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First records and a new subspecies of *Rhinolophus stheno* (Chiroptera, Rhinolophidae) from Vietnam.

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SYNOPSIS. The recently discovered populations of *Rhinolophus stheno* from North Vietnam, along with specimens previously collected in Thailand, are described as a new subspecies, *Rhinolophus stheno microglobosus*. The median anterior rostral swellings of the new subspecies are notably smaller than those of the nominate subspecies. A morphological and statistical comparison is given between the two subspecies of *R. stheno*, and the closely related *R. malayanus*.

INTRODUCTION

Rhinolophus stheno Andersen, 1905 was originally described from peninsular Malaysia. The known range of the species was later extended to Thailand (Lekagul & McNeely, 1977), Sumatra and Java (Corbet & Hill, 1992; Koopman, 1994) and Tioman Island, off the coast of Malaysia (Csorba et al., 1997). Recent expeditions to Vietnam led by British and Hungarian researchers have discovered the first specimens of *R. stheno* to be recorded from that country. Comparative examination of these specimens with other populations in the collections of The Natural History Museum, London revealed that specimens from Vietnam were most similar to those from Thailand, and that both were sufficiently different from material from Malaysia, Sumatra and Java to represent an undescribed subspecies.

Andersen (1905) considered *R. stheno* to belong to the *borneensis* subgroup of the *simplex*-group of *Rhinolophus*, which Tate & Archbold, 1939 subsequently termed the *ferrumequinum*-group. Andersen distinguished *R. stheno* from other members of the *borneensis* sub-group by the much more projecting anterior nasal swellings of the rostral part of the skull. Lekagul & McNeely (1977) reported that *R. stheno* resembles *R. malayanus* Bonhote, 1903 but that the two are separable by a set of external features (body size, shape of lancet and relative proportions of the first and second phalanges of the third digit). Subsequently, McFarlane & Blood (1986) concluded that, although there are no reliable differences between *R. stheno* and *R. malayanus* in these features, they are instead distinguishable by supraorbital and rostral characters of the cranium. They suggested that the general similarity of the noseleaf and skull of *R. stheno* and *R. malayanus* implied a closer relationship than formerly supposed. This view was accepted by Corbet & Hill (1992), who continued to group both species in the *ferrumequinum* group, and keyed the two species on the basis of the shape and size of the anterior and posterior rostral compartments. Bogdanowicz (1992), in a phenetic analysis of the whole family, proposed different group-level classifications for the two species (*R. malayanus* in the *megaphyllus* group but *R. stheno*, with a question mark indicating uncertainty, in the *euryotis* group).

Specimens of *R. malayanus* and *R. borneensis* Peters, 1861 were also collected during the recent expeditions, confirming the presence of *R. borneensis* in Vietnam (see Hill & Thonglongya, 1972, Corbet & Hill, 1992 and discussion below). In view of the various theories outlined above concerning the relationship between *R. stheno* and *R. malayanus*, morphological comparisons and a Principal Components Analysis are given below between the two subspecies of *R. stheno* and *R. malayanus*.

MATERIALS AND METHODS

All available specimens were included in the morphological comparisons but for the multivariate analysis, which requires the use of complete sets of measurements, the reduced number of specimens is given in parentheses as follows: 12 (8) specimens of *R. s. microglobosus* described below, 21 (13) specimens of the nominate subspecies of *R. stheno* (from Sumatra, Java and Malaysia) and 14 (11) specimens of *R. malayanus* (from Thailand and Malaysia).

