

## A New Horseshoe Bat, *Rhinolophus chiewkweeae* (Chiroptera, Rhinolophidae), from Malaysia

Mizuko Yoshiyuki<sup>1</sup> and Boo Liat Lim<sup>2</sup>

<sup>1</sup>4–14–213, Tsukudohachiman-cho, Shinjuku-ku, Tokyo, 162–0815, Japan

<sup>2</sup>Department of Wildlife and National Parks (DWNP),  
km 10 Jln. Cheras 56100, Kuala Lumpur, Malaysia

**Abstract** A new horseshoe bat, *Rhinolophus chiewkweeae* is described on the basis of specimens collected from the Malay Peninsula. The new species is classified in the *R. pearsoni* group composed of *R. pearsoni* and *R. yunanensis*. *Rhinolophus chiewkweeae* shows adequate coefficients of differences in external and osteological characters to be separated at species level from *R. pearsoni* and *R. yunanensis*. The dimensional characters of the new species except short ears and tail are intermediate between those of the two species. The new species also shows color differences from *R. pearsoni* and *R. yunanensis*: the dorsal fur of the new species is orange brown, instead of the dark brown of *R. pearsoni* and *R. yunanensis*. *Rhinolophus chiewkweeae* inhabits a dipterocarp forest of the Malayan division, Sundai subregion, of the Indo Malayan region.

**Key words:** Chiroptera, Rhinolophidae, *Rhinolophus*, coefficient of difference, new species, Malayan division.

### Introduction

The species of *Rhinolophus* are distributed in the tropics, subtropics, and temperate zones of the Old World from Europe and Africa to Japan, New Guinea, the Bismarck Archipelago, and East Australia. Other authors have recognized in this genus about 60 species (Corbet and Hill, 1992), 64 species (Wilson & Reeder, 1993) and 71 species (Csorba *et al.*, 2003).

From 1990 to 1998, the junior author researched the mammalian fauna of the forests of the Malay Peninsula. Among the collected materials, there were seven specimens of a large *Rhinolophus* Lacepède, 1799 characterized by a complex noseleaf consisting of an anterior horseshoe, a perpendicular median sella, and a posterior erect lancet. The seven collected specimens were classified in the *R. pearsoni* group composed of *R. pearsoni* Horsfield, 1851 and *R. yunanensis* Dobson, 1872. After carefully examining the collected specimens, we came to the conclusion that they represent a new species which is described below under the name of

*Rhinolophus chiewkweeae*.

### Methods

Mist nets were placed along forest pathways in five localities, and they were opened at 18:30 and closed at 23:00 hours. Bats caught were transferred into cloth bags and kept in the field station until the following morning for processing. Standard external measurements in mm such as head and body, tail, forearm, tibia, and ear length were taken with dial calipers, and weight (in grams) was taken with a balance (Tanita Model 1211) in fresh specimens by the junior author. The other measurements were made by the senior author. They were subsequently injected with 75% ethyl alcohol solution and preserved in a jar filled with 75% alcohol solution.

We examined variations in the quantitative and the qualitative characters of the new species and neighboring species, and determined whether the quantitative characters of samples are taxonomically different by the coefficient of difference (CD) (Imaizumi, 1966; Yoshiyuki, 1989). Among

qualitative characters we gave attention to the shape of the noseleaf, upper and lower lips, ear, skull, teeth, baculum, and fur color.

Among them, the skin and skull of two specimens and alcoholic skin and skull of five specimens were studied. The holotype and paratypes were registered in the Mammal Section, Department of Zoology, National Science Museum, Tokyo.

***Rhinolophus chiewkweeae* sp. nov.**

[Japanese name: Rimu Kikugashira-koumori ]

(Figs. 1–4, Tables 1–3)

*Holotype.* Adult female, NSMT-M 33472, Gunung Ledang, 2°84'N, 102°57'E, Tangkak, Muar, Johore, a submontane dipterocarp forest approximately 1276 m in elevation, Malaysia, collected on 13 September 1998, by Boo Liat Lim.

