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Taxonomical Study on Four *Myotis* (Vespertilionidae) Species in Korea

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한국산 큰수염박쥐류 *Myotis* (Vespertilionidae) 4종에 대한 분류학적 연구

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적 요

1985년 10월부터 1987년 7월까지 남한 18개 장소에서 채집된 애기박쥐과 (Vespertilionidae)에 속하는 *Myotis* 4종, *Myotis formosus tsuensis, Myotis macrodactylus, Myotis daubentonii ussuriensis* 및 *Myotis nattereri bombinus* 에 대하여 외부 및 내부골격(두개골, 하악골 및 상완골)의 형태를 이용하여 분류학적인 검토를 하였다. 그 중, 한국 및 동부 시베리아에 분포하는 *Myotis nattereri*에 속하는 집단은 *M. nattereri amurensis*인지, 또는 일본산 *M. nattereri bombinus*와 같은 아종인지 그 분류학적 위치가 분명치 않았다. 본 연구에서는 한국산 및 일본산 *M. nattereri*에 속하는 개체들에 대한 상세한 검토를 통하여 Wallin(1969)이 보고한 바와 같이 *M. nattereri amurensis*가 *M. nattereri bombinus*의 synonym임을 확인하였다.

Key words: taxonomy, subspecific revision, Korean *Myotis* species.

INTRODUCTION

Twenty-one bat species of 10 genera belonging to three families (one rhinolophid, 19 vespertilionids

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and one molossid) have been hitherto known from Korea (Yoon & Son, 1989). Of them as for the genus *Myotis* (Vespertilionidae), the following seven species occur in Korea: *Myotis (Selysius) gracilis* Ognev, 1927 [=*M. mystacinus gracilis*], *M. (S.) ikonnikovi* Ognev, 1912, *M. (S.) frater longicaudatus* Ognev, 1927, *M. (Chrysopteron) formosus tsuensis* Kuroda, 1922, *M. (Leuconoe) daubentonii ussuriensis* Ognev, 1927, *M. (L.) macrodactylus* (Temminck, 1840) and *M. (Isotus) nattereri amurensis* Ognev, 1927. In this connection, *M. frater longicaudatus* has been collected only from northern Korea (Kishida & Mori, 1931; Won, 1967; Won, 1976), except for a collection by Son (unpublished). With respect to *M. nattereri amurensis*, the question whether it is a good separate subspecies or a synonym of *M. nattereri bombinus* Thomas, 1905 has remained unsettled, as indicated by Wallin (1969).

The aim of the present study was to make a taxonomical review of four Korean *Myotis* species and to discuss the synonymy of *M. nattereri amurensis* for *M. nattereri bombinus*, based on detailed examinations of the external and skeletal (cranium, mandible and humerus) morphology.

MATERIALS AND METHODS

One hundred and twenty-nine specimens of four Korean *Myotis* species (*M. formosus tsuensis*, *M. macrodactylus*, *M. daubentonii ussuriensis* and *M. nattereri bombinus*) were examined in this work (Table 1). They were collected at 18 localities during the period from October 1985 to July 1987 (Fig. 1), and have been preserved in Kyungnam University. For accurate identification of bats, foreign specimens collected from Japan and USSR were supplied by favor of Emeritus Professor T. A. Uchida in Kyushu University. The arrangement of subgenera and species followed Yoshiyuki (1989). A detailed description was given only in *M. n. bombinus* which involves a vexed taxonomic question, while a brief diagnosis alone was made in the other three species. In all cases, the measurements were dealt with *en bloc* regardless of sex, because of no significant difference between both sexes. The technical term for the external, cranial and mandibular morphology and the terminology of the humerus were based on Yoshiyuki (1989) and Yoon & Uchida (1983a, b), respectively.

Table 1. Specimen list of Korean bat species examined.

Species	No.	Date collected	Locality
Myotis formosus tsuensis	1, 2	5 Nov. '85	Tongyeong
	7—9	10 Apr. '86	Ditto
	3	30 Nov. '85	Gimje
	10—13	19 May '86	Ditto
	4, 5	4 Jan. '86	Gongju
	6	4 Feb. '86	Ditto
	14	7 Jan. '87	Ditto
	15	4 Feb. '87	Ditto
	16—18	17 Feb. '87	Ditto
	19—24	24 Feb. '87	Haman
	32—34	8 Mar. '87	Ditto

Table 1. Continued

Species	No.	Date collected	Locality
	39—42	20 Apr. '87	Ditto
	35	29 Mar. '87	Bongwha-ri, Namhae
	25—31	7 Mar. '87	Gwangsan
	36—38	16 Apr. '87	Ditto
	43—45	29 Arp. '87	Maewol-ri, Haenam
	46—52	3 May '87	Ditto
Myotis macrodactylus	1	10 Nov. '85	Haman
	6	13 Jan. '86	Ditto
	34	4 May '87	Ditto
	2	20 Nov. '85	Yeongdeok
	5	27 Dec. '85	Ditto
	30—32	7 Jul. '86	Ditto
	3	4 Dec. '85	Gongju
	4	20 Dec. '85	Bukjeju
	7	23 Jan. '86	Sangju
	8—10	11 Feb. '86	Inje
	11—13	16 Feb. '86	Uijeongbu
	14	5 Apr. '86	Tongyeong
	15—20	8 Apr. '86	Shindeok-ri, Haenam
	21, 22	11 Apr. '86	Maewol-ri, Haenam
	35—43	3 May '87	Ditto
	23, 24	12 Apr. '86	Bongwha-ri, Namhae
	25, 26	28 Apr. '86	Gwangyang
	27—29	20 Jun. '86	Gimje
	33	16 Apr. '87	Gwangsan
Myotis daubentonii ussuriensis	1, 2	20 Jan. '86	Ditto
	6—10	23 Jul. '86	Ditto
	3, 4	24 Jan. '86	Yeongdeok
	5	4 Feb. '86	Samcheok
	11—18	23 Jul. '86	Gimje
	19, 20	1 Aug. '86	Imsil
	21, 22	15 Jul. '87	Seungju
Myotis nattereri bombinus	1—4	16 Jan. '86	Tongyeong
	5—10	21 Jun. '86	Ditto
	11, 12	30 Apr. '87	Jeju

