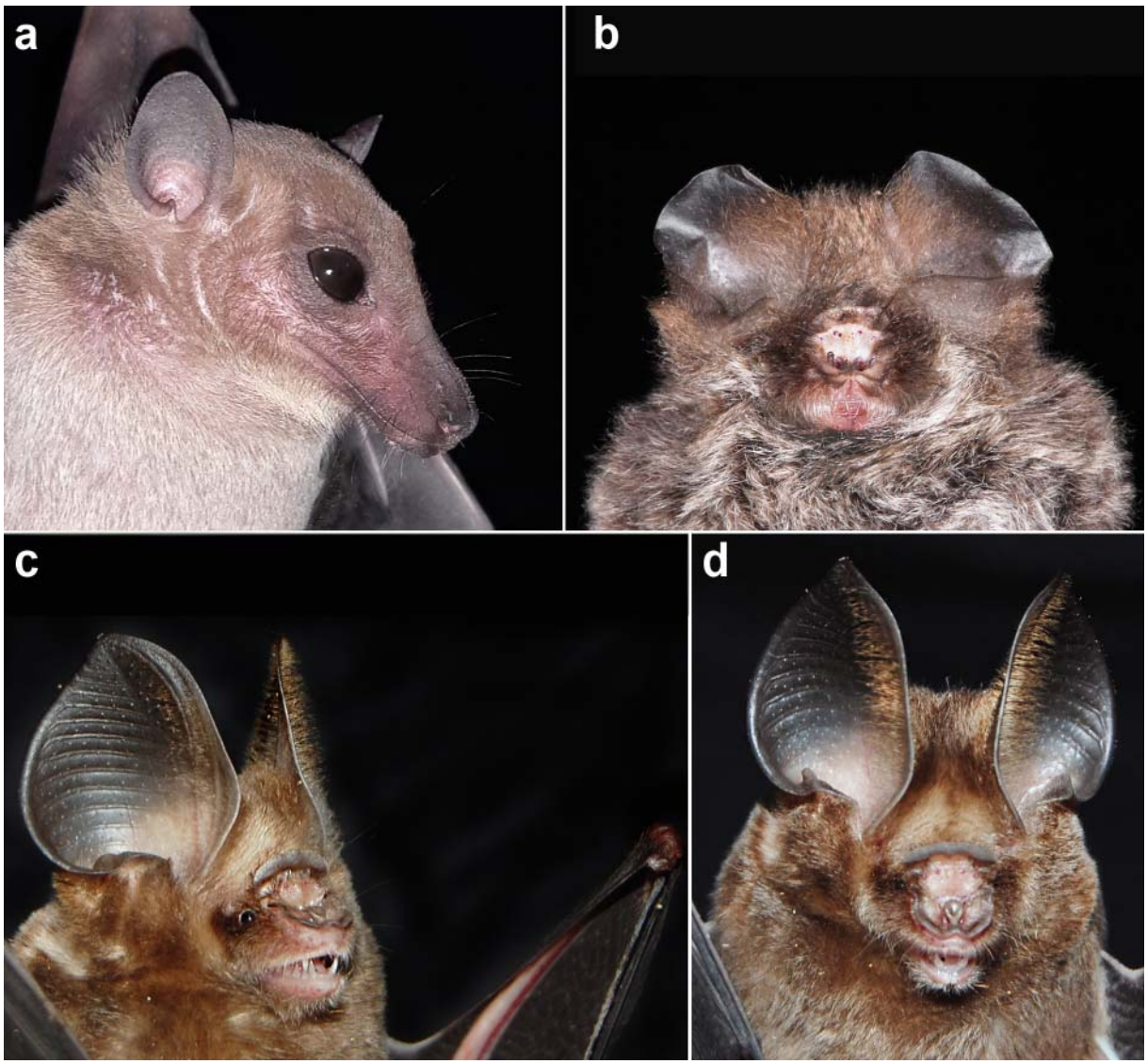

Fig. 3. *Eonycteris spelaea* (a), *Coelops frithii* (b) and *Hipposideros khaokhouayensis* (c, d), captured on Tay Con Linh for the first time for the Ha Giang Province. Photos by S. Kruskop (a) and T.S. Nguyen (b–d).

ecologically flexible species as *Rhinolophus affinis*, *R. pearsonii* and *Murina huttoni*. Most probably this record represents the most high-altitude *Coelops* capture in Vietnam.

Voucher specimens: IEBR TCL17.12B m, IEBR TCL17.3B m.

Family Rhinolophidae

Rhinolophus perniger Hodgson, 1843 — Giant Indochinese horseshoe bat

In 2023, two specimens of the giant horseshoe bat (both adult males with forearm lengths of 75.9 and 72.3 mm) were captured in the vicinity of Cao Bo Village (Fig. 4a): in a heavily disturbed forest with a lot of bamboo in the undergrowth, and on the edge of the forest above a stream.

