Journal of Mammalogy, 90(4):980–991, 2009

THREE NEW SPECIES OF *MURINA* (CHIROPTERA: VESPERTILIONIDAE) FROM TAIWAN

HAO-CHIH KUO, YIN-PING FANG, GÁBOR CSORBA, AND LING-LING LEE*

Graduate Institute of Ecology and Evolutionary Biology, National Taiwan University, 1, Sec. 4, Roosevelt Road, Taipei, 10617, Taiwan, Republic of China (H-CK, L-LL)
Department of Biological Resources, National Chiayi University, 300, Syuefu Road, Chiayi City, 60004, Taiwan, Republic of China (Y-PF)
Department of Zoology, Hungarian Natural History Museum, H-1083 Budapest, Ludovika tér 2, Hungary (GC)

We report 3 new species of bats of the genus *Murina* from Taiwan. One is a larger species that closely resembles *Murina leucogaster* and *Murina rubex* both externally and cranially. However, this new species differs from either or both of the latter 2 species in the color of the face and the dorsum, the attachment point of the plagiopatagium, the shape of the upper canine, and dimensions of the skull. The other 2 new species are smaller and differ from each other in the dorsal coloration, brightness of the pelage and the face, the shape of the basioccipital pit, the shape of the 1st upper premolar, and dimensions of the skull. These 2 new species can be distinguished from all known species of *Murina* by either the body size, the pelage coloration, the shape of the ear, or relative sizes and shapes of various teeth in both upper and lower toothrows, or a combination of these characters.

Key words: identification key, morphology, morphometric measurements, *Murina*, Murininae, new species, Taiwan, taxonomy, tube-nosed bats, type specimens

Miller (1907) erected the subfamily Murininae within the family Vespertilionidae to include bats of the genera *Murina*, *Harpiocephalus*, and the subsequently described *Harpiola*. Within the subfamily, authors have proposed different arrangements of the supraspecific taxa. *Harpiocephalus* has had its generic rank widely accepted since Miller (1907), whereas *Harpiola* has been considered as a full genus (Bhattacharyya 2002; Kuo et al. 2006; Tate 1941), or as a subgenus of *Murina* (Corbet and Hill 1991, 1992; Ellerman and Morrison-Scott 1951; Koopman 1994; Simmons 2005). Separation of *Harpiocephalus* and *Harpiola* from *Murina* was based on their morphologically diagnostic differences but has not been tested in a phylogenetic context of synapomorphies (i.e., reciprocal monophylies). Delineation and arrangement of supraspecific taxa are beyond the scope of this study, but we treat them as separate genera for the purposes of our study.

Species of *Murina* occur over large areas from mainland Asia to northeastern Australia including many islands between these landmasses. They are small to medium-sized bats and are, in contrast with other species of Vespertilionidae, characterized by having tubular nostrils; thick and wooly fur; furred forearm, hind limb, proximal part of wing membrane, and upper surface of interfemoral membrane; and an unusually large 1st upper premolar. The form and proportion of teeth in both upper and lower toothrows further distinguish species of *Murina* from those of *Harpiocephalus* and *Harpiola* (Kuo et al. 2006; Miller 1907). Within *Murina*, Simmons (2005) recognized 16 species. Subsequently 2 more species, *Murina harrisoni* and *Murina tiensa*, were described by Csorba and Bates (2005) and Csorba et al. (2007), respectively. Primarily because of the scarcity of specimens stored in museum collections, delimitations of these species are difficult and usually controversial. For example, there are different opinions on the species boundaries of *Murina florium* and *Murina suilla* (Corbet and Hill 1992; Koopman and Danforth 1989). Similarly, authors did not agree on the status of *Murina silvatica* in relation to *Murina ussuriensis* (Fukui et al. 2005; Kruskop 2005). Nonetheless, taxonomic research within this genus has advanced through detailed comparisons of many external and craniodental characters (Csorba and Bates 2005).

Murina has been collected in Taiwan by members of several research institutes and laboratories during a number of field surveys. Among these collections, we found 37 specimens representing 3 species clearly distinguishable from each other

* *Correspondent: leell@ntu.edu.tw*

as well as from *Murina puta*, the only hitherto known species of the genus in Taiwan. Because they also differ considerably from all other known species of the genus, we describe them as new species.

Materials and Methods

Specimens examined.—In addition to the 37 specimens of the 3 new species described below, 146 other specimens of *Murina* were examined (Appendix I). We followed Simmons (2005) and Csorba and Bates (2005) for taxonomy but treated *Murina rubex* as a full species based on its distinction from *Murina leucogaster* (described later in the text). Museum acronyms are defined in Appendix I.

Authors of this study and their associates collected bats in Taiwan under the constraint of the Wildlife Conservation Act. We captured and handled bats in the field with methods conforming to the guidelines approved by the American Society of Mammalogists for the use of wild mammals in research (Gannon et al. 2007).

Morphometric measurements.—Forearm length (FA) and 15 craniodental measurements were recorded to assess the morphometric distinction among species. We recorded values of the forearm length using digital calipers to the nearest 0.1 mm. H-CK recorded all craniodental measurements for most specimens using digital calipers with an accuracy of 0.01 mm. Craniodental measurements from 1 specimen (NMNH 578586) were recorded by Y-PF. The craniodental measurements are as follows: greatest length of the skull (GLS) is from the anterior point of the 1st upper incisor to the posteriormost point of the occipital region; condylocanine length (CCL) is from the posteriormost point of the occipital condyle to the front of the upper canine; zygomatic width (ZYW) is the greatest width across the outer borders of the zygomatic arches; breadth of braincase (BBC) is the greatest width across the sides of the braincase; mastoid width (MAW) is the greatest distance across the mastoids; lacrimal width (LW) is the width across the lacrimal tubercles at the rostral margins of the orbits; postorbital width (POW) is the least width of the postorbital constriction; maxillary toothrow length (IM3L) is from the anterior point of the 1st upper incisor to the back of the crown of the last upper molar; maxillary toothrow length (CM3L) is from the front of the upper canine to the back of the crown of the last upper molar; width across upper canines (CCW) is across the outer borders of the upper canines; width across upper molars (M3M3W) is across the outer crowns of the last upper molars; mandibular toothrow length (im3L) is from the anterior point of the 1st lower incisor to the back of the crown of the last lower molar; mandibular toothrow length (cm3L) is from the front of the lower canine to the back of the crown of the last lower molar; length of mandible (MDL) is from the anterior point of the 1st lower incisor to the most posterior part of the condyle; and height of ramus (RAH) is the least distance from the extremity of the coronoid process to the indentation of the lower border of the ramus mandibula. Measurements were recorded only from animals judged as adults from the knobby appearance of the joints in digits of the forelimbs. Ages of certain individuals with their skins not available were identified by the degree of tooth wear or by information on tags.

Females are usually larger than males for these Taiwanese species described below, therefore different sexes were separated for comparison. In addition, we relied heavily on the qualitative characters summarized by Csorba and Bates (2005) to draw the species boundaries. When describing dimensions of teeth, we followed definitions of Miller (1907).

Results and Discussion

Murina bicolor, new species

Holotype.—ZMNTU 2002.2.1, adult female, dry skin, skull, and postcranial skeleton. Collected by H.-C. Cheng on 25 February 2002.

Type locality.—Taiwan, Nantou County, Renai Township, Taroko National Park, Hehuanshan, 3,020 m.

Paratypes.—HNHM 2007.29.1, adult male, dry skin, skull and postcranial skeleton, collected at Ilan County, Nanau Township, Nanaunan logging road, 990 m, 24°23′51.0″N, 121°44′33.9″E. ESRI B0356, adult female, dry skin, skull, and postcranial skeleton, and ESRI B0357, adult female, in alcohol, skull extracted, both collected at Hsinchu County, Guanshi Township, Chihkoshan, 400 m. NCYU KHC038, adult female, dry skin, skull and postcranial skeleton, collected at Hsinchu County, Wufong Township, Bailan, 1,300 m, 24°34′33.6″N, 121°04′42.8″E. THU 7497, adult male, dry skin and skull, collected at Nantou County, Shinyi Township, Chunda logging road. NCYU FYPB058, adult male, in alcohol, skull extracted, collected at Chiayi County, Alishan Township, Tzuyun Temple, 2,200 m, 23°30′55.9″N, 120°48′32.1″E. NMNS 11423, adult male, dry skin, skull, and postcranial skeleton, collected at Kaoshiung County, Taoyuan Township, Meilong logging road, 780 m.

Etymology.—The specific epithet *bicolor* refers to the different colorations of the dorsum and ventrum.