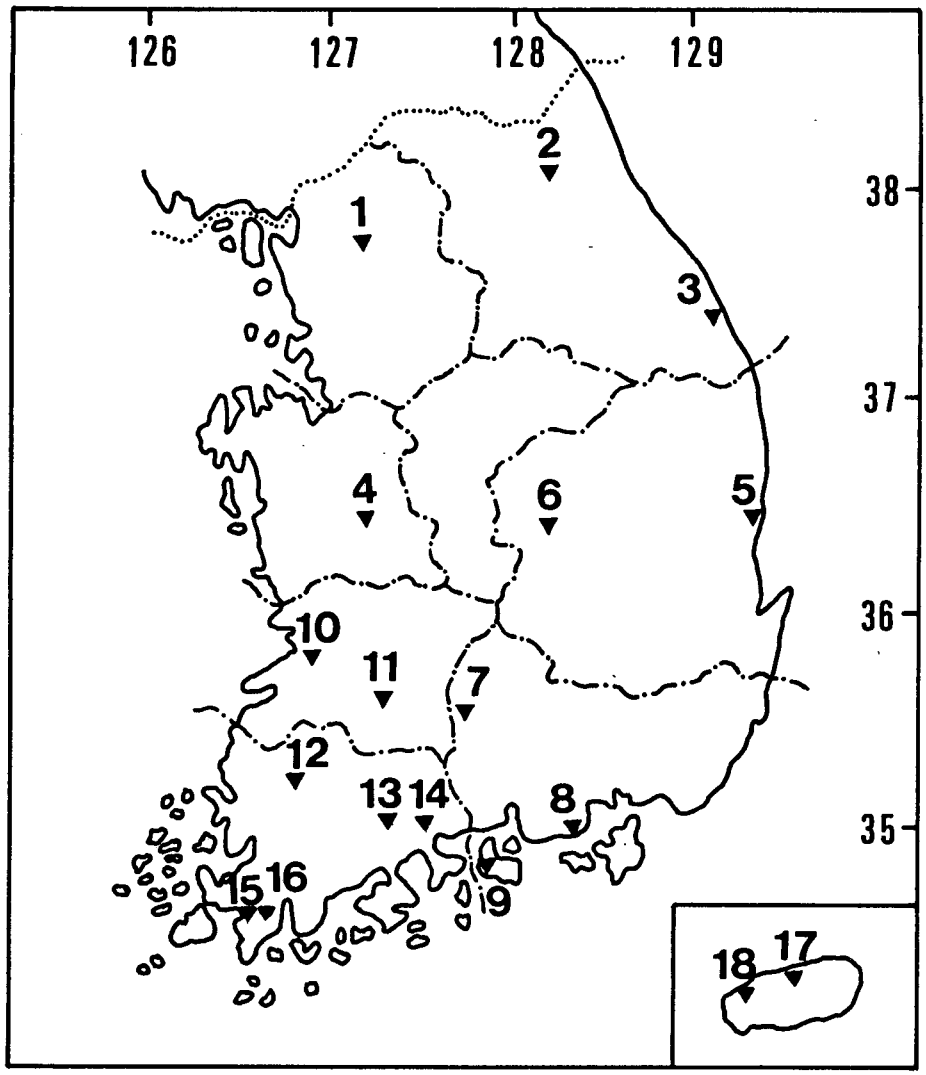

Fig. 1. Collecting places in Korea. 1, Uijeongbu; 2, Inje; 3, Samcheok; 4, Gongju; 5, Yeongdeok; 6, Sangju; 7, Haenam; 8, Tongyeong; 9, Bongwha-ri, Namhae; 10, Gimje; 11, Imsil; 12, Gwangsan; 13, Seungju; 14, Gwangyang; 15, Maewol-ri, Haenam; 16, Shindeok-ri, Haenam; 17, Jeju; 18, Bukjeju.

RESULTS AND DISCUSSION

1. *Myotis formosus tsuensis* Kuroda, 1922 (Fig. 2)

Myotis tsuensis Kuroda, 1922 (p. 43).

Myotis chofukusei Mori, 1928 (pp. 389-391).

Myotis formosus tsuensis: Kuroda, 1940 (p. 220); Won, 1967 (pp. 317-318, pl. 38, fig. 81); Imaizumi & Yoshiyuki, 1969 (pp. 261-262); Corbet, 1978 (p. 50); Son, 1978 (p. 352); 1980 (p. 176); 1981 (pp. 163-164).

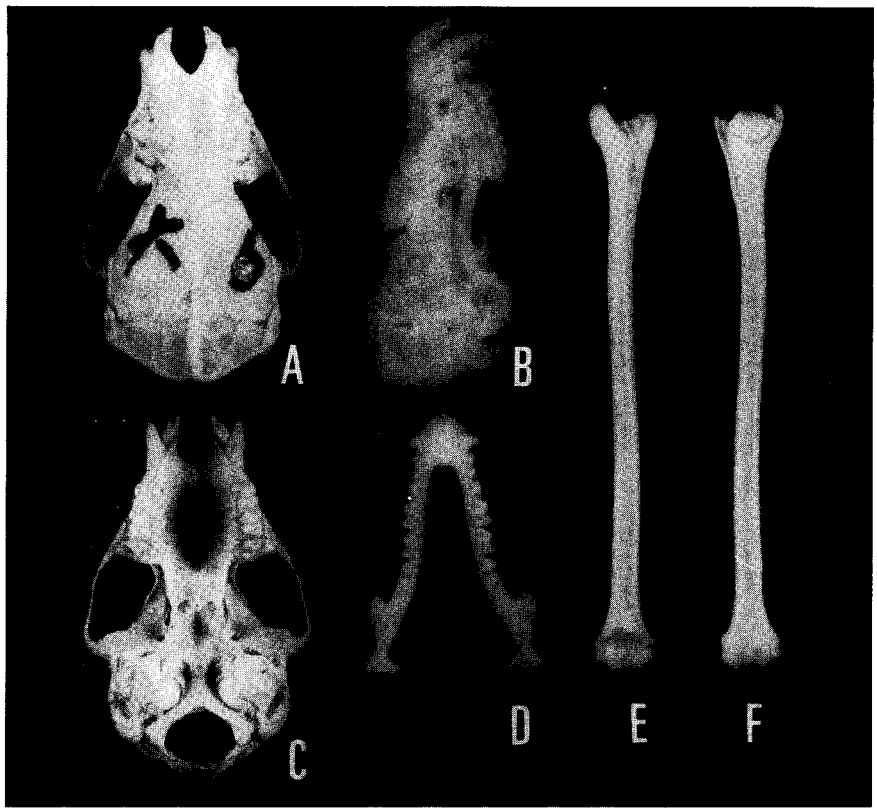

Fig. 2. Skull (× 2.7) and right humerus (× 2.5) of *Myotis formosus tsuensis* Kuroda, 1922 (No. 10). A, B and C, dorsal, lateral and ventral views of cranium, respectively; D, ventral view of mandible; E and F, anterior and posterior views of humerus, respectively.

Myotis formosus chofukusei: Ellerman & Morrison-Scott, 1951 (p. 146).

Specimens examined: See Table 1 for Korean 52 specimens (42 ♂♂, 10 ♀♀).