Until relatively recently, all giant horseshoe bats were classified as *R. luctus* (Kruskop 2013), but later the species level of differences between individual populations of this complex was shown (Volleth *et al.*, 2015, 2017). However, the data on which this was shown are solitary and do not allow one to adequately assess the boundaries of the distribution of the identified taxa. Currently, the giant horseshoe bats of Indochina are generally classified as *R. perniger* (Csorba *et al.*, 2019), but the actual number of species in the region and their spatial distribution require further study. Based on its range, Tay Con Linh may occupied by *R. lanosus*, which is common in southern China, but the larger size of the specimens captured is a better match for *R. perniger* (Volleth *et al.*, 2017). The frequency of the echolocation calls (second and first harmonics — about 93 and 31 kHz, respectively) does not differ from

that of the specimen from central Vietnam (orig., unpubl. data).

Voucher specimens: ZMMU S-209685 m, ZMMU S-209686 m.

Rhinolophus marshalli Thonglongya, 1973 — Marshall's long-eared horseshoe bat

This horseshoe bat is well distinguished from the related species mentioned above by the distinct lappets on each side of the relatively broad sella (Vuong *et al.*, 2017a). In 2023, an adult male with a forearm length of 43.0 mm was captured near a trail in disturbed forest at approximately 1000 m asl (Fig. 4b). An adult female was captured near the village of Cao Bo on a slope covered with disturbed forest with bamboo thickets in undergrowth, at an altitude of approximately 570 m asl. We previously found the same species of horseshoe bat at similar altitudes in highly anthropogenically modified habitats in the Bat Dai Son Nature Reserve in the same province (unpubl. data).

Voucher specimens: ZMMU S-209680 m, ZMMU S-209681 f.

Rhinolophus cf. *episcopus* G. Allen, 1923 — Long-eared horseshoe bat

In 2023, three individuals (all adult males) with forearm lengths of 41.6, 42.8 and 44.9 mm were captured on the ridge leading to the main summit at 1900 m asl in an open forest with bamboo thickets (Fig. 4c).

The taxonomy of the "*macrotis*" species complex is extremely confusing: genetic data reveal several lineages, while mitochondrial DNA data are not fully consistent with nuclear data and morphology (Francis *et al.*, 2010; Vuong *et al.*, 2017a; Zhang *et al.*, 2018). There are three morphotypes known from northern Indochina, differing in overall size, ear size and noseleaf shape (Vuong *et al*., 2017a), one of which is so far known only from Cao Bang province, while the other two overlap widely. Individuals collected from the upper elevations of the Tay Con Linh range have a forearm

Fig. 4. Selected *Rhinolophus* species captured on Tay Con Linh: a — *R. perniger*, b — *R. marshalli*, c — *R.* cf. *episcopus*, d — *R.* cf. *siamensis*. Photos by A. Yuzefovich.

over 41 mm, a relatively high lancet and supplementary leaflets projecting laterally from under the horseshoe rather than forward, which generally fits *R. macrotis* s. str. However, based on at least mtDNA analysis, all animals from southern China and Indochina are distinct from the "true" *R. macrotis* from Nepal (Vuong *et al.*, 2017a). Perhaps *macrotis*-like *Rhinolophus* from northern Indochina should be classified as *R. episcopus* (Liu *et al.*, 2019).

Voucher specimens: ZMMU S-209820 m, ZMMU S-209821 m; ZMMU S-209822 m.

Rhinolophus cf. *siamensis* Gyldenstolpe, 1917 — Lesser long-eared horseshoe bat

In 2023, a single specimen (an adult male with a forearm length of 40.1 mm) was captured in a disturbed forest west of Cao Bo Commune at an altitude of ca. 1050 m asl (Fig. 4d).

With a forearm length of less than 41 mm, a low lancet and poorly developed accessory leaflets protruding more forward than to the sides, the captured specimen corresponds to the "small" form of the "*macrotis*" species complex (Vuong *et al.*, 2017a). This form is not different from *R.* cf. *macrotis* by mitochondrial DNA, but is well differentiated by nuclear markers (Liu *et al.*, 2019), suggesting recent hybridization between them. However, there is currently no strong evidence that it is identical to *R. siamensis* from northern Thailand.

Voucher specimen: ZMMU S-209679 m

Rhinolophus pusillus Temminck, 1834 — Least horseshoe bat

In 2017, eleven individuals were captured on the slope of Tay Con Linh II at about 1100 m asl. In 2023, we found this species of small horseshoe bats in the vicinity of the Cao Bo Commune in the valley of a small river, as well as in forest biotopes at altitudes of 1000–1100 m asl. In total, two males and two adult females with forearm lengths of 36.7, 36.9, 37.1 and 37.8 mm were examined in hand.