Diagnosis.—*Murina bicolor* resembles *M. leucogaster* and *M. rubex* both externally and cranially. *Murina bicolor* can be distinguished from *M. leucogaster* by its well-developed face mask, which is a darker area around the muzzle, eyes, and lower part of the forehead; and the anterior–posteriorly more-compressed upper canine. In addition, females of *M. bicolor* have a longer greatest length of the skull, and a narrower zygomatic width, breadth of braincase, and mastoid width than females of *M. leucogaster*. *M. bicolor* can be distinguished from *M. rubex* by its well-developed face mask, more brownish than reddish dorsal color, and less posteriorly extended plagiopatagium with its insertion point close to the base of the 1st toe, as opposed to the base of the claw. In addition, females of *M. bicolor* have a larger width across upper canines than females of *M. rubex*. *M. bicolor* differs from other species of *Murina* with a

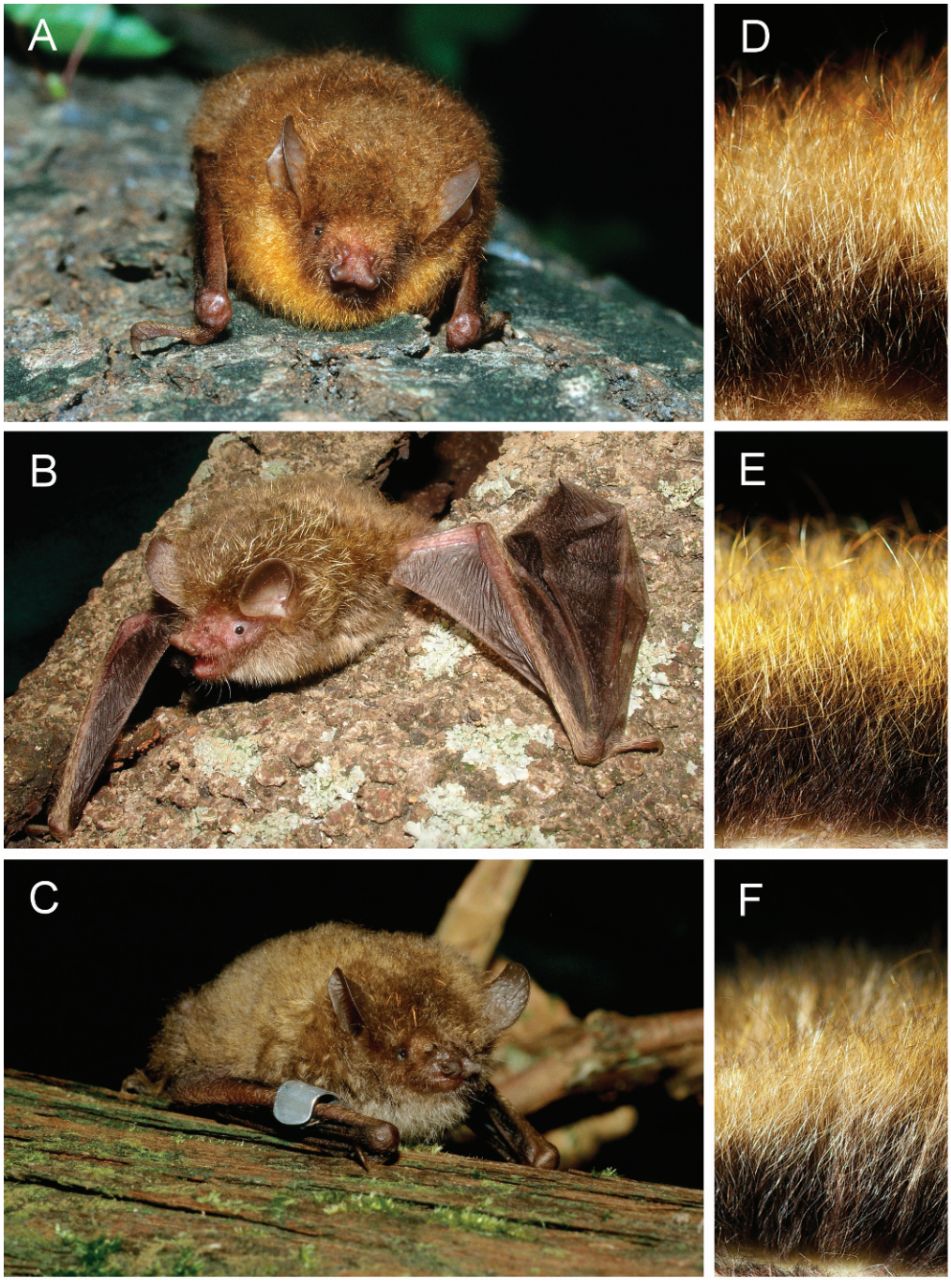

Fig. 1.—Photographs showing A–C) live animals, and D–F) color patterns of the dorsal underfur of 3 new species in Taiwan. A and D) *Murina bicolor* (paratype ESRI B0356 and holotype ZMNTU 2002.2.1, respectively). B and E) *M. gracilis* (paratype NCYU FYPB065 and paratype ZMNTU 2004.3.1, respectively). C and F) *M. recondita* (field no. NTUS069 [individual released after examination] and paratype, ZMNTU 2001.12.1, respectively). The scale bar, which represents 5 mm in length, is for D–F; A–C are not to scale.

combination of characters including larger size; the dorsum with a reddish brown color and the ventrum with colors varied from yellow to patches of yellow and white; the ear with a marked emargination along its posterior border; the insertion point of the plagiopatagium close to the base of the 1st toe; heavily built rostrum; and mesostyles of the 1st and 2nd upper molars moderately developed.

Description.—A larger species of *Murina* with forearm length 37–42 mm. The dorsum is reddish brown (Fig. 1A). The underfur of the dorsum has 3 bands: the basal half is black, the middle section is light gray, and the tip is a gradient ascending from orange to dark brown; the boundary between the latter 2 bands is ill defined (Fig. 1D). Individual guard hairs have a reddish tip. Ventral fur is uniformly yellow on the chest and

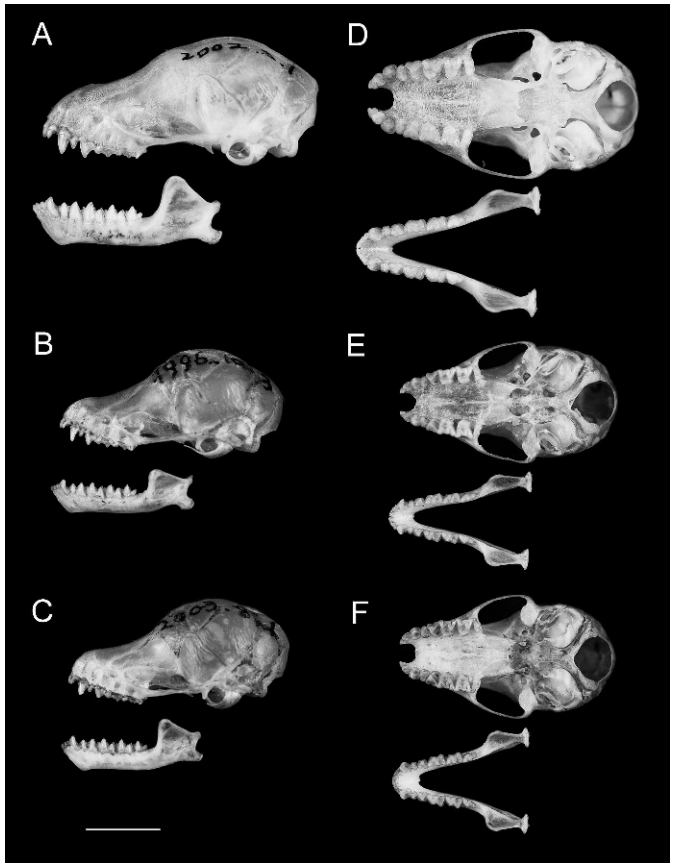

Fig. 2.—Photographs showing A–C) lateral views of skulls and mandibles, and D–F) basal views of skulls and occlusal views of mandibles of 3 new species in Taiwan. A and D) *Murina bicolor* (holotype ZMNTU 2002.2.1). B and E) *M. gracilis* (holotype ZMNTU 1996.10.3). C and F) *M. recondita* (holotype ZMNTU 2003.8.1). Scale bar = 5 mm.

throat, and yellow tipped in the abdominal region and along the flanks, with individual hairs having a dark base. Some specimens have the fur in the chest area uniformly white or yellowish white. The face mask is darker than the surrounding area. The ear is oval in shape with a marked emargination along the posterior border. The wing attaches close to the base of the 1st toe. The dorsal aspect of the interfemoral membrane is well furred, especially along the caudal vertebrae, and has a well-developed fringe of hairs around the posterior border; the underside is primarily naked but haired near the body.