Diagnosis: Large species belonging to the subgenus *Chrysopteron*. FA 47.64mm, HB 51.75mm, T 46.19mm, T/HB 91.19%, Tib 23.83mm, E 15.86mm, III/V 1.23, CBL 17.35mm, ZYW 11.29mm, DW/PW 0.92 in average (Table 2). Fur of body and ear reddish orange, but margin of ear blackish. Wing membrane and uropatagium colored by reddish orange, with black patches. Stout braincase low in depth and narrow in width. Upper first canine (C^1) large, about twice as high as upper posterior premolar (P^4). Upper second premolar (P^2) lies in tooth row, while upper third premolar (P^3) whose height and crown area are about one-half and more than two-thirds of those of upper second premolar (P^2), respectively, dislocated inside tooth row. Both upper first (M^1) and second molars (M^2) lacking in protoconules, and both lower first (I_1) and second incisors (I_2) having four tubercles.

Remarks: This subspecies occurs also in Tsushima Island, Nagasaki Prefecture, Japan (Imaizumi, 1949, 1960; Yoshiyuki, 1989). The Korean specimens, however, were different from the Japanese ones in the following characters. The uropatagium had black patches in the Korean specimens as mentioned above, but lacked patches in the Japanese ones. The anterior naris was one and half or twice of its width in length in the Korean specimens, whereas it usually had double the length of its width in the Japanese specimens. The posterior cusp of the upper second incisor (I^2) was significantly lower than the interior cusp of the up-

Tabe 2. External, cranial, mandibular and humeral measurements(mm) in *Myotis formosus tsuensis* Kuroda, 1922 from Korea.

	N	Range	M ± SD
FA	50	42.55— 51.50	47.64 ± 1.84
HB	31	42.75— 56.55	51.75 ± 3.05
T	41	35.60— 56.10	46.19 ± 4.25
T/HB (%)	31	73.95—101.76	91.19 ± 7.55
Hfcu	52	9.00— 13.95	11.00 ± 1.34
Tib	52	13.75— 27.20	23.83 ± 2.42
Hfcu/Tib (%)	52	35.81— 87.27	46.74 ± 9.22
E	52	13.15— 19.00	15.86 ± 1.34
Tra	52	5.95— 11.15	8.63 ± 1.09
DIII	51	72.20— 90.35	76.42 ± 3.39
DV	52	60.00— 71.35	64.61 ± 2.50
III/V	50	1.17— 1.33	1.23 ± 0.03
Mc II	52	32.90— 45.30	41.05 ± 2.30
Mc III	52	38.70— 47.05	43.08 ± 1.16
Mc IV	52	37.50— 44.80	41.08 ± 1.58
Mc V	52	39.00— 45.05	41.94 ± 1.69
GLS	38	17.40— 18.90	18.14 ± 0.39
CBL	39	16.30— 18.15	17.35 ± 0.37
ZYW	37	10.50— 11.85	11.29 ± 0.28
ZYW/CBL (%)	37	62.29— 75.16	65.92 ± 2.77
MW	39	8.45— 9.45	9.01 ± 0.21
IoC	39	3.85— 4.80	4.18 ± 0.19
B.BC	40	7.75— 8.65	8.17 ± 0.18
D.BC	39	6.15— 7.00	6.49 ± 0.20
D.BC/B.BC (%)	39	71.14— 86.25	79.04 ± 3.22
M	39	12.80— 14.55	13.72 ± 0.43
C—M^3	39	7.15— 7.75	7.43 ± 0.17
HL	34	26.25— 29.90	28.57 ± 0.85
PW	34	3.45— 3.95	3.69 ± 0.13
DW	35	3.15— 3.60	3.39 ± 0.13
DW/PW	34	0.85— 0.97	0.92 ± 0.03

FA, forearm; HB, head and body; T, tail; Hfcu, hind foot cum unguis; Tib, tibia; E, ear; Tra, tragus; DIII and DV, 3rd and 5th digits, respectively; III/V, wing-type ratio; Mc II—V, 2nd-5th metacarpals, respectively; GLS, greatest length of skull; CBL, condylobasal length; ZWY, zygomatic width; MW, mastoid width; IoC, interorbital constriction; B.BC, breadth of braincase; D.BC, depth of braincase; M. mandible; C-M^3, upper tooth row; HL, humerus length; PW, proximal epiphysis width of the humerus; DW, distal epiphysis width of the humerus.

per third incisor (I^3) in height in the Korean specimens, but both cusps were subequal in the Japanese specimens. However, the Japanese specimens examined are so small in number that a taxonomical review by the use of a large number of specimens is required.

Distribution: Japan (Tsushima Island); Korea.

2. *Myotis macrodactylus* (Temminck, 1840) (Fig. 3)

Vespertilio macrodactylus Temminck, 1840 (p. 231, pl. 58, figs. 3-5).

Myotis (Leuconoe) macrodactylus: Thomas, 1905 (p. 337); Tate, 1941 (pp. 542, 551, 559).

Myotis macrodactylus: Son, 1978 (pp. 352-353); 1980 (p. 176); 1981 (pp. 164-165).

Specimens examined: See Table 1 for Korean 43 specimens (31 ♂♂, 12 ♀♀). For a morphological comparison, the following Japanese specimens also were observed: Two skulls, Fukuoka City, 15 September, 1956; a skull, Tsushima Island, Nagasaki Prefecture, date unknown; a skin (♂), Iwate Prefecture, 26 August 1957; a skin (♀), Akiyoshi-dō, Yamaguchi Prefecture, 28 July 1959.

Diagnosis: Belongs to the subgenus *Leuconoe*, medium in size. FA 38.71mm, HB 44.07mm, T 36.15mm, T/HB 82.03%, Tib 17.10mm, E 13.60mm, III/V 1.25, CBL 14.46mm, ZYW 9.24mm, DW/PW 0.90 in average (Table 3). Smaller than *M. nattereri* in size. Dorsal pelage dark greyish brown in color, soft fur extending dorsally from proximal half of upper arm to heel and to basal one-third of uropatagium, and ventrally from elbow to heel and basal protion of uropatagium, and from hind leg to basal one-third of calcar. Soft hairs scattered in basal protion of plagiopatagium. Hind foot large and stout, whose length with claw