External measurements, to the nearest 0.1 mm, were taken from dry and alcoholic museum specimens using digital calipers. Cranial measurements, to an accuracy of 0.01 mm, were collected using digital calipers and a binocular microscope. Characters for the multivariate analysis included one external and nine cranial measurements, as follows, with the abbreviation in parentheses:

1. forearm length (FA)
2. greatest skull length (GSL) – measured from the anterior of the canine to the posteriormost part of the occiput;
3. maxillary toothrow length (MTL) – the crown length from the anterior of the upper canine (C) to the posterior of the third upper molar (M3);
4. zygomatic width (ZW) – the greatest distance across the zygoma;
5. mastoid width (MW) – the greatest distance across the mastoid region of the braincase;
6. mandible length (ML) – the distance from the most posterior portion of the articular process to the anteriormost edge of the alveolus of the first lower incisor (i1);
7. lower toothrow length (LTL) – the crown length from the anterior of the lower canine (c) to the posterior of the third lower molar (m3);
8. interorbital width (IW) – the least width of the interorbital constriction;

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9. rostral swelling width (RSW) – the greatest width of the nasal swellings;
10. median anterior rostral swelling width (MARW) – greatest width in dorsal view.

To reveal the taxonomic differences and relations between the taxa included in this study the Mann-Whitney U Test and Principal Component Analysis (PCA) were used. For the univariate analysis a non-parametric method was applied since the raw data did not meet the criteria for a normal distribution based on the F-test Both statistical methods were performed by Statistica 5.1, 1984–1995 statistical programme of StatSoft Inc. run on a 486 PC.

Abbreviations used for institutions are: BMNH – The Natural History Museum, London, formerly the British Museum (Natural History); HNHM – Hungarian Natural History Museum, Budapest; MNHN – Muséum National d'Histoire Naturelle, Paris; IEBR – Institute of Ecology and Biological Researches, Hanoi.

RESULTS

Rhinolophus stheno microglobosus ssp. nov.

Figs 1–4, Table 1

HOLOTYPE. BMNH 1997.360 (field number 9601/B11), adult male in alcohol, skull extracted, collected by members of 'Frontier' the Society for Environmental Exploration – Vietnam, between 17 January and 18 March 1996.

TYPE LOCALITY. Na Hang Nature Reserve, Tuyen Quang Province, Vietnam, between 22°16' and 22°31'N, 105°22' and 105°29'E, altitude 100–1082 m. Highly diverse evergreen and semi-evergreen primary limestone rainforest (see Hill & Kemp, 1996).

PARATYPES. The same collection data as the holotype: BMNH 1997.359 (field number 9601/B10) adult female in alcohol, skull extracted; BMNH 1997.361 (field number 9601/B25) adult male in alcohol, skull extracted; BMNH 1997.362 (field number 9601/B28) adult female in alcohol; 2 km SE of Pac Ban, Na Hang Nature Reserve, Tuyen Quang Province, Vietnam, 22°19'N, 105°25'E, altitude 300 m, 3 March 1997, collected by Gábor Csorba and Pham Duc Tien: HNHM 98.1.1. (field number CSOVI 30) adult female, skin, skull and skeleton; HNHM 98.1.2–3. (field number CSOVI 32, 33) adult males, in alcohol, skull extracted; IEBR (not catalogued, field number CSOVI 31) adult female, in alcohol, skull extracted.

Referred material: Tham Tap Tao, Fang, Chiangmai, Thailand, 19°55'N 99°13'E BMNH 1978.974, adult female in alcohol, skull extracted, BMNH 1978.2301, adult skull only; Chanthaburi, Pong Nam Ron, Khao Soi Dao Tai, Thailand, 12°36'N 102°09'E 850 m: BMNH 1978.2298–2300, adult skulls only.

COMPARATIVE MATERIAL. *Rhinolophus stheno stheno* –West Malaysia: Selangor (BMNH 1898.3.13.1 [holotype], 1898.3.13.2–3, 1973.606–607); Gunong Benom, Pahang (BMNH 1967.1492, 1967.1494, 1967.1497, 1967.1533–1534); Batu Pahat, Kangar, Perlis (BMNH 1968.817–818); Tioman Island (HNHM 95.55.2–4); Indonesia: Saekaranda, N. E. Sumatra (BMNH 1907.1.9.2, MNHN 1903.3); Kalipoetjang, Tji-Tandoei River, Java (BMNH 1909.1.5.179–182).