*Measurements (in mm) of the holotype.* Forearm 55.4, head and body 63.0, tail 19.0, tail percent 30%, tibia 27.0, ear 26.0, antitragus anterior 13.0, posterior 3.5, hind foot cum unguis 12.5, third metacarpal 38.6, fourth metacarpal 42.3, fifth metacarpal 42.9, nose leaf (length×width) 18×12, greatest length of skull to front of upper incisors 25.9, length of skull from condyle to canine 22.6, interorbital constriction 2.7, zygomatic width 13.1, width of braincase 10.3, depth of braincase 6.81, mastoid width 11.6, width across from left upper canine to right upper canine 6.4, width across from left upper last molar to right upper last molar 9.5, length from upper canine to upper last molar 10.3, mandibular length 17.4, length from lower canine to lower last molar 10.9.

*Paratypes.* One skin, five alcoholic skins and six skulls collected by Boo Liat Lim: NSMT-M 33470, female, 14 Feb. 1991, Asahan Forest Reserve (2°39'N, 102°56'E), Jasin, Malacca, a hill dipterocarp forest approximately 800 m in elevation; NSMT-M 33471, male, 13 Sept. 1998, Gunung Ledang (2°84'N, 102°57'E), Tangkak, Johore, a submontane dipterocarp forest approximately 1276 m in elevation; NSMT-M 33473, female, 16 Jan. 1990, Asahan Forest Reserve

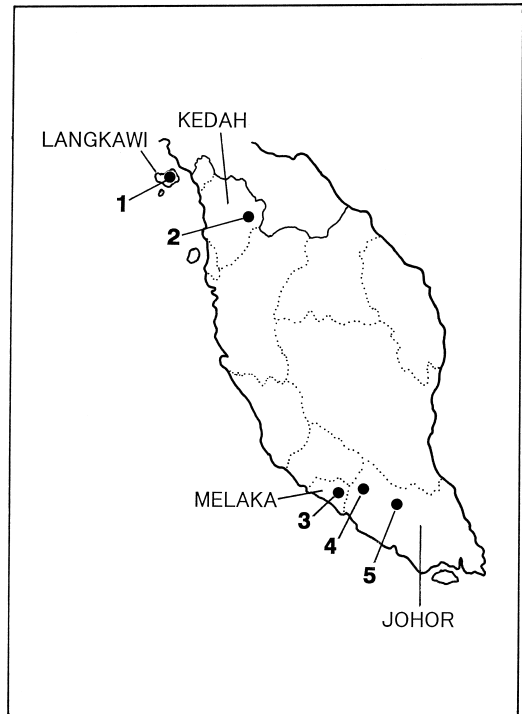


Fig. 1. Map showing the collection sites of *Rhinolophus chiewkweeae* sp. nov. 1, Lubok Semilan; 2, Weng Subcatchment Area; 3, Asahan Forest Reserve; 4, Gunung Ledang; 5, Labis Forest Reserve.

(2°39'N, 102°56'E), Jasin, Malacca, a hill dipterocarp forest approximately 800 m in elevation; NSMT-M 33474, female, 30 Feb. 1998, Labis Forest Reserve (2°28'N, 103°04'E), Segamat, Johore, a lowland dipterocarp forest about 150 m in elevation; NSMT-M 33475, male, 19 Aug. 1992, Lubok Semilan (6°37'N, 99°87'E), Ulu Melaka, Pulau Langkawi, Kedah, a lowland dipterocarp forest approximately 100 m in elevation; NSMT-M 33476, male, 19 Dec. 1990, Weng Subcatchment Area (6°34'N, 100°57'E), Ulu Muda Forest Reserve, Baling Kedah, a hill dipterocarp forest approximately 900 m in elevation.

*Diagnosis.* Belongs to *Rhinolophus pearsoni* group (Csorba *et al.*, 2003), medium in size (see Table 1), but ear and tail lengths shorter than those of the *R. pearsoni* group, antitragal lobe high. Lower lip with single groove. Hairs on connecting process, sella, anterior and posterior nose



Fig. 2. Head of *Rhinolophus chiewkweeae* sp. nov., paratype, NSMT-M33471, male (top) and dorsal aspect of *Rhinolophus chiewkweeae* sp. nov., holotype, NSMT-M33472, female (bottom).

leaf sparse. Dorsal fur color orange brown, ventral surface lighter, membrane brownish. Zygomatic width greater, crown areas of incisor and anterior upper premolar large. Baculum long, ampulla and ala thick.