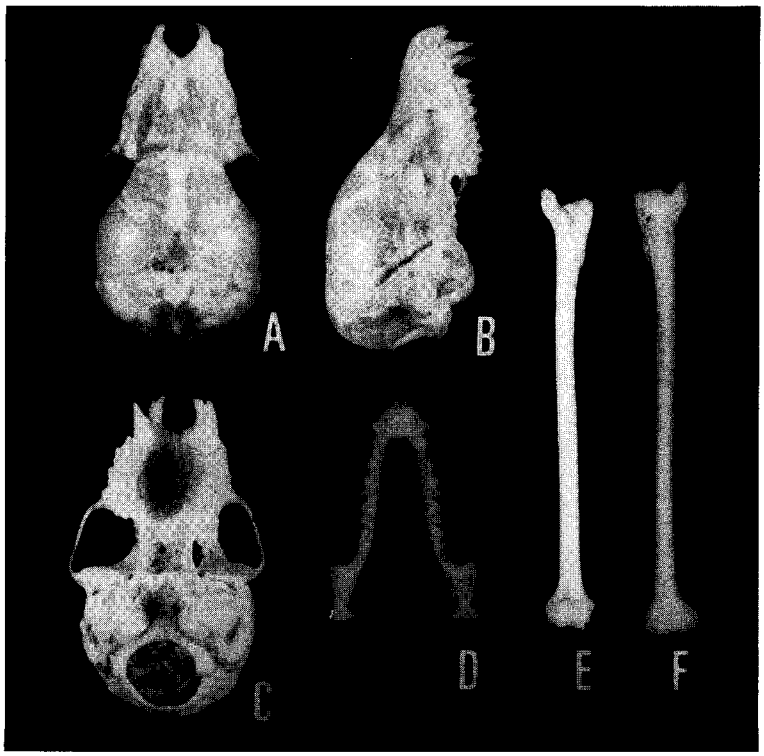

Fig. 3. Skull (×2.7) and right humerus (×2.5) of *Myotis macrodactylus* (Temminck, 1840) (No. 3). Alphabetical symbols as in Fig. 2.

Table 3. External, cranial, mandibular and humeral measurements (mm) in *Myotis macrodactylus* (Temminck, 1840) from Korea.

	N	Range	M ± SD
FA	42	37.00—41.65	38.71 ± 1.21
HB	37	40.65—48.00	44.07 ± 2.46
T	37	31.35—39.90	36.15 ± 2.22
T/HB (%)	34	68.52—96.20	82.03 ± 6.11
Hfcu	42	8.90—13.00	10.57 ± 0.79
Tib	42	15.80—17.80	17.10 ± 0.52
Hfcu/Tib (%)	42	50.57—74.07	61.89 ± 4.87
E	42	11.70—15.35	13.60 ± 0.88
Tra	41	5.75— 9.00	7.33 ± 0.75
DIII	42	61.00—70.70	65.16 ± 2.77
DV	42	44.05—56.80	52.00 ± 2.54
III/V	42	1.20— 1.47	1.25 ± 0.04
Mc II	42	31.45—38.45	34.17 ± 1.35
Mc III	42	33.95—39.20	36.46 ± 1.18
Mc IV	42	32.60—38.10	35.45 ± 1.36
Mc V	42	32.25—36.85	34.54 ± 1.23
GLS	40	14.25—15.90	15.50 ± 0.44
CBL	40	12.35—15.00	14.46 ± 0.57
ZYW	34	8.00— 9.85	9.24 ± 0.36
ZYW/CBL (%)	33	60.42—74.08	64.09 ± 2.76
MW	41	7.45— 8.35	7.98 ± 0.17
IoC	41	3.70— 4.85	3.95 ± 0.17
B.BC	40	7.40— 8.15	7.75 ± 0.16
D.BC	38	5.40— 6.15	5.80 ± 0.17
D.BC/B.BC (%)	38	68.79—79.87	74.93 ± 2.24
M	41	9.85—11.70	11.11 ± 0.35
C—M^3	40	5.50— 6.00	5.77 ± 0.12
HL	37	21.55—24.50	23.16 ± 0.82
PW	37	2.85— 3.50	3.11 ± 0.11
DW	37	2.55— 3.00	2.79 ± 0.11
DW/PW	37	0.85— 0.95	0.90 ± 0.03

Abbreviations as in Table 2.

about 62% of that of tibia. Ear long and narrow, tragus turned slightly outward at tip with a greatest width at base of anterior border. Plagiopatagium attached to lower part of leg. Protoconules of upper molars evident and anterior internal cusp of upper premolar (P^4) low.

Remarks: The species resembled *M. daubentonii ussuriensis* Ognev, 1927, but differed from the latter

in the following features: In this species, the dorsal pelage was somewhat darker in color, and the furred area was wider; the slightly longer tragus had a uniform type in shape in general, turning outward at the apical portion, as against three types in *M. d. ussuriensis* mentioned below; the distal insertion of the plagiopatagium was posited higher.

Distribution: Eastern Siberia; Japan; Korea.

3. *Myotis daubentonii ussuriensis* Ognev, 1927 (Fig. 4)

Myotis daubentonii ussuriensis Ognev, 1927 (p. 146); Mori, 1928 (p. 287); Kishida & Mori, 1931 (p. 378); Kuroda, 1934 (p. 239); 1938 (p. 96); 1967 (p. 164, figs. 3, 4); Won & Woo, 1958 (p. 92); Won, 1961 (p. 51); 1967 (pp. 312-314, pl. 37, fig. 77); Imaizumi & Yoshiyuki, 1969 (pp. 261-262); Son, 1980 (p. 176).

Specimens examined: See Table 1 for Korean 22 specimens (19 ♂♂, 3 ♀♀). As for foreign specimens, two alcoholized specimens (1 ♂, 1 ♀) of *Myotis daubentonii volgensis* collected from Moscow district, USSR on 16 June, 1974 also were observed.

Diagnosis: A member of the subgenus *Leuconoe*, medium in size. FA 38.67mm, HB 44.69mm, T 36.20mm, T/HB 82.44%, Tib 17.20mm, E 12.77mm, III/V 1.26, CBL 13.94mm, ZYW 9.03mm, DW/PW 0.89 in average (Table 4). Similar to *M. macrodactylus* on the whole, particularly in large foot (Hfcu/Tib, about 61%) and distinct protoconules on upper molars. Dorsal fur greyish brown in color, and confined nearly to body, though extending to basal portion or basal one-third of uropatagium, sometimes to lower part of leg on plagiopatagium. Ventral fur extending sparsely from elbow to knee on plagiopatagium and to base of uropatagium, as well as calcaneal region on uropatagium and basal portion of plagiopatagium

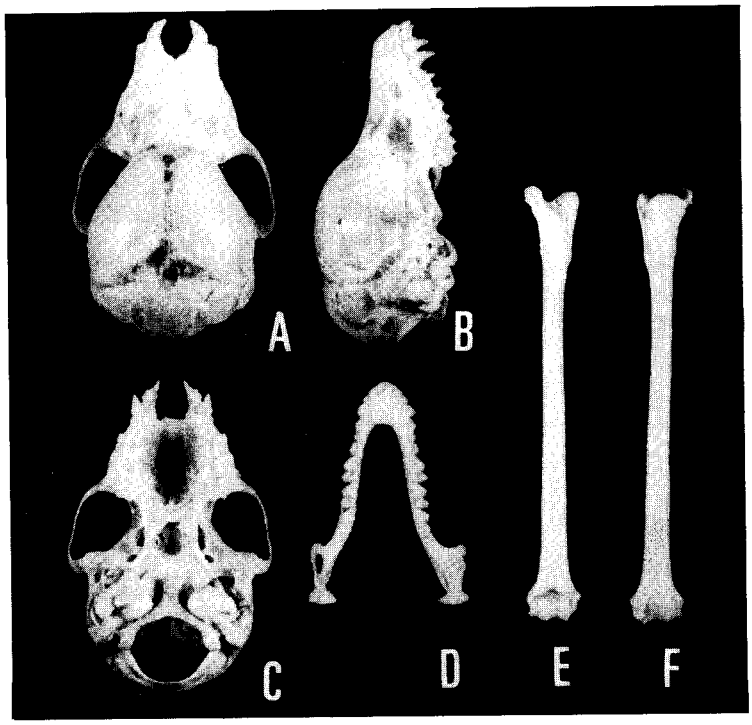

Fig. 4. Skull (×2.7) and right humerus (×2.5) of *Myotis daubentonii ussuriensis* Ognev, 1927 (No. 8). Alphabetical symbols as in Fig. 2.