The species boundaries of the horseshoe bats of the "*pusillus*" species group are not completely clear. E.g., Chornelia *et al.* (2022) suggest the presence of six "candidate species" in this complex. In this regard, an exact identification could be difficult. In two individuals (male and female), the length of the upper tooth row was 5.62 and 5.80 mm, which corresponds to *R. pusillus* (Kruskop, 2013). In all captured individuals, the length of the forearm corresponds rather to the "small" species of the group (*pusillus* and *subbadius*). Shape of the connecting process varied slightly between individuals, being sharply pointy and somewhat deflected forward as in *R. subbadius* or blunter at tip and relatively wide at base, which better fits *R. pusillus* s. str. However, previously was already shown that this feature is not reliable for species identification (Abramov & Kruskop, 2012).

Voucher specimens: IEBR B170323DF-01 f, IEBR B170323DF-03 f, IEBR B170323DF-04 f, IEBR B170323DF-05 f, IEBR B170323DF-06 f, IEBR B170324DF-04 f, IEBR B170324DF-15 f, IEBR B170324DF-16 m, IEBR TCL17.30B f, IEBR TCL17.37B f, IEBR TCL17.9B m, ZMMU S-209687 m, ZMMU S-209688 f, ZMMU S-209689 f, ZMMU S-209690 m.

Rhinolophus affinis Horsfield, 1823 — Asian horseshoe bat

This horseshoe bat, which is quite common throughout Vietnam, turned out to be rare on Tay Con Linh. In 2017 twelve individuals (seven males and five females) were captured on the slope of Tay Con Linh II at about 1100 m asl and close to the top of Tay Con Linh I at the altitude of approximately 1700 m asl. In 2023 we examined only one individual (an adult male), captured in a disturbed forest west of Cao Bo at an altitude of about 1000 m asl.

Voucher specimens: IEBR B170324DF-05 m, IEBR B170324DF-06 m, IEBR B170324DF-09 m, IEBR B170324DF-18 f, IEBR TCL17.10B m, IEBR TCL17.2B f, IEBR TCL17.33B m, IEBR TCL17.35B f, IEBR TCL17.5B m, IEBR TCL17.6B f, IEBR TCL17.7B m, ZMMU S-209677 m, ZMMU S-209678 m.

Rhinolophus sinicus Andersen, 1905 — Chinese horseshoe bat

This horseshoe bat appears to be relatively common on Tay Con Linh and was found by us at a greater range of altitudes than other species. In 2017, two individuals were captured at on the slope of Tay Con Linh II at about 1100 m asl. In 2023, several individuals (including an adult male with a forearm length of 47.8 mm) were captured in a moss forest near the summit of Tay Con Linh I at an altitude of approximately 2100 m asl. At the same time, an adult female was caught on the slope of a valley 1 km east of Cao Bo Commune at an altitude of about 600 m. We also noted this species in a disturbed primary forest at an altitude of about 1000 m (close to the capture site of 2017).

Voucher specimens: IEBR B170324DF-07 m, IEBR B170324DF-11 m, ZMMU S-209691 m, ZMMU S-209692 f.

Rhinolophus thomasi Andersen, 1905 — Thomas' horseshoe bat

In March, 2017, one individual of this horseshoe bat (male) was captured on the slope of Tay Con Linh II at about 1100 m asl.

Voucher specimen: IEBR B170322DF-04 m.

Rhinolophus pearsonii Horsfield, 1851 — Pearson's horseshoe bat

This species, common to Vietnam, was also found by us in a wide range of elevations. In 2017, eight individuals (seven males and a female) were captured on the slope of Tay Con Linh II at about 1100 m asl and close to the Tay Con Linh II top at the altitude of ca. 1700 m asl. In 2023, five specimens were examined and measured in hand (all adult males with a forearm length of 52.2–54.4 mm), netted above a mountain stream at an altitude of 1000 m asl; in a disturbed forest not far from this stream, in a clearing with individual surviving trees on the outskirts of Cao Bo at an altitude 620 m; in a heavily disturbed forest 1 km east of Cao Bo Commune (same site as *R. sinicus*); and on the main ridge

near Tay Con Linh I at 1900 m asl in open forest with bamboo thickets (same site as *R.* cf. *episcopus*).

Voucher specimens: IEBR B170322DF-01 m, IEBR B170322DF-02 m, IEBR B170322DF-03 m, IEBR B170323DF-02 f, IEBR B170324DF-08 m, IEBR B170324DF-17 m, IEBR TCL17.13B f, IEBR TCL17.22B m, IEBR TCL17.8B m, ZMMU S-209682 m, ZMMU S-209683 m, ZMMU S-209684 m.