Rhinolophus malayanus – Thailand: Biserat, Jalor (BMNH 1903.2.6.83 [holotype], 1903.2.6.84, 1908.2.5.24–25); Phu Nam Tok, Saraburi (BMNH 1970.1462); Phu Nam Tok Tap Kuang, Khaeng Khoi, Saraburi (BMNH 1978.973); Satun, Muang, Wang Bla Chan (BMNH 1978.2295); Chiangmai, Fang, Tham Tap Tao (BMNH 1978. 2296–2297); West Malaysia: Batu Pahat, Kangar, Perlis (BMNH 1968.812); Kisap Forest Reserve, Pulau Langkawi (BMNH 1968.813–816).

DIAGNOSIS. Anterior median rostral compartments abruptly elevated but narrow and globular in outline; posterior median rostral compartments very small but slightly inflated dorso-laterally. Skull slender, rostral swelling width < 5.1, zygomatic and mastoid width < 9.1.

DESCRIPTION. A medium-sized horseshoe bat belonging to the *ferrumequinum* group (*sensu* Corbet & Hill, 1992), forearm length 43.8–47.2, mean 45.46, SD 1.21, n = 8; head and body length 38.8–45.2, mean 43.39, SD 2.73, n = 8; tail length 17.7–23.0, mean 20.0, SD 1.49, n = 8; hindfoot length 7.8–8.4, mean 8.0, SD 0.18, n = 8; ear length 16.9–18.7, mean 17.89, SD 0.64, n = 8; weight 9–9.5 grams, mean 9.33, SD 0.24, n = 3. Ear medium in length, just reaching the tip of nose when laid forward. Noseleaf with sella almost parallel-sided, only narrowing very slightly, rounded at tip; the connecting process rounded, typical for the *ferrumequinum* group; the lancet long, straight-sided, its tip cuneate; the supplementary noseleaf clearly visible; the lower lip has three groves (Fig. 1). The dorsal pelage is light yellowish-brown at the base of hairs, reddish cinnamon-brown above and c. 8 mm long, that of the venter paler and shorter. The wing membranes are uniformly dark brown. The fifth metacarpal is subequal or slightly longer than the fourth, the third shorter than fourth. Ratio of first to second phalange of third digit 1.56–1.67, mean 1.62, SD 0.04, n = 8.

Skull averaging smaller than in *R. s. stheno;* slender, rostral swelling width less than 5.1 mm, zygomatic and mastoid width subequal, not exceeding 9.1 mm (see Table 1). The anterior median rostral compartments are high and abruptly elevated but narrow and not forming the lateral walls of the rostrum, in profile they are posteriorly concave but less sharply so than in *R. s. stheno*; the posterior median rostral compartments are slightly inflated dorso-laterally so that the anterior region of the supraorbital depression is shallow and narrow, unlike the deep broad depression of *R. s. stheno*; lateral rostral compartments slightly inflated (see Fig. 2). The sagittal crest moderately developed. Palatal bridge less than one-third of the upper toothrow length. Anterior upper premolar well