Table 4. Comparison of external, cranial, mandibular and humeral measurements (mm) in *Myotis daubentonii ussuriensis* Ognev, 1927 from Korea, Vladivostok, USSR and Hokkaidō, Japan.

	Korea	Vladivostok*	Hokkaidō†
	M ± SD (N) (range)	M ± SD (N) (range)	M ± SD (N) (range)
FA	38.67 ± 1.27 (18) (37.30—41.90)	37.2 ± 1.01 (9) (35 — 38.6)	36.3 ±0.92 (29) (34.1 —38.2)
HB	44.69 ± 2.58 (14) (40.00—49.70)	42.7 ± 2.72 (9) (39 — 46)	49.1 ±2.69 (29) (44.0 —58.0)
T	36.20 ± 2.49 (14) (31.70—40.05)	36.9 ± 2.00 (9) (35.1— 41)	36.7 ±3.83 (29) (27.0 —41.2)
T/HB (%)	82.44 ± 7.81 (12) (67.74—96.51)	86.6 ± 7.76 (9) (77.3—105.1)	75.3 ±7.03 (29) 60.0 —89.0)
Hfcu	10.46 ± 0.49 (20) (9.75—11.60)	—	10.8 ±0.87 (28) (9.0 —12.0)
Tib	17.20 ± 0.65 (20) (16.20—18.35)	17.5 ± 0.72 (9) (16.7— 19.1)	15.6 ±0.94 (29) (13.6 —17.0)
Hfcu/Tib (%)	60.89 ± 3.62 (20) (54.79—70.73)	—	69.5 ±7.95 (28) (52.9 —82.8)
E	12.77 ± 1.37 (20) (9.10—15.70)	14.4 ± 0.61 (9) (13.2— 15.2)	13.7 ±0.86 (29) (11.5 —15.3)
Tra	6.50 ± 0.71 (20) (5.30— 7.85)	6.7 ± 0.58 (9) (6 — 8)	6.2 ±0.99 (29) (4.0 — 7.1)
DIII	63.06 ± 1.70 (18) (60.40—66.15)	—	—
DV	50.13 ± 1.34 (18) (46.95—51.90)	—	—
III/V	1.26 ± 0.02 (18) (1.20— 1.29)	—	—
Mc II	32.94 ± 1.16 (19) (30.95—35.00)	—	—
Mc III	35.31—1.26 (19) (33.00—36.95)	—	—
Mc IV	34.59 ± 1.03 (19) (32.65—36.85)	—	—
Mc V	33.39 ± 1.24 (19) (31.55—35.65)	—	—
GLS	14.77 ± 0.32 (18) (14.35—15.45)	14.3 ± 0.22 (6) (14.2— 14.7)	—
CBL	13.94 ± 0.36 (17) (13.20—14.70)	13.6 ± 0.30 (6) (13.2— 14)	13.29 ± 0.32 (20) (12.60—13.72)

Table 4. Continued.

	Korea	Vladivostok*	Hokkaido†
	M±SD (N) (range)	M±SD (N) (range)	M±SD (N) (range)
ZYW	9.03±0.22 (18) (8.60— 9.25)	9.1±0.16 (7) (8.9— 9.3)	8.67±0.34 (18) (7.78— 9.11)
ZYW/CBL (%)	64.60±1.91 (17) (60.82—68.15)	—	65.25±1.90 (18) (61.75—67.44)
MW	7.81±0.13 (18) (7.50— 8.00)	—	—
IoC	4.13±0.11 (18) (3.95— 4.30)	4.2±0.24 (7) (4 — 4.7)	3.74±0.13 (19) (3.45— 4.00)
B.BC	7.63±0.17 (18) (7.25— 7.90)	7.8±0.10 (7) (7.7— 8)	7.36±0.20 (18) (7.00— 7.60)
D.BC	5.47±0.13 (17) (5.30— 5.70)	—	5.34±0.19 (18) (4.90— 5.62)
D.BC/B.BC (%)	71.67±1.84 (17) (68.59—75.17)	—	72.65±2.91 (18) (68.42—76.97)
M	10.84±0.43 (17) (9.95—11.45)	—	9.54±0.27 (18) (9.08— 9.95)
C—M^3	5.30±0.18 (18) (5.05— 5.70)	5.2±0.17 (7) (5.1— 5.6)	4.89±0.18 (19) (4.56— 5.10)
HL	23.27±0.67 (17) (22.30—24.30)	—	—
PW	3.14±0.09 (17) (3.00— 3.35)	—	—
DW	2.79±0.11 (17) (2.60— 2.90)	—	—
DW/PW	0.89±0.04 (17) (0.84— 0.94)	—	—

Abbreviations as in Table 2.

*, Calculated from the data of Ognev (1928).

†, Calculated from the data of Yoshiyuki (1989).

near hind foot. There are three variations in shape of tragus, i.e. one type with anterior border of tragus straight, widest at base of anterior border, and the other two types with apical portion turned outward, widest at center of posterior border or at base of anterior border. Plagiopatagium inserted on metatarsus of first toe.

Remarks: According to Ognev (1928), the eastern form *M. d. ussuriensis* is differentiated from the western form *M. d. daubentonii* and the central form *M. d. volgensis* in the following features: Dimensions are

somewhat smaller than those in *M. d. volgensis*. The ear is markedly narrower at the tip, the notch on the posterior (external) edge of the ear is more marked, the tragus is considerably narrower and thinner at the tip, and its coloring is darker than that of the nominotypical subspecies *M. d. daubentonii* which is very similar to *M. d. volgensis* in general morphological features except for their size. My observations on *M. d. volgensis* from Moscow district confirmed the above characters. Meanwhile, Imaizumi & Yoshiyuki (1969) have reported that *M. daubentonii* specimens of South Korea differ from *M. d. ussuriensis* specimens of Vladivostok in the shorter tibia (coefficient of difference, $CD = (M_B - M_A)/(SD_A + SD_B)$, 1.30) and the wider zygoma (CD, 0.95), and consequently suggested that the Korean form is a possible new subspecies. However, there was nothing extraordinary for the dimensions of the Korean form examined by myself as compared with those of Vladivostok's form (Ognev, 1928). Further, the CD values of several characters between them were 0.81 and below (Table 5). Such low values suggest that both forms are not taxonomically different at the subspecies level (Mayr *et al.*, 1953).