The skull (Figs. 2A and 2D) is domed, the rostrum is robust, the frontal swelling is well developed, the sagittal crest is weak or absent, and the lambdoid crest also is weak. The narial emargination is approximately as long as the width. The basioccipital pits are relatively shallow, widen slightly anteriorly, and extend posteriorly well beyond the middle of the cochlea. The 1st upper incisor (I2) is bifid; the 2nd upper incisor (I3) has a well-developed lingual cingular cusp and its principal cusp reaches between the main and secondary cusp of I2; the basal area of I2 is more than two-thirds that of I3. The height of the upper canine (C1) exceeds that of the 2nd upper premolar (P4), and the basal area of the former tooth is approximately three-fourths that of the latter; the 1st upper premolar (P2) has the basal area approximately half that of P4 and has a height much less than that of the latter. The 1st and 2nd upper molars (M1 and M2, respectively) have moderately developed mesostyles, and the labial surfaces of these teeth have shallow concavities. The lower canine (c1) is roughly the same height or slightly higher than the 2nd lower premolar (p4); the 1st lower premolar (p2) has a height much less than that of p4, and the basal area of the former tooth is less than half that of the latter; the hypoconid and entoconid of the 1st and 2nd lower molars (m1 and m2, respectively) are the same height and are well separated from the protoconid and metaconid in each respective tooth.

Comparisons.—Murina bicolor can be distinguished from *Murina aenea*, *Murina cyclotis*, *Murina huttoni*, *Murina rozendaali*, *M. harrisoni*, *M. puta*, and *M. tiensa* by its markedly anteriorly positioned I2 relative to I3, and the smaller size of C1 (crown area less than that of P4) and P2 (crown area approximately one-half that of P4, as opposed to a proportion of more than two-thirds). *M. bicolor* is larger in overall size than *Murina aurata*, *Murina tenebrosa*, *Murina tubinaris*, *M. florium*, *M. silvatica*, *M. suilla*, *M. ussuriensis*, and the other 2 new species from Taiwan described herein (Table 1). It also differs from these smaller species in the insertion point of the wing to the hind foot (close to the base of the 1st toe, as opposed to the base of the claw) and the heavily built rostrum.

Species with overall size comparable to *M. bicolor* can be distinguished as follows. *Murina ryukyuana* is characterized by its relatively larger C1 (its crown area is subequal to that of P4); well-developed mesostyles of M1 and M2; less-robust rostrum; narrower breadth of braincase, lacrimal width, and postorbital width; and shorter forearm (Table 1).

Murina hilgendorfi is a Palearctic species and is distinguished by its relatively larger teeth in both upper and lower toothrows, especially P2, whose crown area is evidently more than half that of P4, and by its generally dark dorsal fur with the tip of the guard hairs shiny silver. However, coloration of *M. hilgendorfi* was reported to be geographically variable (Wallin 1969), and more than 1 species may be present (Simmons 2005). The coloration of *M. hilgendorfi* described above is based on specimens from Japan and Korea. In addition, *M. hilgendorfi* has a longer forearm in both sexes and is larger in many craniodental characters than *M. bicolor* (Table 1).

Murina leucogaster has the coloration of both the dorsum and ventrum very similar to those of *M. bicolor*. The face mask of *M. leucogaster* is ill defined (versus well expressed in *M. bicolor*). The C1 of *M. leucogaster* is more robust and has its base subcircular (versus a more slender and anterior–posteriorly compressed C1 in *M. bicolor*; Figs. 3A and 3B). The only female specimen of *M. leucogaster* (NMNH 578586) with craniodental measurements has smaller greatest length of the skull and larger zygomatic width, breadth of braincase, and mastoid width than female *M. bicolor* (Table 1). This specimen also has its maxillary toothrow length and width across upper molars at the lower limit, and height of ramus at the upper limit of corresponding measurements of female *M. bicolor* (Table 1).

Murina rubex has its face mask only slightly darker than the forehead and back, dorsal coloration more reddish, and the

Table 1.—Forearm length (FA) and craniodental measurements (in mm) of *Murina* species. Values of the mean ± *SD* (for $n \geq 4$) and the range are given for Taiwanese species, whereas only those of the range are given for other species. Sample sizes are given in parentheses. Acronyms of craniodental measurements are defined in the ''Materials and Methods.''

Species	Morphometric measurement					
	FA	GLS	CCL	ZYW	BBC	MAW
M. bicolor ♀ (4)	41.1 ± 0.5	19.05 ± 0.34	16.54 ± 0.32	10.23 ± 0.27	8.58 ± 0.13	8.76 ± 0.19
	40.4–41.6	18.74–19.54	16.28–17.00	9.89–10.53	8.41–8.72	8.51–8.95
M. bicolor ♂ (4)	38.9 ± 1.4	18.33 ± 0.33	15.88 ± 0.29	9.75 ± 0.27	8.51 ± 0.13	8.48 ± 0.10
	37.2–40.5	18.00–18.79	15.64–16.29	9.47–10.09	8.35–8.65	8.38–8.58 (3)
M. gracilis ♀ (2)	30.5	15.48	13.19	8.07	7.43	7.34
	30.2–30.7	15.38–15.57	13.10–13.27	7.95–8.18	7.23–7.63	7.15–7.53
M. gracilis ♂ (5)	29.3 ± 0.8	14.99 ± 0.29	12.71 ± 0.19	8.02 ± 0.12	7.39 ± 0.12	7.20 ± 0.07
	28.4–30.7 (6)	14.53–15.26	12.46–12.96	7.91–8.21	7.26–7.57	7.09–7.29
M. recondita ♀ (4)	30.9 ± 0.3	15.48 ± 0.24	13.26 ± 0.16	8.52 ± 0.11	7.30 ± 0.13	7.51 ± 0.04
	30.6–31.3	15.28–15.74 (3)	13.10–13.42 (3)	8.36–8.63	7.15–7.38 (3)	7.47–7.54 (3)
M. recondita ♂ (12)	29.2 ± 0.6	15.12 ± 0.24	12.78 ± 0.21	8.28 ± 0.13	7.25 ± 0.10	7.28 ± 0.08
	28.0–30.1	14.73–15.64	12.51–13.30	8.09–8.51	7.13–7.44	7.14–7.44
M. aurata ♀ (1)	30.1	—	—	—	—	—
M. aurata ♂ (2)	28.5–29.0 (3)	—	12.08 (1)	8.03 (1)	7.35 (1)	7.26 (1)
M. florium ♀ (2)	32.2–37.1 (7)	17.14 (1)	14.74 (1)	9.20 (1)	8.01 (1)	8.19 (1)
M. florium ♂ (1)	34.1–36.2 (5)	16.96	14.59	9.25	7.77	8.08
M. hilgendorfi ♀ (7)	41.5–44.4 (6)	17.91–20.33	15.83–17.91	10.23–11.90	8.40–9.21	8.93–9.92
M. hilgendorfi ♂ (13)	40.5–43.4 (12)	18.19–20.67	15.99–17.80	10.32–11.74	8.29–9.44 (12)	8.91–9.80
M. leucogaster ♀ (1)	40.9–41.8 (1♀, 1♂)	18.60	16.69	10.85	8.97	9.13
M. rubex ♀ (1)	41.2	18.81	16.31	9.98	8.68	8.55
M. ryukyuana[a] ♂ (1)	35.5–37.0 (3♀, 2♂)	18.79	16.42	9.91	8.24	8.53
M. silvatica[b] ♀ (1)	30.9–32.5 (9)	15.24	13.24	8.10	6.96	7.27
M. silvatica[b] ♂ (2)	28.4–31.5 (13)	15.11–15.68	12.89–13.42	7.86–8.31	7.13–7.59	7.08–7.40
M. suilla ♀ (4)	29.5–33.6 (8)	14.04–15.05	12.18–12.90	8.15–8.46	7.06–7.24	7.16–7.40
M. suilla ♂ (4)	28.8–30.6 (7)	14.52–15.28	12.02–12.81 (3)	8.31–8.33 (3)	7.02–7.48	7.13–7.38 (3)
M. tenebrosa ♀ (1)	33.8	16.81	14.74	9.13	7.84	8.03
M. tubinaris ♀ (4)	30.8–33.2 (8)	15.60–15.79 (3)	13.54–13.86	8.66–9.02 (2)	7.03–7.71	7.22–7.59 (3)
M. tubinaris ♂ (1)	29.5–30.5 (2)	—	13.36	8.79	—	7.45
M. ussuriensis[c] ♀ (2)	28.9–30.6 (2♀, 1?)	14.97–15.47	13.07–13.38	7.85–8.17	7.09 (1)	7.12–7.33

[a] Values of forearm length from Maeda and Matsumura (1998).
[b] Values of forearm length from Yoshiyuki (1989); only those from specimens assigned to age categories adult and old are included.
[c] Values of forearm length from Kruskop (2005).

insertion point of the plagiopatagium is close to the base of the claw. The only female specimen of *M. rubex* (BM[NH] 16.3.25.111) has its width across upper canines smaller than that of female *M. bicolor* (Table 1). This specimen also has its maxillary toothrow length, width across upper molars, and height of ramus at the lower limit, and lacrimal width and postorbital width at the upper limit of corresponding measurements of female *M. bicolor* (Table 1). This specimen has a higher ratio of breadth of braincase to mastoid width (1.015) than female *M. bicolor* (0.964–0.988, $n = 4$).