*Description.* External characters. — In general characters similar to the *R. pearsoni* group

(see Table 1, Figs. 2 and 3). Ear short, 25.0 mm (average), antitragal lobe relatively large and high, height of anterior border 12.2 mm (average) from basal portion; tail short, 18.9 mm (average).

Horseshoe large, greatest length 18.0 mm (average) and greatest width 11.6 mm (average); anterior horseshoe wide, anteriorly emarginated

Table 1. Comparisons of external, cranial, and dental measurements in the species of the *Rhinolophus pearsoni* group.

Character	(in mm)					
	<i>R. chiewkweeae</i> sp. nov. Malaysia		<i>R. pearsoni</i> Thailand		<i>R. yunanensis</i> Thailand	
	N	M±SD	N	M±SD	N	M±SD
Forearm	7	56.1±0.81	8	51.5±1.897	9	58.7±1.498
Head and body	7	64.0±0.93	8	60.8±1.639	9	67.2±0.230
Tail	7	18.9±0.99	8	21.9±1.965	9	20.9±1.969
Hind foot cum unguis	7	14.0±0.926	8	13.0±0.559	9	14.7±0.527
Tibia	7	26.4±0.903	8	24.8±0.707	9	27.8±1.106
Ear length	7	25.0±0.76	8	27.7±0.827	9	30.9±0.667
Condyllo-canine length	7	22.3±0.404	8	20.3±0.349	7	23.4±0.307
Interorbital constriction	7	2.8±0.186	8	2.2±0.196	7	2.9±0.217
Zygomatic width	7	13.2±0.106	8	11.1±0.360	7	13.6±0.214
Width of braincase	7	10.3±0.186	8	9.1±0.298	—	—
Mastoid width	7	11.5±0.202	7	10.5±0.184	7	11.8±0.12
Width from left upper canine to right upper canine	7	6.7±0.213	8	5.9±0.167	7	7.0±0.22
Width from left upper last molar to right upper last molar	7	9.5±0.215	8	8.6±0.192	7	9.8±0.14
Length from upper canine to upper last molar	7	10.1±0.122	8	9.2±0.318	7	10.7±0.21
Mandible	7	17.2±0.307	8	15.5±0.240	7	18.2±0.33
Length from lower canine to lower last molar	7	10.8±0.203	8	9.7±0.238	7	11.4±0.29

deeply at central portion with hairs scarce on the surface. Lancet broadly triangular with three deep cells of lancet; intercellular septum swollen. Connecting process from apex of sella without hair, rounded and low in profile, its height a little less than that of the apex of the sella. Sella broadly rounded at apex with small basal lappets; in the facial view constricted in one-third and two-thirds portion parallel on sides. Lower lip with single groove.

Plagiopatagium attached to base of metatarsal and uropatagium inserted into lower portion of lower leg. The third metacarpal the shortest (38.2 mm, average); the fourth slightly shorter than the fifth (42.7 mm, average). The fur dense, long, and wooly in texture; dorsal color orange brown, ventral surface lighter, and membrane brownish.

Cranial and dental characters. — Skull with large braincase, with high sagittal and lambdoid crests and weak temporal crests: zygomatic arch wide, nose swelling high, and interorbital region narrow. Zygomatic width greater than that of

mastoid width. The ratio of zygomatic width to condyllo-canine length 59% instead of 55% in *R. pearsoni* and 58% in *R. yunanensis*. Interorbital constriction narrow, the ratio of interorbital constriction to condyllo-canine length 13% instead of 11% in *R. pearsoni*, and 12.5% in *R. yunanensis*.