On the other hand, *M. d. ussuriensis* specimens from Korea as well as from Vladivostok were larger in dimensions than those from Hokkaidō, Japan, although they were similar in appearance to one another (Table 4). In particular, the interorbital constriction (IoC) in the Korean specimens was considerably larger in width, so the CD values of Hokkaidō's specimens versus Korean and Vladivostok's specimens in this feature were 1.62 and 1.22, respectively (Table 5). The value 1.62, together with another CD value (1.6) in breadth of the braincase between Vladivostok's and Hokkaidō's specimens was much higher than the level of conventional subspecific difference (1.28) (Mayr *et al.*, 1953). In this connection, if CD values between two samples of neighboring populations A and B exceed 1.28 in two or three different characters which are not correlated with each other, it seems probable that populations A and B are different at the species level (Mayr *et al.*, 1953).

Table 5. Comparison of coefficients of difference in external and cranial measurements in *Myotis daubentonii ussuriensis* populations between Korea, Vladivostok, USSR and Hokkaidō, Japan.

	Korea/Vladivostok	Hokkaidō/Korea	Hokkaidō/Vladivostok
FA	0.64	1.08	0.47
HB	0.37	0.83	1.17
T	0.15	0.08	0.03
Tib	0.20	1.03	1.14
E	0.80	0.41	0.46
Tra	0.16	0.17	0.32
GLS	0.81	—	—
CBL	0.52	0.96	0.5
ZYW	0.11	0.94	0.8
IoC	0.17	1.62	1.22
B.BC	0.78	0.73	1.6
C—M^3	0.17	1.14	1

Abbreviations as in Table 2.

Each value was calculated on the basis of the data presented in Table 4.

Reviewing the paleogeography, Japan has been isolated from the Palaeartic continent after the Würmian age in the Late Pleistocene (Kawamura, 1979), and north-originating *M. d. ussuriensis* may be a remainder which was unable to retreat to the northern continent because of inferiority in flight ability (Yoon *et al.*, 1984a, b). It is thus assumed that Hokkaidō's population in Japan may be another separate subspecies or in the process of speciation. A detailed taxonomic examination on the *M. d. ussuriensis* populations of the continent and Japan, based on a large number of specimens, is demanded.

Distribution: Amur, Ussuri, Sakhalin, Kamtchstka, Transbaikalia, Iskutsk; Japan (Hokkaidō); Korea.

4. *Myotis nattereri bombinus* Thomas, 1905 (Fig. 5)

Myotis nattereri bombinus Thomas, 1905 (p. 337); Imaizumi, 1949 (p. 105, fig. 30); 1954 (pp. 40-41, fig. 1); Ellerman & Morrison-Scott, 1951 (p. 143); Wallin, 1969 (pp. 279-285, figs. 21-25); Corbet, 1978 (p. 49); Son, 1978 (p. 353); 1980 (p. 176); 1981 (p. 162); Yoshiyuki, 1989 (pp. 126-131, figs. 56-57).

Myotis nattereri amurensis Ognev, 1927 (p. 144); 1928 (pp. 337-338, figs. 228-230); Kishida, 1927 (p. 417); Kishida & Mori, 1931 (p. 378); Ellerman & Morrison-Scott, 1951 (p. 143); Won, 1961 (p. 51); 1967 (pp. 314-315); Imaizumi & Yoshiyuki, 1969 (pp. 260-261); Corbet, 1978 (p. 49); Son, 1980 (p. 176).

Specimens examined: See Tables 1 and 6 for Korean 12 specimens (11 ♂♂, 1 ♀). The following Japanese *M. n. bombinus* specimens taken from Akiyoshi-dai Plateau, Yamaguchi Prefecture also were dealt with (see Table 6): A skull (Bat J1), cave and date unknown; a skin (♀, Bat J2), Akiyoshi-dō cave, 28 July, 1959; an alcoholized specimen (♀, Bat J3), Akiyoshi-dō cave, 2 August, 1976; two alcoholized specimens (♂♂, Bats J4, J5), Kagekiyo-dō cave, 20 October, 1970.

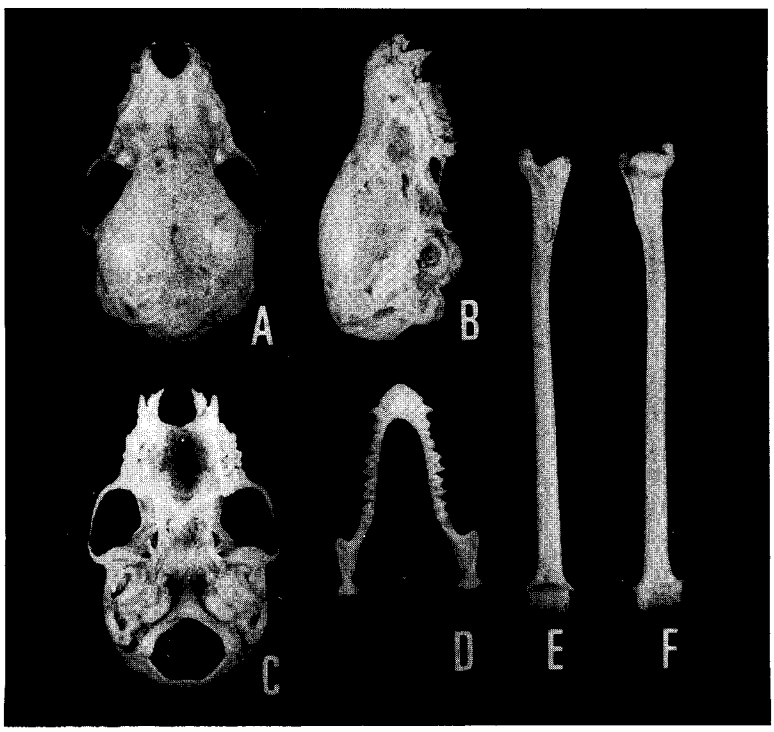

Fig. 5. Skull (×2.6) and right humerus (×2.5) of *Myotis nattereri bombinus* Thomas, 1905 (No. 2). Alphabetical symbols as in Fig. 2.

Diagnosis: A medium sized member of the subgenus *Isotus*. FA 39.76mm, HB 42.92mm, T 44.62mm, T/HB 103.89%, Tib 17.04mm, E 16.20mm, III/V 1.24, CBL 14.97mm, ZYW 9.73mm, DW/PW 0.98 in average (Table 6). Foot small, as in members of the subgenus *Selysius*. Ear and tragus very lengthened;

Table 6. Comparison of external, cranial, mandibular and humeral measurements (mm) in *Myotis nattereri bombinus* Thomas, 1905 from Korea and Japan.