The dorsal coloration of *Murina fusca* (its specific distinction is questionable and may represent a junior synonym of *M. hilgendorfi*—Simmons 2005) was described as ''General greyish, or dusky brown, with no sign of reddish'' (Sowerby 1922:47), and thus differs from that of *M. bicolor*.

Distribution.—This new species occurs sporadically in mountainous areas with elevations from 400 to 3,020 m. The holotype was collected in a tunnel of a pillbox in Hehuanshan, where it hung alone on the wall; 2 other individuals observed were in close contact (H.-C. Cheng, pers. comm.). The locality is very close to the main peak of Hehuanshan, surrounded by open fields covered overwhelmingly with Yushan cane (*Yushania niitakayamensis*). Other specimens were caught in forests predominated by various broad-leaved trees (at Chihkoshan and Meilong logging road), planted conifers (at Tzuyun Temple), mixed forests (at Nanaunan logging road), or mosaic vegetation with fragments of mixed forests and bamboos (at Bailan village).

Murina gracilis, new species

Holotype.—ZMNTU 1996.10.3, adult male, in alcohol, skull and postcranial skeleton extracted. Collected by S.-H. Yang and P.-J. Chiang on 30 October 1996.

Type locality.—Taiwan, Ilan County, Datung Township, Yuanyang Lake Nature Reserve, 1,670 m.

Paratypes.—ZMNTU 2004.3.1, adult female, dry skin, skull, and postcranial skeleton, collected at Hualien County, Sioulin Township, Heping logging road, 1,440 m. ZMNTU 1995.10.1, adult male, dry skin, skull, and postcranial skeleton, collected at Hualien County, Sioulin Township, Taroko National Park, Da

Table 1.—Extended.

Species	Morphometric measurement					
	LW	POW	IM3L	CM3L	CCW	M3M3W
M. bicolor ♀ (4)	6.24 ± 0.10	5.33 ± 0.20	7.28 ± 0.18	6.21 ± 0.17	4.72 ± 0.15	6.33 ± 0.07
	6.15–6.38	5.07–5.53	7.13–7.52	6.08–6.45	4.63–4.95	6.25–6.39
M. bicolor ♂ (4)	6.06 ± 0.13	5.30 ± 0.18	6.96 ± 0.14	5.90 ± 0.11	4.44 ± 0.08	6.12 ± 0.16
	5.92–6.18	5.15–5.52	6.77–7.08	5.78–5.99	4.38–4.55	5.95–6.33
M. gracilis ♀ (2)	4.59	4.35	5.81	4.99	3.41	5.03
	4.56–4.62	4.31–4.38	5.71–5.90	4.92–5.05	3.34–3.47	4.94–5.11
M. gracilis ♂ (5)	4.55 ± 0.11	4.32 ± 0.06	5.54 ± 0.13	4.75 ± 0.10	3.33 ± 0.06	4.97 ± 0.04
	4.39–4.68	4.25–4.39	5.40–5.68	4.63–4.86	3.28–3.42	4.91–5.01
M. recondita ♀ (4)	4.69 ± 0.11	4.21 ± 0.04	5.82 ± 0.07	4.99 ± 0.08	3.69 ± 0.09	5.24 ± 0.08
	4.53–4.78	4.15–4.25	5.73–5.90	4.91–5.10	3.55–3.74	5.15–5.34
M. recondita ♂ (12)	4.65 ± 0.14	4.24 ± 0.11	5.65 ± 0.11	4.83 ± 0.10	3.55 ± 0.05	5.16 ± 0.10
	4.45–4.88	4.10–4.42	5.43–5.83	4.68–5.01	3.47–3.63	5.00–5.34
M. aurata ♀ (1)	4.56	4.17	5.51	4.67	3.29	4.89
M. aurata ♂ (2)	4.28–4.56	4.10–4.25	5.24–5.32	4.55–4.56	3.14–3.27	4.65–4.84
M. florium ♀ (2)	5.29–5.41	4.47–4.61	6.45–6.47	5.48–5.66	4.06–4.26	5.36–5.61
M. florium ♂ (1)	5.11	4.38	6.33	5.49	3.95	5.38
M. hilgendorfi ♀ (7)	5.91–6.72	4.85–5.19	7.14–7.78	6.13–6.67	4.92–5.28	6.38–6.90
M. hilgendorfi ♂ (13)	5.91–6.54	4.72–5.27	7.16–7.82	6.17–6.57	4.81–5.39	6.38–7.07 (12)
M. leucogaster ♀ (1)	6.30	5.32	7.14	6.08	4.81	6.22
M. rubex ♀ (1)	6.41	5.51	7.16	6.07	4.51	6.20
M. ryukyuana[a] ♂ (1)	5.32	4.83	7.16	6.29	4.39	5.97
M. silvatica[b] ♀ (1)	4.34	4.12	5.96	4.98	3.68	5.18
M. silvatica[b] ♂ (2)	4.61–4.78	4.03–4.45	5.72–5.83	4.80–4.99	3.50–3.58	5.11–5.12
M. suilla ♀ (4)	4.49–4.65	3.91–4.20	5.58–5.80	4.78–5.00	3.48–3.62	4.94–5.12
M. suilla ♂ (4)	4.40–4.82	3.97–4.14	5.52–5.76	4.76–5.07	3.54–3.72	5.00–5.11
M. tenebrosa ♀ (1)	4.95	4.53	6.32	5.39	3.92	5.63
M. tubinaris ♀ (4)	4.77–4.93	4.31–4.44	5.74–6.05	4.96–5.29	3.67–3.90	4.97–5.35
M. tubinaris ♂ (1)	4.71	4.44	5.57	4.81	3.71	4.98
M. ussuriensis[c] ♀ (2)	4.61–4.63	4.20–4.42	5.68–5.98	4.83–5.08	3.40–3.67	5.04–5.21

Yu Ling, 2,565 m, 24°10′49.5″N, 121°18′33.5″E. ZMNTU 2003.8.2, juvenile female, dry skin, skull, and postcranial skeleton, collected at Hualien County, Jhuosi Township, Rueisuei logging road, 1,450 m. BAT 060001, adult female, dry skin, skull and postcranial skeleton, and NCYU FYPB048, adult male, in alcohol, skull extracted, both collected at Chiayi County, Alishan Township, Nantzuhsien River Wildlife Refuge. HNHM 2005.1.1, adult male, dry skin and skull, collected at Chiayi County, Alishan Township, Lulinshan Major Wildlife Habitats, 2,400 m, 23°28′06.7″N, 120°51′11.6″E. ZMNTU 1989.9.1, adult male, dry skin, collected at Chiayi County, Alishan Township, Tungpu mountain hut, 2,650 m, 23°29′04.9″N, 120°53′09.9″E. NCYU FYPB065, adult male, dry skin, skull, and postcranial skeleton, collected at Chiayi County, Alishan Township, Sister Pond, 23°31′09.6″N, 120°48′51.0″E. NCYU FYPB057, adult male, dry skin, skull, and postcranial skeleton, collected at Taitung County, Haiduan Township, Siangyang.

Etymology.—The specific epithet *gracilis* (meaning slender) refers to the small size and delicate skull of the new species.

Diagnosis.—*Murina gracilis* differs from other species of *Murina* by a combination of characters including smaller size; the dorsum with a mixed color of dark brown, yellowish brown, and shiny golden; the ventrum with the color varied from grayish brown to grayish white, and with individual hairs always black-based; the ear with a small emargination along its posterior border; the insertion point of the plagiopatagium close to the base of the claw; I2 with its basal area less than half that of I3; M1 and M2 with well-developed mesostyles; and c1 tapered abruptly above the cingulum.

Description.—A smaller species of *Murina* with forearm length 28–31 mm. The dorsum is dark brown mottled with yellowish brown and has shiny golden guard hairs scattered on the back (Fig. 1B). The underfur of the dorsum has 3 bands: the basal section is black, the middle section is yellowish brown, and the very tip is black (Fig. 1E). Individual guard hairs are scattered over the back with the basal section black and the tip shiny golden; around the rump the terminal band is longer. The fur on the ventrum has a black base and the tip varies among individual bats from grayish brown to grayish white. The ear is relatively broad and has a weakly developed emargination along its posterior border (Fig. 4A). The wing attaches near the base of the claw of the 1st toe. The interfemoral membrane has moderately dense hairs on the upper surface and has a marked fringe of

Table 1.—Extended.