Family Vespertilionidae

Harpiocephalus harpia (Temminck, 1840) — Hairy-winged tube nosed bat

This bat does not seem to be quite common, and is a solitary species (Dahal *et al.*, 2022), but it has a wide range and is found in many places across Vietnam; however, it has not been previously reported for Ha Giang province (Nguyen, Csorba *et al.*, 2015). In 2017, three specimens (two males and one female) were captured by mist net and harp trap close to the Tay Con Linh II top at the altitude of ca. 1700 m asl. In 2023, an adult female with a forearm length of 51.0 mm was mist-netted in a disturbed forest at an altitude of 1050 m asl. A second adult female with a forearm length of 52.2 mm was captured at the intersection of a trail with a small stream at an altitude of ca. 970 m asl. This second individual taken as a voucher specimen was found to be early pregnant and had two embryos, each 4.5 mm long. We found no published information on the reproductive biology of this species; it can be assumed that our finding represents the first evidence of the presence of twins in *Harpiocephalus*.

Voucher specimens: IEBR TCL17.15B m, IEBR TCL17.21B f, IEBR TCL17.27B m, ZMMU S-209662 f, ZMMU S-209663 f.

Murina cyclotis Dobson, 1872 — Round-eared tube-nosed bat

In 2017 three adult males were captured on the slope of Tay Con Linh II at about 1100 m asl. In 2023, an adult female was mist-netted on the same slope (apparently on the same trail) in hardly disturbed forest in ca. 3.5 km NW from the Cao Bo Village at elevation of 970 m asl, but it escaped before it was measured. An adult male of the same species with the forearm length of 31.3 mm and ear and teeth shapes typical to *M. cyclotis* was netted in the exact same place one day later (Fig. 5a).

Voucher specimens: ZMMU S-209669 m, IEBR B170324DF-19 m.

Murina chrysochaetes Eger et Lim, 2011 — Golden tube-nosed bat

In 2017, three specimens (one male and two females) were captured near the Tay Con Linh II at 1800 m asl (N 22.7742°, E 104.8156°; Fig. 5b). In 2023, one individual was captured also near the Tay Con Linh II summit at an altitude of 1900 m asl. Unfortunately, the animal was subsequently missed before measurements and high-quality photographs could be taken. This bat has a very characteristic appearance and specific fur coloration, which does not allow it to be confused with any other species of the genus, except for the related *M. harpioloides* Kruskop et Eger, 2008 from the Dalat Plateau (Eger *et al.*, 2011; Kruskop, 2013). Previously, *M. chrysochaetes* was found in only three sites: in Guangxi in China (type locality), in the vicinity of Sa Pa, and in the Phia Oak-Phia Den Nature Reserve (Nguyen, Csorba *et al.*, 2015). Thus, the registration at Tay Con Linh is the fourth for the species and the third for the territory of Vietnam. All the records in Northern Vietnam were made at high elevations and close to the Chinese border.

Voucher specimens: IEBR TCL17.20B m, IEBR TCL17.29B f, IEBR TCL17.31B f.

Murina leucogaster Milne-Edwards, 1872 — Greater tube-nosed bat

In 2023, one individual of relatively large tube-nosed bat was observed and photographed by expedition member I. Semenyuk in the daytime on the northern macroslope of the valley, at ca.1000 m asl (N 22.789°, E 104.845°). The animal roosted in a rolled up dry banana leaf, but, according to Semenyuk's communication, it was quite active and flew away before she could catch it. The color pattern of *M. leucogaster*, with a brownish back without red tones and a yellow "collar" is very characteristic and is not found in other species of tube-nosed bats living in the region (Nguyen *et al.*, 2015), which made it possible to identify the species. This is the third record of this species in Vietnam. Daytime roosts in dry (but not fallen) leaves are known for tube-nosed bats (Fukui *et al.*, 2012; Preble *et al.*, 2021), but we have found no published references to the use of this type of shelter by *M. leucogaster*.

Murina huttoni (Peters, 1872) — Hutton's tube-nosed bat

In 2017, five individuals (four males and a female) were captured by mist net and harp trap close to Tay Con Linh II at the altitude of approximately 1700 m asl. Forearm length in these specimens was between 33.1 and 33.7 mm for males and 36 mm for the female, which well fits to this particular species and not to closely related but somewhat larger *M. harrisoni* Csorba et Bates, 2005 (Nguyen, Csorba *et al.*, 2015). In 2023, two adult males (forearm lengths 33.0 and 33.3 mm) were captured on the main range of Tay Con Linh I: one in open mountainous forest with bamboo thickets at 1900 m asl (in association with *Rhinolophus* cf. *macrotis* and *R. pearsonii*), and another in a moss forest near the summit of Tay Con Lin I at an altitude of approximately 2100 m asl. Body size and teeth shape (relatively massive dentition, pronounced entoconids on lower molars, P2 equal in height to P4) are well-correspond with features of *M. huttoni* (Kruskop, 2013; Nguyen, Csorba *et al.*, 2015). Although *M. huttoni* is relatively widespread in Indochina, this is the first documented species record for Ha Giang province. At the same time, there is a reason to assume the presence of deeply divergent genetic lineages within *M. huttoni* (e.g., Francis *et al.*, 2010). Its intraspecific taxonomy requires special study; island ecosystems such as Tay Con Linh are highly likely to serve as the home of a distinct local race.