	Korea		Japan				
	M±SD (N)	(range)	J1	J2	J3	J4	J5
FA	39.76± 1.60 (12)	(37.40— 42.40)	—	40.60	40.30	38.40	37.80
HB	42.92± 2.77 (12)	(36.50— 47.70)	—	—	44.00	45.20	45.50
T	44.62± 6.72 (11)	(34.15— 53.70)	—	—	46.00	43.80	42.50
T/HB (%)	103.89±12.14 (11)	(90.84—121.30)	—	—	104.55	96.90	93.41
Hfcu	9.57± 0.89 (12)	(7.65— 11.35)	—	9.30	9.90	8.90	9.60
Tib	17.04± 1.06 (11)	(15.20— 18.30)	—	16.30	18.30	17.40	16.50
Hfcu/Tib (%)	56.13± 3.63 (11)	(49.35— 63.06)	—	57.06	54.10	51.15	58.18
E	16.20± 1.01 (12)	(14.50— 17.80)	—	14.85	17.00	16.60	17.40
Tra	10.00± 0.60 (12)	(8.60— 10.85)	—	9.40	10.90	11.40	10.25
DIII	67.85± 1.91 (12)	(63.40— 70.60)	—	67.60	65.90	62.40	—
DV	54.61± 1.59 (12)	(52.00— 56.00)	—	52.90	53.40	49.90	51.20
III/V	1.24± 0.02 (12)	(1.21— 1.29)	—	1.28	1.23	1.25	—
Mc II	34.36± 1.32 (12)	(32.00— 36.45)	—	32.90	—	32.10	32.40
Mc III	37.30± 1.23 (12)	(35.00— 39.30)	—	36.05	35.50	34.00	34.70
Mc IV	36.19± 1.20 (12)	(34.15— 38.60)	—	35.40	35.20	33.40	34.00
Mc V	35.73± 1.14 (12)	(33.30— 37.70)	—	34.45	34.00	32.60	33.20
GLS	16.04± 0.26 (9)	(15.75— 16.60)	15.45	—	16.25	—	15.70
CBL	14.97± 0.37 (11)	(14.50— 15.60)	14.15	—	15.10	—	14.40
ZYW	9.73± 0.39 (9)	(8.85— 10.25)	9.45	—	9.90	9.55	9.65
ZYW/CBL (%)	64.73± 1.94 (9)	(60.62— 67.59)	66.78	—	65.56	—	67.01
MW	8.08± 0.13 (11)	(7.80— 8.30)	7.95	—	7.85	—	—
IoC	4.02± 0.11 (11)	(3.90— 4.25)	4.00	—	4.10	3.80	3.85
B.BC	8.05± 0.12 (11)	(7.85— 8.30)	8.00	—	7.95	—	7.90
D.BC	5.80± 0.08 (11)	(5.70— 5.90)	5.90	—	5.90	5.60	5.90
D.BC/B.BC (%)	72.16± 1.37 (11)	(69.94— 74.21)	73.75	—	74.21	—	74.68
M	11.85± 0.38 (11)	(11.05— 12.50)	11.35	—	11.70	11.00	11.20
C—M^3	5.99± 0.11 (11)	(5.85— 6.15)	5.95	—	5.90	6.20	6.25
HL	23.09± 0.95 (10)	(21.85— 24.85)	—	—	23.10	20.40	22.30
PW	3.01± 0.07 (9)	(2.90— 3.15)	—	—	2.90	—	2.80
DW	2.95± 0.09 (11)	(2.85— 3.10)	—	—	2.85	2.80	2.75
DW/PW	0.98± 0.03 (9)	(0.95— 1.05)	—	—	0.98	—	0.98

Abbreviations as in Table 2.

posterior part of uropatagium fringed by short and dense hairs, but calcaneal and basal regions of plagiopatagium naked. There were no differences in morphological features between specimens from Tongyeong-gun, Kyungsangnam-do Province and Jeju-gun, Jeju-do Province.

External characters: Grandular masses scattered on muzzle with a flat median surface between nostrils. Ear long, whose length about twice of its greatest width. Anterior border of ear turned outward from lower one-third or a half of its length, its extremity rounded off; upper two-fifths of posterior border of ear nearly straight, but its lower portion convex. Tragus very long and narrow, about 65% of ear in length, widest near base of anterior border; both anterior and posterior borders straight in general, although curved outward at upper one-third of the borders in some specimens.

Wing membrane moderately wide (III/V, 1.24), plagiopatagium inserting on distal two-thirds of first toe or on a nearly central point of metatarsus. Hind foot with claw about 56% of tibia in length. Slender calcar terminating at about two-thirds of lateral border's length of uropatagium with vestigial keel. Posterior edges of uropatagium forming an obtuse angle. Tail subequal to head and body in length, whose terminal vertebra with a length of about 1mm free beyond posterior edge of uropatagium.

Dorsal fur glossy and dark yellowish brown at its tip and blackish brown at base in color. Ventral fur ivory at its tip and blackish brown at base. Dorsal pelage nearly confined to body laterally, though having a few hairs on basal portion of uropatagium. Ventrally, plagiopatagium furred with scarce hairs from upper arm to thigh. Posterior edge of uropatagium fringed with dense, short and pale brown hairs, whereas calcaneal region naked. Wing membrane and uropatagium pale blackish brown in color.

Skull: Zygomatic width about 65% of condylobasal length, facial portion relatively short, i.e. the facial index (facial to cranial portion) about 90% and below. Braincase large and high, whose depth about 72% of its breadth. In dorsal view, anterior naris one and half times longer than its width, whose posterior margin ending at level of posterior end of upper canine (C^1) or more backward. Temporal crest evident although low, saggital crest undeveloped. Lambdoid crest somewhat developed only at lateral region. In lateral view, rostrum almost straight in dorsum, dorsal profile of skull rising abruptly from posterior region of nasal bone to parietal bone, although varying slightly with specimens in gradient. Parietal region higher than or as high as occipital region, border line between them concaved. Anteorbital foramen large, whose posterior margin extending to middle level of upper first molar (M^1). Anteorbital ridge evident, lacrimal foramen lying on anterior margin of orbit, and not exposed. In ventral view, palatal emargination U-shaped, its width and length subequal, and its posterior margin extending to anterior border of upper canine (C^1). Auditory bulla covering about a half of cochlea.

Mandible: Coronoid process forming an acute angle; anterior margin of the process slightly turned anteriorly and upper portion of posterior margin descending toward condyloid process with variable gradients. Lower portion of posterior margin concaved or smoothly curved. Angular process turned backward or posteriorly and downward.

Teeth: In maxilla, upper incisors two pairs, inner incisor (I^2) with a secondary cusp posterior to a main cusp, lower than a main cusp of outer incisor (I^3). A distance between I^3 and C^1 narrower than width of I^3. Upper anterior and middle premolars (P^2 and P^3) in tooth row, although the latter (P^3) sometimes dislocated inward. P^3 about a half and two-thirds of P^2 in height and in crown area, respectively. Anterior internal cusp of posterior premolar (P^4) low. Molars devoid of protoconules, upper second molar (M^2) wider than first molar (M^1) in crown area.