In the dorsal view of skull (see Fig. 3), anterior naris deep, rectangular, its posterior margin extending to level of center of upper first molars; nasal swelling expanded, mainly anterior median swellings swollen, lateral swellings slightly swollen, posterior swellings relatively concave; rostral portion low, temporal crest weak; sagittal crest from the crossing point temporal and anterior sagittal crest to lambdoid crest developed, mainly anterior portion high and lambdoid crest low, braincase wide and swollen. In the ventral view of skull, palatal emargination deep, as a square, the posterior margin extending to level of middle of upper posterior premolar. Palate length slightly longer than that of *R. pearsoni* and *R. yunanensis*, mesopterygoid fossa U-shaped, wider than that of *R. pearsoni* and *R. yunanensis*. Size





Fig. 3. Skull of *Rhinolophus chiewkweeae* sp. nov., holotype, NSMT-M33472, female; dorsal surface (top, left), ventral surface (top, right), lateral surface (bottom, right), and mandible (bottom, left). Bar indicates 5 mm.

of auditory bulla and cochleae similar to *R. pearsoni* group, covering one-third of surface of large cochleae. In the lateral view of skull, dorsal profile with anterior and posterior swellings; the former is the median nasal swelling, and the latter is the anterior portion of the sagittal crests. The lower portions with anterior naris, interorbital re-

gion, and lambda. Lacrimal foramen about 1 mm in diameter exposed, anterorbital foramen large.

Teeth heavy relative to size of skull. Upper and lower incisors larger than in the other species of *R. pearsoni* group and the crown area of upper incisor wider than root. Upper canine weak, cingulum developed, but inner portion weak, lower

canine thick with strong cingulum; anterior upper premolar clearly separated from upper canine and posterior premolar, its crown area large, nearly pentagon-shaped with small cingulum in the tooth row.

Posterior upper premolar large, its crown area about equal to half of that of upper first molar, posterior border of crown straight; in contact with anterior upper premolar. Lower first premolar and third premolar similar to each other, but crown area of lower first premolar slightly small, middle lower premolar minute, rounded crown, about 1 mm in diameter, external to tooth row with weak cingulum, crowded closely together. First and middle upper molars similar to each other, but crown area of upper last molar about equal to two-thirds of that of upper first molar and upper middle molars, lower molars similar to one another.

**Baculum.** — General outline of baculum (Topal, 1975) similar to that of *R. pearsoni*, but the shape of ampulla and ala (Imaizumi & Yoshiyuki, 1963) remarkably different. Total length 3.3 mm, the greatest width 0.8 mm; length of ampulla 1.5 mm, occupies 53% of baculum length. Fossa on ampulla deep, ala of ampulla developed, thick. Dorsal central portion of ampulla emarginate deeply in a U-shape.

**Etymology.** The new species is named after the late Mrs. Chiew Kwee, the junior author's wife.

**Remarks.** The *Rhinolophus pearsoni* group (Csorba *et al.*, 2003) consists of *R. pearsoni* Horsfield, 1851 (type locality; Darjeeling, West Bengal, Northeastern India) and *R. yunanensis* Dobson, 1872 (type locality; Hotha, Yunnan, China). *Rhinolophus pearsoni* and *R. yunanensis* are recognized as distinct species by Lekagul and