Fig. 5. Selected Murininae and Myotinae species found on Tay Con Linh: a — *Murina cyclotis*, b — *Mur. chrysochaetes*, c — *Harpiola isodon*, d — *Myotis altarium*. Photos by S. Kruskop (a) and T.S. Nguyen (b-d).

Voucher specimens: IEBR TCL17.18B m, IEBR TCL17.23B m, IEBR TCL17.28B m, IEBR TCL17.36B f, ZMMU S-209670 m.

Harpiola isodon Kuo, Fang, Csorba et Lee, 2006 — Even-tooth tube-nosed bat

In 2017, two individuals (male and female) individuals were captured by mist net and harp trap close to the Tay Con Linh II at the elevation of 1700 m asl (Fig. 5c). This species has wide but highly fragmented distribution range from Taiwan to the Central Highlands of Vietnam (Kruskop, 2013; Li *et al*., 2024). In Vietnam it was previously reported only from two places in Lao Cai and Kon Tum provinces (Nguyen, Csorba *et al*., 2015), and supposed to correlate mainly with elevations above 1800 m asl. Therefore, current record in Tay Con Linh is only the third in Vietnam.

Voucher specimens: IEBR TCL17.19B f, IEBR TCL17.25B m.

Myotis altarium Thomas, 1911 — Szechwan myotis

In 2017, one specimen of this poorly studied bat was captured at the elevation of ca. 1980 m asl (Fig. 5d). This record was previously described in detail by Vu *et al*. (2018). Main known range of *M. altarium* is situated in the mountainous regions of central China (Wilson, 2008). This species has close phylogenetic relations with the strictly Palearctic *M. ikonnikovi* Ognev, 1912 (Ruedi *et al*., 2013); so, it can be considered as a Palearctic element in the fauna of Tay Con Linh and Vietnam as a whole.

Voucher specimen: IEBR TCL17.34B m.

Arielulus cf. *circumdatus* (Temminck, 1840) — Black-gilded serotine

In 2017, one individual of the small black-gilded serotine (adult male) was mist-netted close to Tay Con

Linh II at the altitude of approximately 1780 m asl (N 22.7767°, E 104.8147°; Fig. 6a). This record was briefly mentioned previously, but without peculiarities (Görföl *et al.*, 2020). In 2023, one individual (adult male, forearm length 36.9 mm) was mist-netted near the Tay Con Linh I summit at the upper edge of the forest (N 22.7983°, E 104.8093°, elevation ca. 2290 m asl). Although in general the altitude of the area and the nature of the habitat correspond to the supposed preferences of *Arielulus*, this genus (with the exception of the much larger *A. aureocollaris* (Kock et Storch, 1996)) was previously known in Vietnam only from southern and central provinces: the Dalat Plateau (and the nearby Hon Ba Mountain), Ngoc Linh Mountain, and from Vu Quang Nature Reserve (Kruskop, 2013). Thus, our finds, tentatively identified as *Arielulus* cf. *circumdatus*, turns out to be the first record of the "smaller" *Arielulus* in northern Vietnam.

Noteworthy, the color tone of the captured individual was somewhat different from that of the animals from the Dalat Plateau (the tips of the hairs are rather golden, whereas in the Dalat individuals they are reddish-bronze). In terms of measurements, the animal from Tay Con Linh is similar to animals from Nepal and Thailand, and is also close to the holotype of *Arielulus societatis* from Malaysia. At the same time, specimens from southern and central Vietnam are somewhat larger on the average. Following this, one may suggest presence of two different types of small black-gilded serotines on the territory of mainland Asia and of Vietnam in particular. The solution to this issue requires genetic and more thorough morphological analysis.

Voucher specimens: ZMMU S-209661 m, IEBR TCL17.11B m.