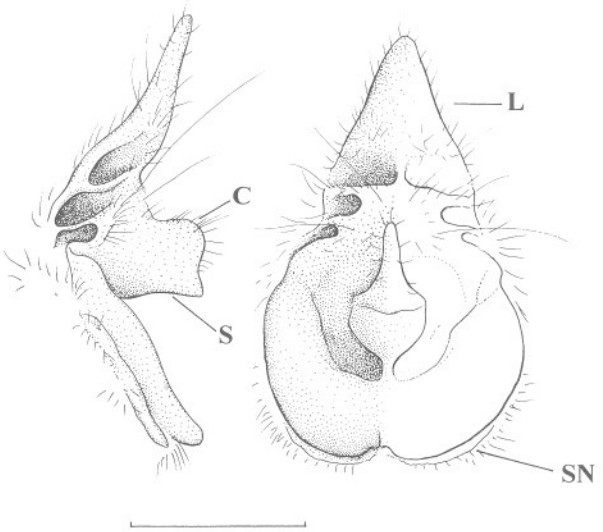

Fig. 1 Lateral (left) and frontal (right) views of noseleaves of *R. s. microglobosus* (HNHM 98.1.2. [paratype]). L = lancet; C = connecting process; S = sella; SN = supplementary noseleaf. Scale = 5 mm.

Table 1 Selected external and craniodental measurements (in mm) of *R. s. microglobosus*, *R. s. stheno* and R. *malayanus* presented as range, mean ± standard deviation and number of specimens in parentheses. Column 1: character. Column 2–4: taxon. Column 5–7: Mann-Whitney U Test p-levels between groups.

Character	Taxon			p-levels between groups		
	R. s. microglobosus	*R. s. stheno*	*R. malayanus*	*R. s. stheno–R. s. microglobosus*	*R. s. stheno–R.malayanus*	*R. s. microglobosus–R. malayanus*
FA	43.8–47.2	43.6–47.2	38.3–42.4			
	45.46± 1.21 (8)	45.55± 1.06 (21)	40.45± 1.18 (14)	0.828	0.000	0.000
GSL	18.22–19.38	18.84–19.92	17.25–17.79			
	18.73± 0.35 (10)	19.37± 0.31 (15)	17.56± 0.22 (11)	0.001	0.000	0.000
MTL	6.74–7.45	7.25–7.78	6.54–7.09			
	7.05± 0.20 (12)	7.49± 0.15 (16)	6.75± 0.16 (11)	0.001	0.000	0.001
ZW	8.81–9.06	9.29–9.75	8.47–8.94			
	8.93± 0.08 (11)	9.56± 0.16 (15)	8.77± 0.13 (11)	0.000	0.000	0.019
MW	8.71–9.07	9.09–9.66	8.14–8.45			
	8.87± 0.11 (12)	9.41± 0.16 (15)	8.23± 0.11 (11)	0.000	0.000	0.000
ML	11.83–12.85	12.59–13.31	11.18–12.08			
	12.23± 0.29 (12)	12.95± 0.21 (16)	11.79± 0.25 (11)	0.000	0.000	0.008
LTL	7.04–7.80	7.68–8.40	6.86–7.36			
	7.45± 0.22 (12)	7.98± 0.17 (16)	7.17± 0.17 (11)	0.000	0.000	0.001
IW	1.49–1.85	1.64 –2.00	2.13–2.67			
	1.66± 0.11 (12)	1.82± 0.13 (15)	2.44± 0.18 (11)	0.033	0.000	0.000
RSW	4.78–5.07	5.01–5.38	4.94–5.37			
	4.91± 0.11 (12)	5.13± 0.10 (15)	5.16± 0.12 (11)	0.001	0.885	0.002
MARW	3.53–4.00	4.13–4.36	3.99–4.41			
	3.82± 0.12 (12)	4.23± 0.07 (15)	4.15± 0.13 (11)	0.000	0.016	0.000