Species	Morphometric measurement			
	im3L	cm3L	MDL	RAH
M. bicolor ♀ (4)	7.53 ± 0.20	6.64 ± 0.17	13.04 ± 0.32	4.56 ± 0.17
	7.40–7.82	6.54–6.89	12.75–13.45	4.40–4.79
M. bicolor ♂ (4)	7.21 ± 0.10	6.33 ± 0.09	12.52 ± 0.23	4.23 ± 0.05
	7.07–7.30	6.20–6.40	12.32–12.86	4.17–4.29
M. gracilis ♀ (2)	6.12	5.43	10.04	2.99
	6.04–6.19	5.35–5.51	10.03–10.04	2.93–3.04
M. gracilis ♂ (5)	5.89 ± 0.08	5.22 ± 0.07	9.72 ± 0.18	2.84 ± 0.09
	5.77–5.96	5.13–5.28	9.48–9.91	2.70–2.96
M. recondita ♀ (4)	6.18 ± 0.07	5.45 ± 0.08	10.27 ± 0.09	3.22 ± 0.07
	6.14–6.28	5.40–5.56	10.19–10.38	3.12–3.26
M. recondita ♂ (12)	5.96 ± 0.12	5.28 ± 0.11	9.77 ± 0.20	3.00 ± 0.12
	5.78–6.14	5.11–5.45	9.46–10.27	2.80–3.13
M. aurata ♀ (1)	5.89	5.16	9.72	3.14
M. aurata ♂ (2)	5.21–5.52	4.57–4.90	9.24–9.31	2.97 (1)
M. florium ♀ (2)	6.80–6.98	6.08–6.27	11.59–11.61	3.85–4.01
M. florium ♂ (1)	6.74	5.98	11.46	3.82
M. hilgendorfi ♀ (7)	7.74–8.22	6.71–7.20	12.75–14.46	4.36–5.29
M. hilgendorfi ♂ (13)	7.63–8.32	6.73–7.20	12.80–14.40	4.59–5.32
M. leucogaster ♀ (1)	7.62	6.57	13.37	4.79
M. rubex ♀ (1)	7.55	6.58	13.00	4.37
M. ryukyuana[a] ♂ (1)	7.59	6.82	12.92	4.18
M. silvatica[b] ♀ (1)	6.21	5.45	10.32	3.41
M. silvatica[b] ♂ (2)	6.03–6.18	5.36–5.50	9.72–10.35	3.21–3.52
M. suilla ♀ (4)	5.85–6.08	5.26–5.41	9.30–10.06	3.16–3.34
M. suilla ♂ (4)	5.88–6.23	5.25–5.51	9.66–10.11	3.21–3.36
M. tenebrosa ♀ (1)	6.66	5.90	11.48	3.93
M. tubinaris ♀ (4)	5.90–6.39	5.42–5.70	10.24–10.57	3.38–3.62
M. tubinaris ♂ (1)	5.86	5.23	10.07	3.24
M. ussuriensis[c] ♀ (2)	5.88–6.24	5.23–5.51	9.87–10.19	3.12–3.39

hairs around its posterior border. The ventral surface is essentially naked but with sparse grayish white hairs over the proximal one-third.

The skull (Figs. 2B and 2E) is domed but not abruptly elevated. There is no sagittal crest, and the lambdoid crest is very weak. The narial emargination is about as long as the width. The basioccipital pits are usually short; they are wide anteriorly and narrow posteriorly (Fig. 5A). The 1st upper incisor has a secondary cusp that is posterior to the main cusp; I3 is posterior to I2; the basal area of I2 is less than one-half that of I3. Canines in both upper and lower toothrows are higher than the corresponding posterior premolars, especially the upper ones. The upper canine is shorter and narrower basally than P4, and its basal area is approximately 70% that of the latter (Fig. 6, upper row). The width across upper canines is small, usually less than 3.45 mm (Table 1), and the upper toothrows are distinctly convergent anteriorly (the ratio of width across upper canines to width across upper molars is equal to or less than 0.684; Table 2). The 1st upper premolar is only slightly anterior–posteriorly compressed between C1 and P4 (Fig. 6, upper row); the basal area of P2 is less than half that of P4. Mesostyles of M1 and M2 are well developed. The lower canine has a broad base and is tapered abruptly above the cingulum. The 1st lower premolar is smaller in all dimensions than p4, and its basal area is less than one-half that of the latter. The hypoconid and entoconid of m1 and m2 are equal in height and separated from the protoconid and metaconid by a wide trough.

Murina recondita, new species

Holotype.—ZMNTU 2003.8.1, adult male, in alcohol, skull extracted. Collected by H.-C. Kuo and C.-C. Huang on 1 August 2003.

Type locality.—Taiwan, Hualien County, Jhuosi Township, Rueisuei logging road, 1,300 m, 23°29′54.2″N, 121°16′42.8″E.

Paratypes.—NMNS 6010, adult female, in alcohol, skull extracted, collected at Hsinchu County, Jianshih Township, Sinle. NCYU FYPB001 and KHC040, both adult males, dry skin, skull, and postcranial skeleton, and HNHM 2005.1.2, adult female, dry skin, skull, and postcranial skeleton, collected at Hsinchu County, Wufong Township, Bailan, 1,300 m, 23°34′22.0″N, 121°04′35.0″E. ESRI A0015 and ZMNTU 1.41, both adult males, in alcohol, skull extracted, collected at Nantou County, Renai Township, Hueisuen Forest Park. HNHM 2005.36.1, adult, sex unknown, skull and

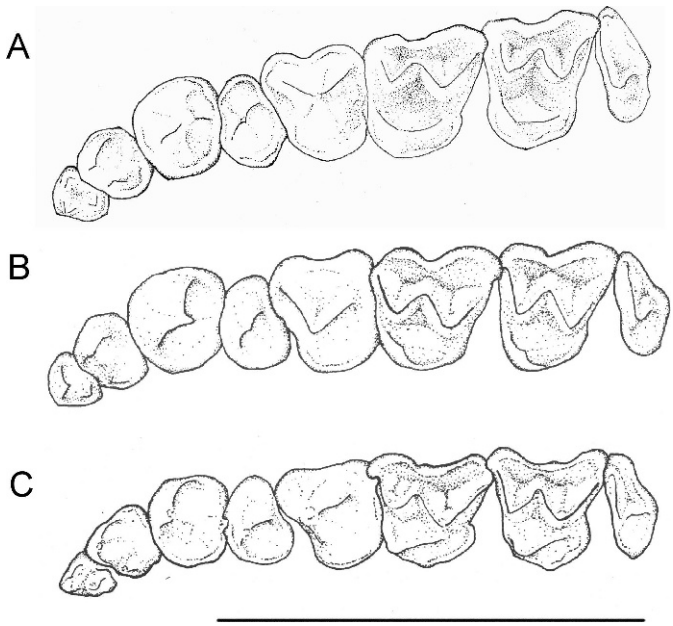

Fig. 3.—Drawings of the occlusal views of the left upper dentitions of A) *Murina bicolor* (holotype ZMNTU 2002.2.1), B) *M. leucogaster* (holotype MNHN 1870-584), and C) *M. rubex* (holotype BM[NH] 16.3.25.111). Scale bar = 5 mm.

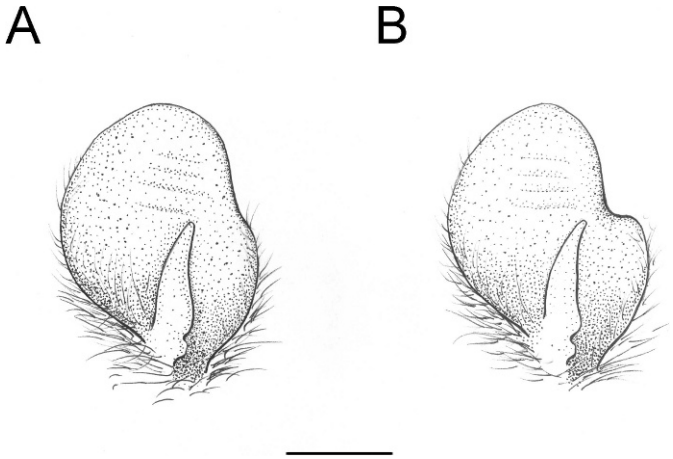

Fig. 4.—Shape of left ear conch of A) *Murina gracilis* and *M. recondita* from Taiwan and B) *M. suilla* from Java. Scale bar = 5 mm.

postcranial skeleton, and HNHM 2005.36.2, adult, sex unknown, in alcohol, skull extracted, both collected at Nantou County, Shinyi Township, Yushan National Park, Tungpu. ZMNTU 2005.4.2, adult male, in alcohol, skull extracted, collected at Nantou County, Renai Township, Meifong Farm, 2,200 m, 24°05′19.1″N, 121°10′26.3″E. BAT 060002, adult female, dry skin, skull, and postcranial skeleton, collected at Chiayi County, Alishan Township, Nantzuhsien River Wildlife Refuge. NMNS 5161, adult female, in alcohol, skull extracted, collected at Chiayi County, Alishan Township, Chashan Village. NMNS 11424, adult male, dry skin, skull, and postcranial skeleton, collected at Kaoshiung County, Taoyuan Township, Meilong logging road, 780 m. NMNS 4856, adult, sex unknown, in alcohol, skull extracted, collected at Pingtung County, Wutai Township. ZMNTU 2001.12.1, adult male, dry skin, skull, and postcranial skeleton, collected at Pingtung County, Chunrih Township, the entrance of the Tawu Taiwan Amentotaxus Nature Reserve. NCYU FYPB012, adult male, dry skin, skull, and postcranial skeleton, collected at Taitung County, Yanping Township, Yanping logging road, 1,020 m. NMNS 5133, adult male, in alcohol, skull extracted, collected at Taitung County, Yanping Township, Lijia logging road. NCYU FYPB013, adult male, dry skin, skull, and postcranial skeleton, collected at Taitung County, Tamali Township, Ema logging road, 22°37′14.0″N, 120°56′20.6″E. ZMNTU 1998.7.4, adult male, dry skin, skull, and postcranial skeleton, collected at Taitung County, Haiduan Township, Wulu logging road, 1,800 m.