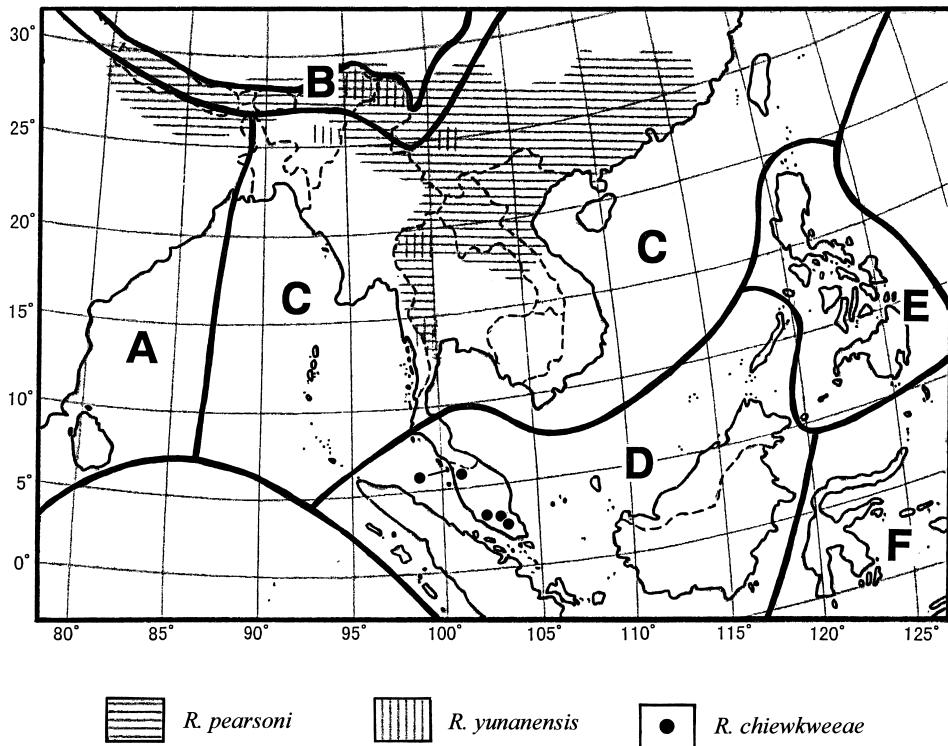


Fig. 4. Map showing the geographic ranges of *Rhinolophus pearsoni*, *R. yunanensis* and *R. chiewkweeae* sp. nov. Thick black lines indicate the boundaries of subregions. A, Indian Subregion; B, Himalayan Subregion; C, Indochina Subregion; D, Sundaic Subregion; E, Philippine Subregion; F, Wallacean Subregion (according to Corbet and Hill, 1992).

Table 2. Coefficient of differences and percentages of nonoverlap of population curves in *Rhinolophus chiewkweeae* sp. nov. and *R. pearsoni*.

Character	CD of <i>R. chiewkweeae</i> and <i>R. pearsoni</i>	Percentage of nonoverlap in both population curves (%)
Forearm	1.69	95.4
Head and body	1.28	90.0
Tail	1.01	84.4
Hind foot cum unguis	0.67	74.9
Tibia	0.99	84.0
Ear length	1.70	95.5
Condylo-canine length	2.66	99.6
Interorbital constriction	1.57	94.2
Zygomatic width	4.51	99.9
Width of braincase	2.48	99.3
Mastoid width	2.59	99.5
Width from left upper canine to right upper canine	2.11	98.2
Width from left upper last molar to right upper last molar	2.21	98.6
Length from upper canine to upper last molar	2.05	98.0
Mandible	3.11	99.9
Length from lower canine to lower last molar	2.49	99.4

Table 3. Coefficient of differences and percentages of nonoverlap of population curves in *Rhinolophus chiewkweeae* sp. nov. and *R. yunanensis*.

Character	CD of <i>R. chiewkweeae</i> and <i>R. yunanensis</i>	Percentage of nonoverlap in both population curves (%)
Forearm	1.13	87.0
Head and body	2.75	99.7
Tail	0.68	75.2
Hind foot cum unguis	0.48	68.4
Tibia	0.69	75.5
Ear length	4.13	99.9
Condylo-canine length	1.55	93.9
Interorbital constriction	4.03	99.9
Zygomatic width	1.05	85.3
Width of braincase	0.93	82.3
Mastoid width	0.69	75.5
Width from left upper canine to right upper canine	0.86	80.5
Width from left upper last molar to right upper last molar	0.85	80.2
Length from upper canine to upper last molar	1.81	96.5
Mandible	1.57	94.2
Length from lower canine to lower last molar	1.22	88.9

Mcneely (1977), Hill (1986), Yoshiyuki (1990), and Csorba *et al.* (2003). The former occurs from China, North India, Nepal, Myanmar, Vietnam, and Laos P. D. R. to Thailand, and the latter occurs from Southeastern China, Northeastern India, and North Myanmar to Thailand (Fig. 4).

The coefficients of differences ( $CD = M_B - M_A / (S.D._B + S.D._A)$ ) of *Rhinolophus chiewkweeae* sp. nov. and the two species in the *pearsoni* group and the percentage of nonoverlap in population curves is shown in Tables 2 and 3.