In mandible, incisors, consisting of three pairs each, laid to overlap each other by one-third of area.

Lower canine (C_1) almost as high as P_4. P_2 and P_3 in tooth row, ratio of P_3 to P_2 in height varying with extent of wear, from about two-thirds to more than three-quarters. P_3 three-quarters of P_2 in crown area. Antero-internal angle of P_4 evident.

Humerus: Humerus about 23mm in length, its head round, trochiter very low. Anterior pit (immediately anterior to head) very shallow, pectoral ridge long, about one-fifth of humeral length. Spinous process terminating at approximately distal one-quarter level of trochlea. Olecranon fossa vestigial, ratio of DW/PW (0.98) highest among the species examined.

Remarks: *M. nattereri* from Tongyeong-gun, Kyungsangnam-do Province and Jeju-gun, Jeju-do Province were similar not only to *M. n. amurensis* from Vladivostok (Ognev, 1927, 1928) but also to *M. n. bombinus* from Japan in all diagnostic characters. Thereafter, it is necessary to ascertain the subspecific name valid for Korean *M. nattereri* specimens.

There have been several reports on the taxonomy of *M. n. amurensis* since Ognev (1927) as listed above, and specimens of the northern Korean population were firstly regarded as *M. n. amurensis* by Kishida (1927). Thereafter, *M. nattereri* specimens inhabiting northern Korea as well as eastern Siberia have been called under the above subspecific name (Kishida & Mori, 1931; Ellerman & Morrison-Scott, 1951; Corbet, 1978). Imaizumi & Yoshiyuki (1969) also have considered *M. nattereri* specimens occurring in Jeju-do Province as *M. n. amurensis*, in spite of failure in distinguishing the Korean specimens from the Japanese ones, except for the difference of their fur color. On the other hand, although Japanese *M. nattereri* specimens have been classified as *M. n. bombinus* since Thomas (1905), Wallin (1969) has regarded *M. n. amurensis* as a synonym for *M. n. bombinus* because of striking similarities in their external and skeletal dimensions and in their mandibular structure. His conclusion is due to the fact that the differences between the nominotypical subspecies *M. n. nattereri* and *M. n. amurensis*, described by Ognev (1928), coincide entirely with those between *M. n. nattereri* and *M. n. bombinus*. In this connection, according to Son (1978, 1980, 1981), *M. nattereri* specimens taken from Hacheong, Geoje-gun and Tongyeong-gun, Kyungsangnam-do Province and Bukjeju-gun, Jeju-do province have been identified as *M. n. bombinus*, while specimens from Jeongseon and Inje, Gangwon-do Province, Mungyeong, Kyungsangbuk-do Province and Haman-gun and Geoje-gun, Kyungsangnam-do Province have been treated as *M. n. amurensis* without showing morphological descriptions. Since such a concept means that the above two different subspecies are sympatric in the same district, Geoje-gun, it is hard to accept his classification.

Recently, Yoshiyuki (1989) has called the Japanese form as *M. n. bombinus* and the eastern Siberian and northern Korean forms as *M. n. amurensis* under the following views. In the latter, the ear is shorter and wider, and the braincase slopes more gentle from the rostrum to the frontal region than in *bombinus*; the lower middle premolar (P_3) is larger, and subequal to the anterior premolar (P_2) in height (in the former, P_3 is two-thirds and below of P_2 in height); the posterior margin of the coronoid process is smoothly curved (in the former, the upper portion of the posterior margin is straight, and concaved at the lower portion); and the angular process is turned posteriorly and downward (in the former, it is turned backward).

However, the specimens from the Korean (N = 12) and the Japanese (N = 5) populations, examined by myself, did not show enough difference to separate them at the subspecies level, unlike the opinion of Yoshiyuki (1989). Firstly, although the ear was slightly shorter in Korean specimens ($M \pm SD = 16.20 \pm 1.01$mm) than in Japanese ones ($M \pm SD = 17.12 \pm 1.09$mm), the CD value between them was 0.948, suggesting that this feature is not adopted as a criterion for classifying them at the subspecies level. Besides, the greatest width of the ear was about a half of the length in all the specimens from both the populations concerned.

Secondly, the specimens from both the populations were not very different in the ratio of the depth to the breadth of the braincase, i.e. 72% in Japanese *M. n. bombinus* measured by Yoshiyuki (1989) and 72.16% in the Korean specimens (Table 6). Further, there were some Korean specimens bearing the same abrupt gradient in the dorsal profile from the rostrum to the frontal bone as in the Japanese ones, although a gentle gradient was seen frequently in the Korean specimens. Thus, the gradient degree also is not employed as a criterion. In this connection, it is worthy of noting that two lateral views of *M. n. amurensis* skulls illustrated by Ognev (1928) and Ma (1986) are contrastive, i.e. the former from Vladivostok exhibits a gentle gradient, whereas the latter from Heilungkiang Province, China shows an abrupt gradient.

Thirdly, the relative height of P_3 to P_2 in the Korean specimens was much the same as in the Japanese ones, i.e. the value was three-quarters in Bats J1 and J3 with the very wearing teeth concerned, but was about two-thirds in Bats J4 and J5 with a little wear on the teeth.

Fourthly, whether the posterior margin of the coronoid process is smoothly curved or concaved in the lower portion varied with specimens in the Japanese specimens as well as in the Korean specimens, i.e. the smoothly curved type was seen in Bats J3, J4 and J5, and the concaved type was found in Bat J1.

Lastly, the angular process was turned backward, or posteriorly and downward not only in the Korean specimens but also in the Japanese ones, i.e. backward in Bats J1, J4 and J5, and posteriorly and downward in Bat J3.

Judging from the above evidence, *M. n. amurensis* seems synonymous with *M. n. bombinus* as pointed out by Wallin (1969), and consequently it may be concluded with some degree of confidence that the Korean form of *M. nattereri* is here regarded as the subspecies *bombinus*.

Distribution: Amur, Eastern Siberia; Japan; Korea.

ABSTRACT

A taxonomic review of four *Myotis* species (*M. formosus tsuensis*, *M. macrodactylus*, *M. daubentonii ussuriensis* and *M. nattereri bombinus*) belonging to the Vespertilionidae was carried out, based on the external and skeletal (cranium, mandible and humerus) morphology. The question whether *M. nattereri* inhabiting Korea and eastern Siberia is a good separate subspecies (*M. nattereri amurensis*) or a synonym of *M. nattereri bombinus* has remained unsolved. Through a detailed examination of Korean and Japanese specimens, the author follows the concept of Wallin (1969) who has regarded *M. nattereri amurensis* as a synonym for *M. nattereri bombinus*.

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