Etymology.—The specific epithet *recondita* (meaning hidden or concealed) refers to both the dull coloration of the underfur and the generally lusterless tip of the guard hairs on the dorsum.

Diagnosis.—*Murina recondita* resembles *M. gracilis* both externally and cranially. *M. recondita* differs diagnostically from *M. gracilis* in the presence of a light gray color in the middle section of the dorsal underfur, and in fewer numbers of guard hairs with shiny golden tips. *M. recondita* also can be distinguished from *M. gracilis* by a combination of characters including the paler pelage and face; the elongated basioccipital pit; more rounded P2; and greater width across upper canines and width across upper molars. *M. recondita* has the dorsal color medium brown or yellowish brown and scattered with bright yellow; only a fraction of dorsal hairs is shiny-tipped. In other aspects, *M. recondita* shares differences with *M. gracilis* from other *Murina* species.

Description.—A smaller species of *Murina* with forearm length 28–31.5 mm. The dorsum is medium brown or yellowish brown scattered with bright yellow and a small amount of shiny golden (Fig. 1C). The underfur of the dorsum has 3 bands: the basal section is black, the middle section is an ascending gradient from light gray to light yellowish brown, and the very tip is black (Fig. 1F). Individual guard hairs are black basally and usually tipped with bright yellow. Certain guard hairs, especially those around the head and nape, have shiny golden tips. A few bats have copper-tipped guard hairs. In the ventral aspect, individual hairs have the underparts black and the tips white in the throat and chest areas, and grayish in the abdomen. In some cases the fur in the ventral aspect has a pale brown tinge. The face of most individual bats is paler than that of *M. gracilis*. The density of fur on the dorsal surface of the interfemoral membrane varies among individual bats from moderately to thinly distributed. The fringe of hairs on the posterior border of interfemoral membrane also varies from thickly to sparsely distributed. The ear conch (Fig. 4A), the insertion point of plagiopatagium, and the ventral surface of the interfemoral membrane are similar to those of *M. gracilis*.

Cranial and dental characters (Figs. 2C and 2F) are essentially the same as those of *M. gracilis* with the exception of the

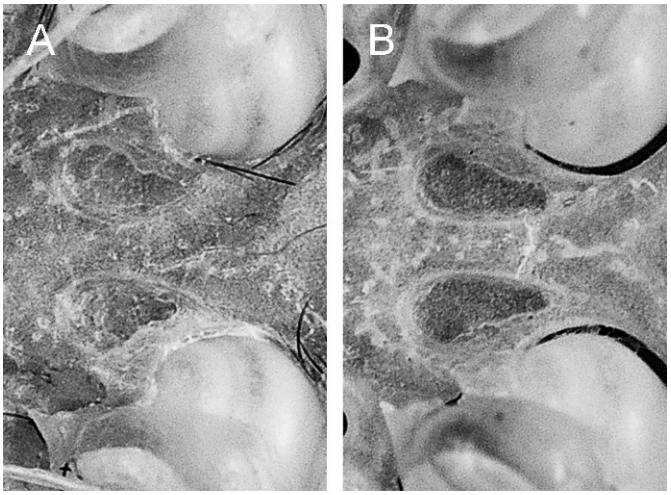

Fig. 5.—Basioccipital pits of A) *Murina gracilis* (paratype NCYU FYPB057) and B) *M. recondita* (paratype NMNS 11424) from Taiwan. Scale bar = 1 mm.

following features: the basioccipital pits are usually elongated and are not especially widened anteriorly (Fig. 5B); the P2 is usually more compressed anterior–posteriorly than that of *M. gracilis*, and is much wider than long (Fig. 6); larger in the width across upper canines and width across upper molars in both sexes; larger in zygomatic width, length of mandible, and height of ramus than *M. gracilis* in females (Table 1); smaller in postorbital width than *M. gracilis* in females; and the zygomatic arches are relatively more expanded outward, the difference between lacrimal and postorbital width is more pronounced, and the upper toothrows are less convergent anteriorly than *M. gracilis* in both sexes (Table 2).

Comparisons.—Murina gracilis and *M. recondita* are readily distinguishable from *M. aenea*, *M. cyclotis*, *M. harrisoni*, *M. huttoni*, *M. puta*, *M. rozendaali*, and *M. tiensa* by the relative sizes of C1 and P2. As compared with other species of the genus, the 2 new species are similar in overall measurements to *M. aurata*, *M. silvatica*, *M. suilla*, *M. tubinaris*, and *M. ussuriensis* (Table 1). These latter species can be distinguished from *M. gracilis* and *M. recondita* based on the following characteristics.

Murina aurata has canines in both upper and lower toothrows that are greatly reduced in height and subequal to or less than that of corresponding posterior premolars (versus the height of canines exceeding that of the corresponding posterior premolars in *M. gracilis* and *M. recondita*). The crown area of C1 is around one-half that of P4 (versus the crown area of C1 more than two-thirds that of P4 in *M. gracilis* and *M. recondita*). The upper toothrows are, in both sexes, more convergent anteriorly in *M. aurata* than in *M. recondita* (Table 2). In the male, *M. aurata* has a relatively larger zygomatic width than *M. gracilis* and *M. recondita* (Table 2), whereas its absolute value is within the range of those for *M. gracilis* and smaller than those for *M. recondita* (Table 1).

Murina silvatica and *M. ussuriensis* are both characterized by having the basal area of I2 surpassing one-half that of I3. Teeth in the lower toothrow are more robust in appearance, especially c1, p2, and p4. *M. silvatica* is, in both sexes, relatively narrower across the zygomatic arches than *M. recondita* and has upper toothrows that are less convergent anteriorly than *M. gracilis* (Table 2). Only 2 female *M. ussuriensis* are available for morphometric comparisons, and they are relatively narrower across the zygomatic arches than *M. recondita*.

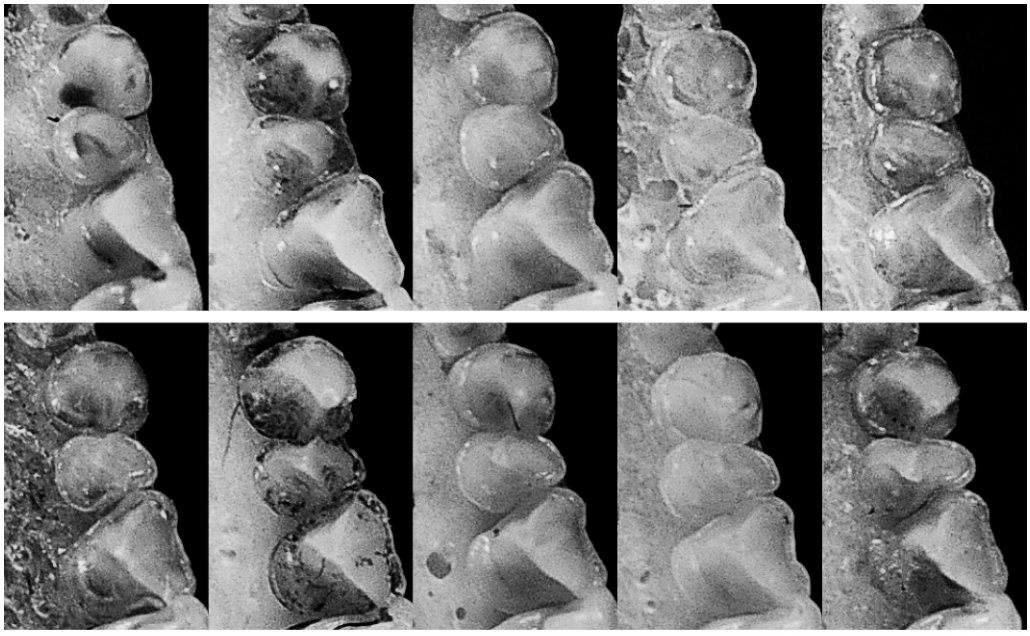

Fig. 6.—Occlusal views of left C1–P4 teeth of different specimens of *Murina gracilis* (upper row) and *M. recondita* (bottom row) from Taiwan. Scale bar = 1 mm.