The conventional level of taxonomic species difference is shown as the value of CD 1.34 (Imaizumi, 1966: 189).

According to this, among 16 dimensions of external, cranial and dental characters of *R. chiewkweeae* and *R. pearsoni* (see Tables 1 and 2), the CD of dimensions of 12 characters is larger than 1.34 and the percentage of nonoverlap in population curves of *R. chiewkweeae* and *R. pearsoni* is 94.2–99.9 percent. These dimensions of charac-

ters are the forearm (95.4%), ear length (95.5%), condylo-canine length (99.6%), interorbital constriction (94.2%), zygomatic width (99.9%), width of brain case (99.3%), mastoid width (99.5%), width from left upper canine to right upper canine (98.2%), width from left upper last molar to right upper last molar (98.6%), length from upper canine to upper last molar (98.0%), mandible (99.9%), and length from lower canine to lower last molar (99.4%). As these characters of *R. chiewkweeae* are different from 94.2–99.9 percent of the individuals of *R. pearsoni*, the two species are recognized to be distinct at the species level.

In the CD of 16 dimensions of characters in *R. chiewkweeae* and *R. yunanensis*, the CD of dimensions of 6 characters is larger than 1.34 and the percentage of nonoverlap in the population curves of *R. chiewkweeae* and *R. yunanensis* is 93.9–99.9 percent.

These dimensions of characters are the head

and body (99.7%), ear length (99.9%), condylocanine length (93.9%), interorbital constriction (99.9%), length from upper canine to upper last molar (96.5%), and mandible (94.2%) (see Tables 1 and 3). As these characters of *R. chiewkweeae* are different from 93.9–99.9 percent of the individuals of *R. yunanensis*, the two species are different at the species level.

### Acknowledgements

We wish to express our heartfelt thanks to Dr. Masatoshi Yasuda, Wildlife Ecology Laboratory, Forestry and Forest Products Research Institute, Tsukuba City, Japan, who kindly collaborated with us.

### References

- Corbet, G. B. & J. E. Hill, 1992. The Mammals of the Indomalayan Region. Oxford University Press, New York. viii+488 pp.
- Csorba, G., P. Ujhelyi, & N. Thomas, 2003. Horseshoe Bats of the World (Chiroptera: Rhinolophidae). Alana Books, Shropshire. xxxi+160 pp.
- Hill, J. E., 1986. A note on *Rhinolophus pearsonii* Horsfield, 1851 and *Rhinolophus yunanensis* Dobson, 1872 (Chiroptera: Rhinolophidae). *J. Bombay Nat. Hist. Soc.*, **83**: 12–18.
- Imaizumi, Y., 1966. Principles and Methods for Zoological Classification (In Japanese). Dai-ichi Hoki, Tokyo. ii+366 pp.
- Imaizumi, Y. & M. Yoshiyuki, 1963. Statistical analysis on taxonomic characters of *Rhinolophus cornutus*. 2. Variations of bacula. *Bull. Natn. Sci. Mus., Tokyo*, **6**: 411–422.
- Lekagul, B. & J. A. Mcneely, 1977. Mammals of Thailand. Kurusapha, Ladprao, Bangkok. li+747 pp.
- Topal, G., 1975. Bacula of some old world leaf-nosed bats (Rhinolophidae and Hipposideridae, Chiroptera: Mammalia). *Vertebr. Hung.*, **16**: 21–34, pls. 1–9.
- Wilson, D. E. & D. M. Reeder, 1993. Mammal Species of the World. A Taxonomic and Geographic Reference. Smithsonian Institution Press, Washington and London. xvii+1206 pp.
- Yoshiyuki, M., 1989. A Systematic Study of the Japanese Chiroptera. National Science Museum, Tokyo. vi+242 pp.
- Yoshiyuki, M., 1990. Notes on Thai mammals 2. Bats of the *pusillus* and *philippinensis* groups of the genus *Rhinolophus*. *Bull. Natn. Sci. Mus. Tokyo*, Ser. A, **16**: 21–40.