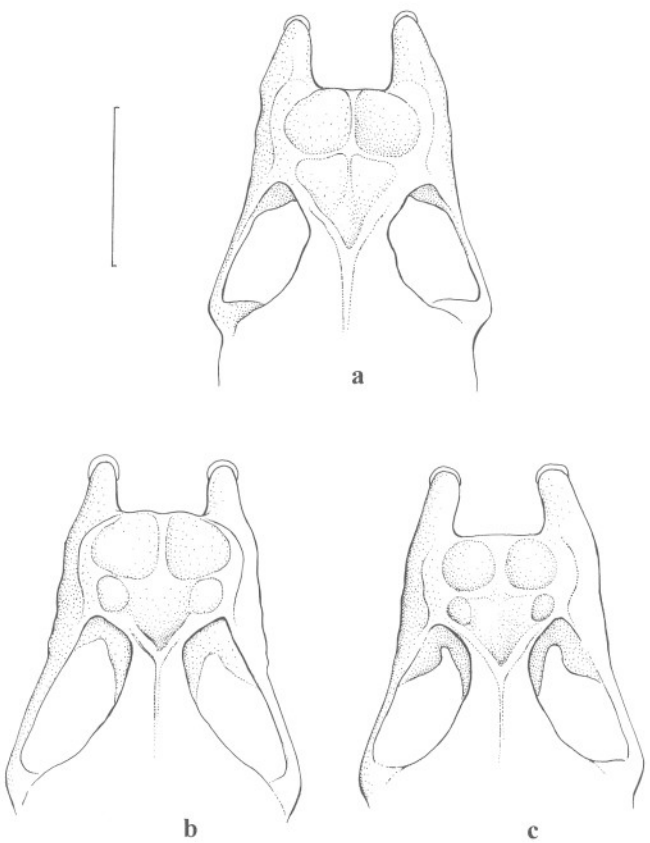

Fig. 2 Dorsal view of rostral part of skulls of a.) *R. malayanus* (BMNH 3.2.6.83 [holotype]), b.) *R. s. stheno* (BMNH 98.3.13.1 [holotype]) and c.) *R. s. microglobosus* (HNHM 98.1.1. [paratype]), Scale = 5 mm.

developed with distinct cusp, included in the toothrow. Lower middle premolar (p3) small and fully extruded from the toothrow; first (p2) and last (p4) lower premolars in contact or nearly so; p2 moderately small and narrow, antero-posterior axis only slightly displaced relative to main axis of toothrow, unlike *R. stheno stheno* in which p2 is slightly larger, overlaps more with the lower canine and p4, and in which the axis is more skewed.

ETYMOLOGY. The Latin word *microglobosus* refers to the size and shape of the median anterior rostral swellings which are considerably smaller than those of the nominate subspecies.

COMPARISONS WITH OTHER TAXA. Besides the classical morphological comparisons of the new subspecies, *R. s. microglobosus* and the nominate subspecies, *R. s. stheno,* the Mann-Whitney U Test was also performed to reveal if statistically significant differences were present in morphological characters. In the course of the analysis highly significant differences (highest $p < 0.01$) were shown in greatest skull length, maxillary toothrow length, zygomatic width, mastoid width, mandible length, lower tooth-row length, rostral swelling width and median anterior rostral swelling width; in all cases the new subspecies was smaller (Table 1).

The same method was used for pair-wise comparisons between *R. malayanus* and *R. s. steno,* and between *R. malayanus* and *R. s. microglobosus* (see Table 1 for p-levels between groups). Significant differences (at $p < 0.01$) were shown for the following variables: forearm length, greatest skull length, lower toothrow length, mastoid width, in which *R. malayanus* was smaller in each parameter, and interorbital width where *R. stheno* was smaller.

To help elucidate the relationships of the three taxa, a Principal Component Analysis (PCA) was performed using the characters recorded in Table 1. The scatterplots of the specimens *against* the factor 1 (F1) and factor 2 (F2) axes showed a *clear* separation of three groups (Fig. 3) supporting the view that *R. s. microglobosus* represents a distinct taxonomic unit. The first two factors represent more than 89% of the total variance where F2 was identified as the 'rostral