Table 2.—Ratios of selected craniodental measurements of small-sized *Murina* bats. Sample sizes are given in parentheses. Acronyms of craniodental measurements are defined in the ''Materials and Methods.''

Species	Ratios			
	ZYW/CCL	POW/LW	CCW/M3M3W	RAH/MDL
M. gracilis ♀ (2)	0.607–0.616	0.945–0.948	0.676–0.679	0.292–0.303
M. gracilis ♂ (5)	0.618–0.641	0.934–0.975	0.661–0.684	0.285–0.302
M. recondita ♀ (4)	0.635–0.653 (3)	0.885–0.916	0.689–0.712	0.301–0.319
M. recondita ♂ (12)	0.637–0.665	0.881–0.935	0.678–0.704	0.290–0.328
M. aurata ♀ (1)	—	0.914	0.673	0.323
M. aurata ♂ (2)	0.665 (1)	0.932–0.958	0.675–0.676	0.319 (1)
M. silvatica ♀ (1)	0.612	0.949	0.710	0.330
M. silvatica ♂ (2)	0.610–0.619	0.874–0.931	0.684–0.701	0.330–0.340
M. suilla ♀ (4)	0.645–0.678	0.841–0.935	0.700–0.723	0.315–0.340
M. suilla ♂ (4)	0.650–0.692 (3)	0.859–0.923	0.693–0.744	0.321–0.347
M. tubinaris ♀ (4)	0.625–0.658 (2)	0.874–0.925	0.700–0.738	0.320–0.351
M. tubinaris ♂ (1)	0.658	0.943	0.745	0.322
M. ussuriensis ♀ (2)	0.601–0.611	0.911–0.955	0.675–0.704	0.316–0.333

Murina suilla has dorsal coloration bright reddish to brownish, and the ventrum has individual hairs nearly uniform in color. The posterior border of the ear is distinctly emarginated (Fig. 4). The c1 is tapered evenly above the cingulum. *M. suilla* has, in both sexes, a relatively greater width across the zygomatic arches, larger difference between lacrimal and postorbital width, and upper toothrows that are less convergent anteriorly than *M. gracilis* (Table 2).

Murina tubinaris has dorsal coloration predominantly gray. In the cranium, this species has, in both sexes, a relatively greater width across the zygomatic arches, and upper toothrows that are less convergent anteriorly than *M. gracilis* (Table 2). In addition to the distinction listed above, *M. gracilis* can be distinguished from these species (except *M. recondita*) by its relatively smaller height of ramus in both sexes.

Distribution.—Both of the smaller new species are apparently forest dependent. Individuals of *M. gracilis* were found above the elevation of 1,400 m, whereas those of *M. recondita* were primarily found below this elevation. However, a few specimens of *M. recondita* were caught at higher elevations, and 1 reached 2,200 m. We have found the 2 species coexisting in Chiayi County, Alishan Township, Nantzuhsien River Wildlife Refuge, and specimens of these species were caught 6 km apart from each other along Hualien County, Jhuosi Township, Rueisuei logging road.

A Key to Species of *Murina* in Taiwan

1a. There is no emargination on the posterior border of the ear; I3 is exterior–posterior to I2; C1 has its basal area equal to or larger than that of P4; P2 has its height and basal area more than two-thirds those of P4. The dorsum is medium brown, sometimes reddish or grayish brown; the ventrum has a similar but paler coloration. Forearm length 33–39 mm . . . . *M. puta*

1b. The ear has an emargination on the posterior border; I3 is posterior to I2; C1 has its basal area smaller than that of P4; P2 has its height and basal area less than two-thirds those of P4 2

2a. Larger in size with forearm length 37–42 mm; the dorsum is reddish brown; the ventral fur has no dark base in the chest and throat; the ear has a marked emargination on the posterior border; wing attaches close to the base of the 1st toe; the rostrum is robust; M1 and M2 have moderately developed mesostyles . . . . . *M. bicolor*

2b. Smaller in size with forearm length 28–31.5 mm; the dorsum is dark brown mottled with yellowish brown and with golden hairs or lusterless medium brown or yellowish brown; the ventral fur has dark bases; the ear has a small emargination on the posterior border; wing attaches close to the base of the claw of 1st toe; the rostrum is not especially robust; the M1 and M2 have well-developed mesostyles 3

3a. The dorsal fur and the face have darker colorations; the dorsal underfur has no light grayish color above the black basal section; the tips of individual guard hairs are shiny golden; basioccipital pits are shorter and widen anteriorly; the P2 is anterior–posteriorly less compressed and is more rounded in shape; the width across upper canines is smaller (usually $<$3.45 mm) . . . . . *M. gracilis*

3b. The dorsal fur and the face have paler colorations; the dorsal underfur has a light gray portion above the black basal section; the tips of individual guard hairs are bright yellow and are rarely shiny; basioccipital pits are usually elongated, not especially wide anteriorly; the P2 is usually anterior–posteriorly compressed, and thus is distinctly wider than long; the width across upper canines is larger ($>$3.45 mm) . . . . . *M. recondita*

Acknowledgments

We thank H.-C. Cheng (ESRI), Y.-J. Chen (NMNS), L.-K. Lin (THU), C.-L. Hsu and C.-H. Chou (BAT), D. Lunde and E. Westwig (AMNH), P. Jenkins and D. Hills (BM[NH]), L. R. Heaney (FMNH),

P. J. J. Bates (HZM), J. Cuisin (MNHN), D. Maharadatunkumsi (MZB), L. K. Gordon (NMNH), S. Kawada (NSM), C. Smeenk (RMNH), D. Kock (SMF), Neil Furey (Aberdeen University), and S. Kruskop (ZMMU) for kindly providing access to the specimens under their care. The work of GC was supported by the European Commission's Research Infrastructure Action via the SYNTHESYS Project. The work of the other authors was supported by the Forestry Bureau, Council of Agriculture, Taiwan, Republic of China.

Literature Cited

Bhattacharyya, T. P. 2002. Taxonomic status of the genus *Harpiola* Thomas, 1915 (Mammalia: Chiroptera: Vespertilionidae), with a report of the occurrence of *Harpiola grisea* (Peters, 1872) in Mizoram, India. Proceedings of the Zoological Society, Calcutta 55:73–76.

Corbet, G. B., and J. E. Hill. 1991. A world list of mammalian species. 3rd ed. Oxford University Press, Oxford, United Kingdom.

Corbet, G. B., and J. E. Hill. 1992. The mammals of the Indomalayan Region: a systematic review. Oxford University Press, Oxford, United Kingdom.

Csorba, G., and P. J. J. Bates. 2005. Description of a new species of *Murina* from Cambodia (Chiroptera: Vespertilionidae: Murininae). Acta Chiropterologica 7:1–7.

Csorba, G., V. D. Thong, P. J. J. Bates, and N. M. Furey. 2007. Description of a new species of *Murina* from Vietnam (Chiroptera: Vespertilionidae: Murininae). Occasional Papers, Museum of Texas Tech University 268:1–12.

Ellerman, J. R., and T. C. S. Morrison-Scott. 1951. Checklist of Palaearctic and Indian mammals 1758 to 1946. Trustees of the British Museum (Natural History), London, United Kingdom.

Fukui, D., K. Maeda, D. A. Hill, S. Matsumura, and N. Agetsuma. 2005. Geographical variation in the cranial and external characters of the little tube-nosed bat, *Murina silvatica* in the Japanese archipelago. Acta Theriologica 50:309–322.

Gannon, W. L., R. S. Sikes, and the Animal Care and Use Committee of the American Society of Mammalogists. 2007. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. Journal of Mammalogy 88:809–823.

Koopman, K. F. 1994. Chiroptera: systematics. Handbook of zoology. Vol. 8. Mammalia, part 60. Walter de Gruyter, New York.

Koopman, K. F., and T. N. Danforth. 1989. A record of the tube-nosed bat (*Murina florium*) from western New Guinea (Irian Jaya) with notes on related species (Chiroptera, Vespertilionidae). American Museum Novitates 2934:1–5.

Kruskop, S. V. 2005. Towards the taxonomy of the Russian *Murina* (Vespertilionidae, Chiroptera). Russian Journal of Theriology 4:91–99.

Kuo, H.-C., Y.-P. Fang, G. Csorba, and L.-L. Lee. 2006. The definition of *Harpiola* (Vespertilionidae: Murininae) and the description of a new species from Taiwan. Acta Chiropterologica 8:11–19.