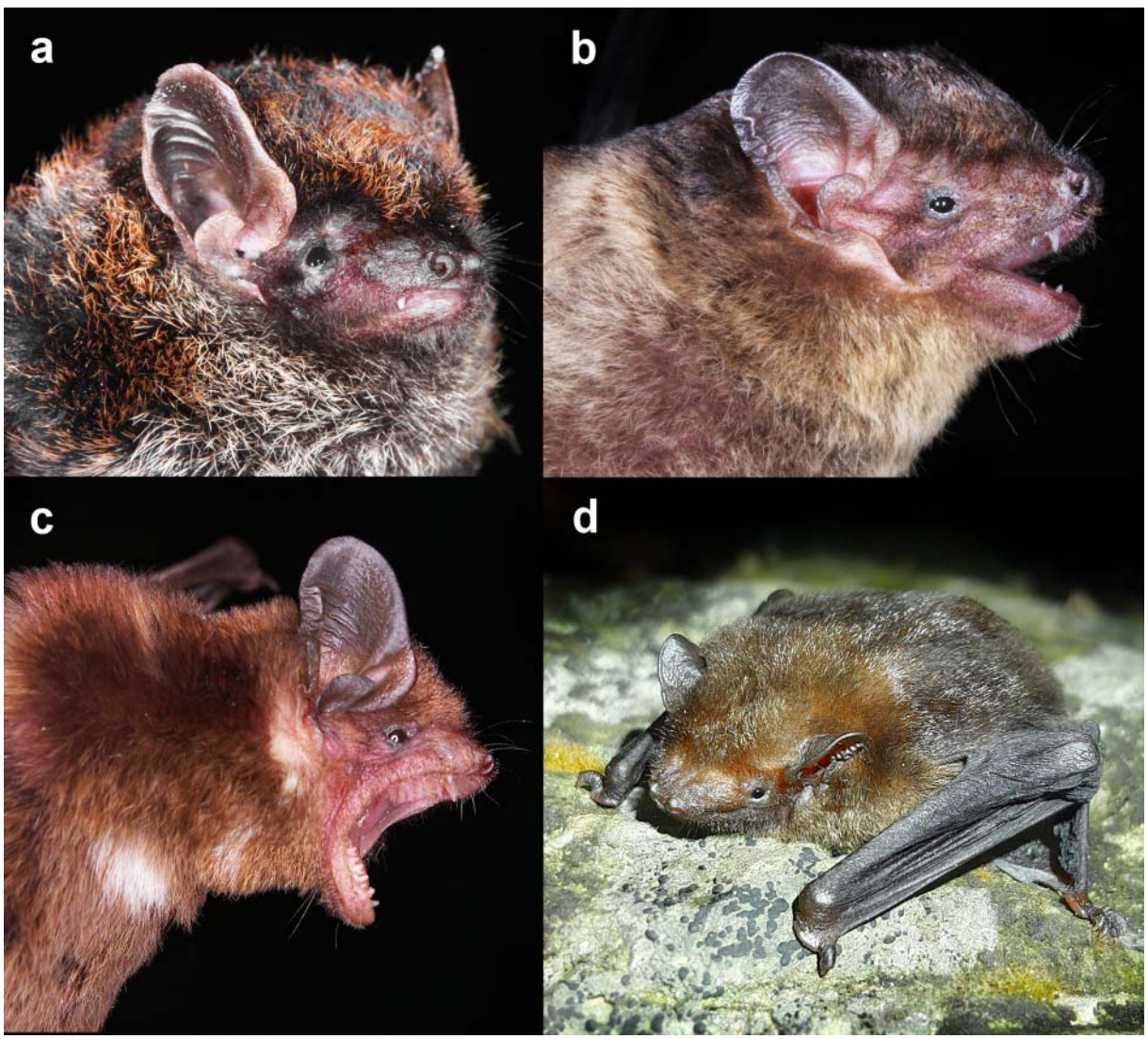

Fig. 6. Selected Vespertilioninae species recorded on Tay Con Linh: a — *Arielulus* cf. *circumdatus*, b — *Mirostrellus joffrei*, c — *Hypsugo cadornae* (individual with white spots), d — *Tylonycteris tonkinensis*. Photos by T.S. Nguyen (a, b) and S. Kruskop (c, d).