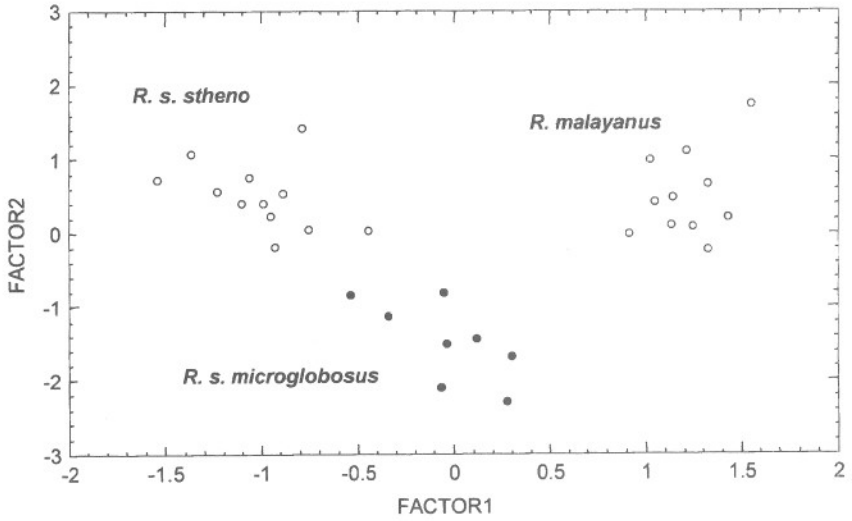

Fig. 3 Principal components analysis of *R. s. microglobosus*, *R. s. stheno* and *R. malayanus* specimens based on 10 external and craniodental characters.

swellings component' in which the two measurements of the rostrum (rostral swelling width and median anterior rostral swelling width) were the most important, and F1 pertained to the other characters (Table 2).

Table 2 Factor loadings of external and craniodental characters obtained by Principal Component Analysis

Character	Factor 1	Factor 2
Forearm length	–0.873	–0.344
Greatest skull length	–0.985	–0.040
Maxillary toothrow length	–0.954	0.075
Zygomatic width	–0.887	0.283
Mastoid width	–0.972	–0.003
Mandible length	–0.943	0.126
Lower toothrow length	–0.955	0.096
Interorbital width	0.740	0.569
Rostral swelling width	–0.050	0.929
Median anterior rostral swelling width	–0.206	0.894
Variance explained	67.67%	22.17%

DISCUSSION

The new records of *R. stheno* extend the known distribution of the species to North Vietnam, and represent a new subspecies which is characterised by its generally smaller, narrower skull and above all, by the small, globular anterior median rostral swellings.

Specimens of *R. stheno* from Thailand in the collection of The Natural History Museum also proved to belong to the new subspecies. It seems possible also, that specimens recorded by Osgood (1932: 219) refer to the same subspecies as described here. His specimens, listed as '*Rhinolophus* sp.', derived from Tonkin (North Vietnam) and Osgood stated that '. . . it is possible that the present [form] is a northern representative of the larger Malayan form *stheno*'. An alternative suggestion, that Osgood's specimens might be referable to *R. borneensis* was, however, made by Hill & Thonglongya (1972). This supposition is equally probable, as affirmed by specimens of *R. borneensis* which were also collected during the recent expeditions to Vietnam. It appears likely that the section on *R. stheno* in Lekagul & McNeely (1977) also refers to the new subspecies; unfortunately, however the accompanying photograph is of a specimen in which the diagnostic characters are not visible on the damaged rostrum.

According to the literature, *R. stheno* and the closely related *R. malayanus* may be distinguished by the shape of the rostral swellings. On the basis of our data set, the width of the interorbital constriction also distinguishes the two species (Table 1).

As regards the external characters, according to Koopman (1994) there is a definite gap between the two species in forearm length (45–48 mm against 40–43 mm) but McFarlane & Blood (1986) concluded 'that there is a probability of overlap between specimens of the two species'. Indeed, during the examination of larger series derived from different geographical regions only very slight differences may be observed between extreme values of forearm length of small *R. stheno* and large *R. malayanus*. Furthermore the ratio of first to second phalange of the third digit in *R. s. microglobossus* shows overlap in size between the smaller *R. malayanus* and the larger *R. s. stheno*, as figured by McFarlane & Blood (1986).

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