Maeda, K., and S. Matsumura. 1998. Two new species of vespertilionid bats, *Myotis* and *Murina* (Vespertilionidae: Chiroptera) from Yanbaru, Okinawa Island, Okinawa Prefecture, Japan. Zoological Science 15:301–307.

Miller, G. S. 1907. The families and genera of bats. Bulletin of the United States National Museum 57:1–282.

Simmons, N. B. 2005. Order Chiroptera. Pp. 312–529 in Mammal species of the world: a taxonomic and geographic reference (D. E. Wilson and D. M. Reeder, eds.). 3rd ed. Johns Hopkins University Press, Baltimore, Maryland.

Sowerby, A. de C. 1922. On a new bat from Manchuria. Journal of Mammalogy 3:46–47.

Tate, G. H. H. 1941. Results of the Archbold Expeditions. No. 40. Notes on vespertilionid bats of the subfamilies Miniopterinae, Murininae, Kerivoulinae and Nyctophilinae. Bulletin of the American Museum of Natural History 78:567–597.

Wallin, L. 1969. The Japanese bat fauna. Zoologiska Bidrag från Uppsala 37:223–440.

Yoshiyuki, M. 1989. A systematic study of the Japanese Chiroptera. National Science Museum, Tokyo, Japan.

Submitted 26 January 2008. Accepted 6 January 2009.

Associate Editor was Burton K. Lim.

Appendix I

Specimens examined.—Specimens with craniodental measurements used for comparisons are marked with asterisks. Specimens examined are deposited at the American Museum of Natural History, New York (AMNH); Bat Association of Taiwan, Taipei (BAT); Endemic Species Research Institute, Nantou (ESRI); Field Museum of Natural History, Chicago (FMNH); Harrison Institute, Sevenoaks, formerly Harrison Zoological Museum (HZM); Hungarian Natural History Museum, Budapest (HNHM); Museum National d'Histoire Naturelle, Paris (MNHN); Museum Zoologicum Bogoriense, Bogor (MZB); National Chiayi University, Chiayi (NCYU); National Museum of Natural History, Leiden, formerly Rijksmuseum van Natuurlijke Historie (RMNH); National Museum of Natural History, Smithsonian Institution, Washington, D.C., formerly United States National Museum (NMNH); National Museum of Natural Science, Taichung (NMNS); National Science Museum, Tokyo (NSM); Natural History Museum, London, formerly British Museum (Natural History) (BM[NH]); Senckenberg Museum, Frankfurt am Main (SMF); Tunghai University, Taichung (THU); Zoological Museum of Moscow State University, Moscow (ZMMU); and the Zoological Museum of National Taiwan University, Taipei (ZMNTU).

Murina aenea (n = 6).—MALAYSIA: Pahang (BM[NH] 64.770, ♂; BM[NH] 1999.299, ♀). Selangor (BM[NH] 75.2148, sex unknown). Sabah (BM[NH] 83.359, 84.2021, 84.2023, ♂).

Murina aurata (n = 6).—CHINA: Szechwan (MNHN CG1870-590, CG1870-590a, ♂). INDIA: Meghalaya (FMNH *76055, ♀). Sikkim (BM[NH] *15.9.1.37, ♂; BM[NH] 91.10.7.58, sex unknown). THAILAND: Chiang Mai (BM[NH] *82.162, ♂).

Murina cyclotis (n = 8).—INDIA: West Bengal (BM[NH] 9.4.4.4, 16.3.25.27, 16.3.25.28, 16.3.25.29, 20.6.24.1, ♂). Manipur (BM[NH] 16.3.26.4, ♀). THAILAND: Chiang Mai (BM[NH] 82.165, ♂). MYANMAR: Sagaing (BM[NH] 16.3.26.89, ♀).

Murina florium (n = 14).—INDONESIA: East Nusa Tenggara (BM[NH] 63.12.26.14, sex unknown). Maluku (RMNH 28120, 30074, ♂; BM[NH] *10.3.4.24, *23.1.2.27, RMNH 30075, ♀; BM[NH] 10.3.4.115, sex unknown). North Maluku (RMNH 33381, ♀). North Sulawesi (RMNH 34894, ♂; RMNH 33374, ♀). South East Sulawesi (MZB 22877, ♂; MZB 22876, 22878, ♀). PAPUA NEW GUINEA: Morobe (BM[NH] *14.4.1.33, ♀).

Murina harrisoni (n = 1).—CAMBODIA: Kampong Speu (HZM 1.36316, ♀).

Murina hilgendorfi (n = 20).—JAPAN: Gifu (NSM *M1408, ♀). Iwate (NSM *M21567, ♀). Nagano (BM[NH] *8.12.1.18, NSM *M1213, *M1354, *M2072, *M2105, *M2586, *M3006, ♂). Shizuoka (NSM *M25625, ♂). Wakayama (NSM *M25092, ♀).

Yamanashi (NSM *M14146, ♂; NSM *M16275, ♀). KOREA: Kangwon (HNHM *2000.64.1, NSM *M11675, *M11678, ♂; NSM *M11676, ♀). Gyeongsangbuk (ZMNTU *2.5, ♀). RUSSIA: Primorsky (AMNH *244272, ♂). Sakhalin (NSM *M7649, ♀).

Murina huttoni (n = 7).—CHINA: Fukien (BM[NH] 8.8.11.6, ♂). Tibet (BM[NH] 75.11.3.19, ♂). INDIA: Uttaranchal (BM[NH] 14.7.10.32, 79.11.21.685, ♂). West Bengal (BM[NH] 16.3.25.25, ♂; BM[NH] 20.6.24.3, ♀). MYANMAR: Kachin (AMNH 114848, ♂).

Murina leucogaster (n = 3).—CHINA: Hunan (NMNH *578586, ♀). Szechwan (MNHN 1870-584, ♂). VIETNAM: Nghe An (HZM 1.31758, ♀).

Murina puta (n = 34).—TAIWAN (ESRI T0072, NCYU FYPB002, KHC039, NMNS 5044, 6011, 6013, 11429, NSM M20281, ZMNTU 1.30, 1.33, 1996.7.1, 1997.1.1, 1998.5.1, 1998.7.5, 1999.11.1, 2002.10.1, 2002.11.2, ♂; ESRI B0352, B0353, B0355, NMNS 11425, 11426, 11427, 11430, 11431, ZMNTU 1.29, 1.31, 1998.2.2, 1998.7.9, 1999.2.2, 1999.6.1, 2002.10.2, 2002.10.3, ♀; ZMNTU 1.28, sex unknown).

Murina rozendaali (n = 4).—MALAYSIA: Pahang (BM[NH] 1999.301, ♂). Sabah (BM[NH] 83.360, 1999.300, ♂; BM[NH] 84.2025, ♀).

Murina rubex (n = 1).—INDIA: West Bengal (BM[NH] *16.3.25.111, ♀).

Murina ryukyuana (n = 1).—JAPAN: Okinawa (NSM *M31305, ♂).

Murina silvatica (n = 3).—JAPAN: Fukushima (NSM *M16690, ♀). Gifu (HNHM *2002.41.1, ♂). Hokkaido (AMNH *526843, ♂).

Murina suilla (n = 17).—INDONESIA: East Java (BM[NH] *79.11.15.15, ♂; BM[NH] *79.11.15.16, ♀). West Java (RMNH 15226, 15236, 15237, ♂; BM[NH] *9.1.5.354, HNHM *2002.13.2, RMNH 15225, 15227, 15228, 15231, 15233, ♀). Uncertain locality in Java (BM[NH] 7.1.1.479, sex unknown). North Sumatra (BM[NH] *23.1.2.28, ♂). MALAYSIA: Sabah (BM[NH] *84.2015, *84.2017, ♂; BM[NH] *84.2018, ♀).

Murina tenebrosa (n = 1).—JAPAN: Nagasaki (NSM *M8812, ♀).

Murina tiensa (n = 4).—VIETNAM: Bac Kan (HZM 2.38178, ♀; HNHM 2007.28.1., ♀; NF.301006.1, ♂, deposited in HZM). Nghe An (HZM 1.31525, ♀).

Murina tubinaris (n = 13).—INDIA: Arunachal Pradesh (FMNH *82776, ♀). Assam (BM[NH] *36.3.24.1, *36.3.24.4, ♀). MYANMAR: Kachin (HZM 2.3596, ♂). Sagaing (BM[NH] 16.3.26.88, ♀; BM[NH] 16.3.26.85, 16.3.26.86, 16.3.26.87, sex unknown). PAKISTAN: North-West Frontier (HNHM *99.14.6, ♀). THAILAND: Chiang Mai (BM[NH] *82.163, ♂; SMF 75355, 75356, ♀). VIETNAM: Nghe An (HZM 1.31780, ♀).

Murina ussuriensis (n = 3).—RUSSIA: Sakhalin (NSM *M7650, *M7651, ♀). Primorsky (ZMMU 96368, ♀).