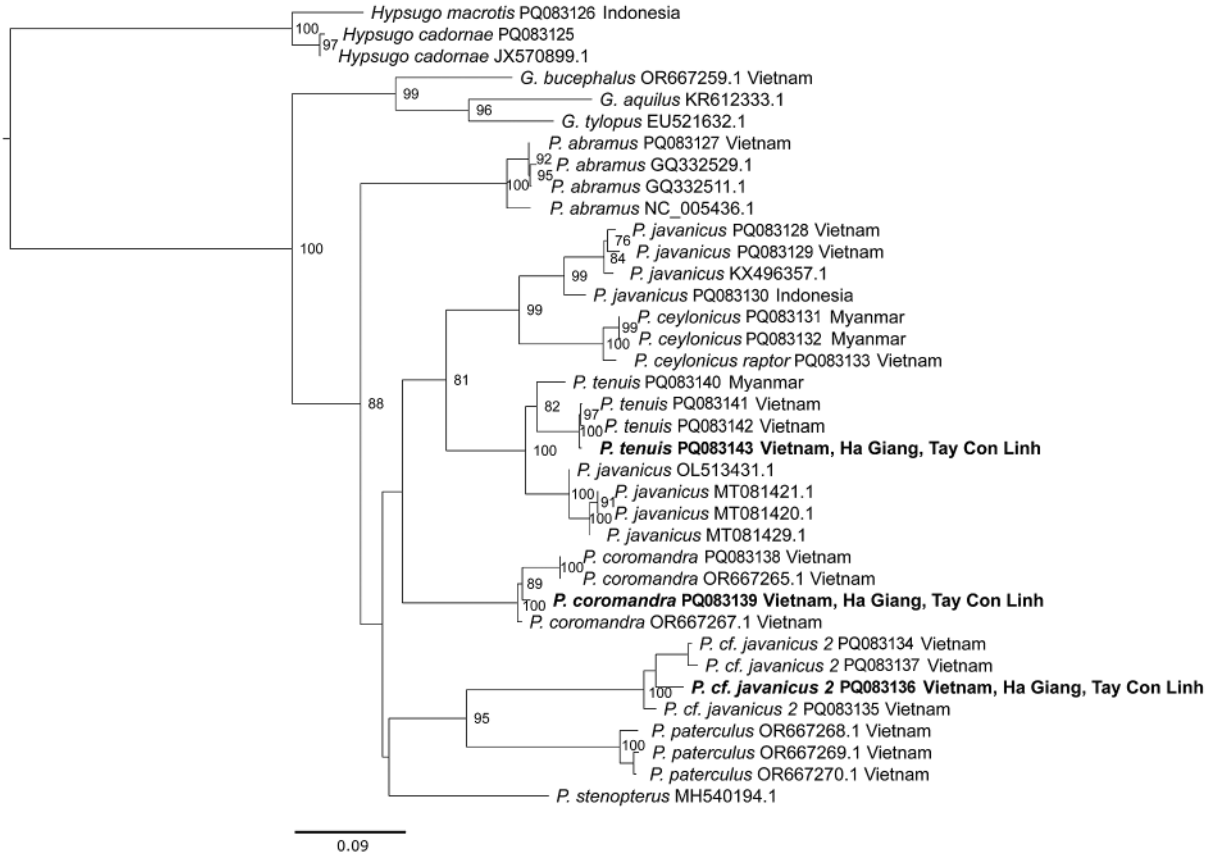

Fig. 7. Maximum likelihood phylogenetic tree based on mitochondrial *cytb* sequences of the eastern pipistrelle-like bats. The phylogeny was inferred in IQ-TREE. Bootstrap (BS) values are indicated adjacent to nodes (nodes with BS < 70% are not labeled).

Mirostrellus joffrei (Thomas, 1915) — Joffre's pipistrelle

In 2017, one specimen was captured at the elevation of ca. 1980 m asl (Fig. 6b). This record was already described by Görföl *et al*. (2020).

Voucher specimen: IEBR TCL 17.026B

Pipistrellus tenuis (Temminck, 1840) — Least pipistrelle

In 2023, one adult female with forearm of 29.4 mm was captured in a stream valley on the edge of the Cao Bo Village. Taken as a voucher, this individual found to be pregnant, with three equally developed embryos which correspond to the high reproductive rate of this species (Bates & Harrison, 1997). Since identification of Asian pipistrelles based solely on morphological characters can be difficult, the captured pipistrelles were identified using *cytb* gene sequences (Fig. 7).

Voucher specimen: ZMMU S-209674 f.

Pipistrellus coromandra (Gray, 1838) — Indian pipistrelle

One individual — an adult male with the forearm length 30.8 mm — was mist-netted in 2023 near the trail in the disturbed forest west from the Cao Bo Village at elevation of ca. 1000 m asl. Another adult male with the forearm length 32.2 mm was captured in 2017 nearby Tay Con Linh II summit. The specimen captured in 2023 was identified based on genetics (Fig. 7).

Voucher specimens: ZMMU S-209673 m, IEBR TCL17.16B m.

Pipistrellus cf. *javanicus* (Gray, 1838) — Java pipistrelle

One individual — an adult male with the forearm of 29.8 mm — was captured in 2023 over the backwater on the stream nearby the Cao Bo Village, at elevation of 570 m asl. In the resulting phylogenetic reconstruction, this specimen belongs to the clade named "*P.* cf. *javanicus* 2" (Fig. 7), which, based on available genetic data, is distinct from *P. javanicus* s. str., found in the Sunda Islands, Malaysia and southern Indochina. This genetic split suggests high-level genetic diversity within *P. javanicus* and its possible polyphyletic nature (Zhukova *et al.*, 2022). That is why here we tend to use open nomenclature.

Voucher specimen: ZMMU S-209672 m.

Hypsugo cadornae (Thomas, 1916) — Cadorna's pipistrelle

In 2017, two specimens were captured by a mist net at the elevation of ca. 1780 m asl nearby the Tay Con

Linh II top. In 2023, three individuals (an adult male with the forearm of 34.6 mm, and two adult females with forearms of 36.3 and 37.2 mm) were netted over the backwater on the stream nearby the Cao Bo Village, at elevation of 570 m asl (together with *Pipistrellus* cf. *javanicus*). One of the captured females had obvious signs of pregnancy and depigmented areas (white spots) in the fur color (Fig. 6c).

Voucher specimens: ZMMU S-209666 f, ZMMU S-209667 m, ZMMU S-209668 f, IEBR TCL17.26B m, IEBR TCL17.14B f.

Tylonycteris fulvida (Blyth, 1859) — Lesser flat-headed bat

In 2023, two reproductively inactive females with the forearm lengths of 24.0 and 25.0 mm were mist-netted, one over a trail in a disturbed forest with bamboo undergrowth nearby the Cao Bo Commune at elevation of ca. 570 m asl; and another in a disturbed forest 1 km east from Cao Bo at elevation of ca. 600 m asl (together with *R. sinicus* and *R. pearsonii*).

Voucher specimens: ZMMU S-209694 f, ZMMU S-209695 f.

Tylonycteris tonkinensis Tu, Csorba, Ruedi et Hassanin, 2017 — Tonkin flat-headed bat

In 2017, three males were netted close to the Tay Con Linh II summit at the elevation of ca. 1780 m asl. In 2023, about twenty individuals were captured and seen in hands (Fig. 6d); eight individuals were examined and measured: four males with forearm lengths 26.3–27.5 mm and four females with forearm lengths 27.1–28.0 mm. This recently described species is currently known from north Indochina only (Vuong *et al.*, 2017b). It was one of the most numerous bat species in the vicinity of Cao Bo Village at ca. 570–580 m asl, on forest edges with sparse tall bamboo thickets and in a disturbed forest with bamboo undergrowth.

Voucher specimens: IEBR TCL17.1B m, ZMMU S-209696 m, ZMMU S-209697 m, ZMMU S-209698 f, ZMMU S-209699 f, ZMMU S-209700 f, ZMMU S-209701 m, IEBR TCL17.17B m, IEBR TCL17.24B m.

Conclusions

Following our results, the fauna of Tay Con Linh mountain range includes at least 30 bat species from four families. Among the species found there are both relatively widespread, generally characteristic of different regions of Southeast Asia (all species of fruit bats, *Hipposideros armiger*, *Murina cyclotis* etc.), at least one representative of the Palearctic fauna (*Myotis altarium*), and also species with disruptive ranges, the distribution patterns of which are not yet completely clear (e.g., *Hipposideros khaokhouayensis*, *Arielulus* cf. *circumdatus*, *Harpiola isodon*). Such richness apparently stems from the large altitudinal gradient of the Tay Con Linh Mountains and their geographical location. As result, the area is inhabited by lowland wide-range species and also by montane forms with restricted or sporadic distribution patterns. Many of the montane species found on Tay Con Linh are also known from more western parts of northern Vietnam (e.g., *Mirostrellus joffrei*, *Harpiola isodon* and *Murina chrysochaetes* are known from Lao Cai Province: Nguyen, Csorba *et al.*, 2015; Görföl *et al.*, 2020; *Myotis altarium* — from Son La Province: Vu *et al.*, 2018; *Pipistrellus coromandra* and *Murina huttoni* are generally widespread in the mountains of northern and central Indochina). Probably, this indicates the absence of the role of the Red River (Hong Ha) valley as a significant zoogeographic barrier for chiropterans.

A number of species found have a clear association with certain altitudes. Thus, Tylonycteris fulvida, *Hypsugo cadornae* and *Rhinolophus perniger* were found only at altitudes up to 700 m, *Murina cyclotis*, *Hipposideros armiger* and *Rhinolophus affinis* — only at medium altitudes, and *Rhinolophus* cf. *episcopus*, *Murina huttoni*, *M. chrysochaetes*, *Harpiola isodon*, *Mirostrellus joffrei* and *Arielulus* cf. *circumdatus* — only at altitudes above 1800 m. In some cases, this is probably due to the sporadic nature of records and, accordingly, occasion, but in general it reflects environmental preferences. Some species, in contrast, were present at a wide range of altitudes; in particular *Rhinolophus sinicus* and *Rhinolophus pearsonii* were found at altitudes ranging from 600 to at least 2300 m. Of interest is the record of *Tylonycteris tonkinensis* in the vicinity of the top of Tay Con Linh II; obviously, it reflects the ability of this species, characteristic of lower elevation habitats, to live in mountainous subtropics.

It seems obvious that our list hardly exhausts the full local chiropteran diversity: the upper parts of the ridges connecting to the top of Tay Con Linh may provide paths for typically Chinese, as well as Himalayan species that we would have expected to find here, but did not record. A brief study of the high part of the range did not intend to obtain information that could be assessed as more than a pilot. It is also worth noting that the taxonomic affiliation of some of the found species requires clarification through comparison with collection and other materials and detailed genetic analysis. The latter is also necessary to clarify the influence of Tay Con Linh as a "sky island" on bat populations. Due to their relatively greater mobility, bats are less susceptible to the island effect than terrestrial small mammals. However, it can be assumed that it will have some impact on populations of mountain sedentary taxa, such as tube-nosed bats and small horseshoe bats. Proof or refutation of this assumption requires phylogeographic studies of the corresponding species complexes.

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