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Research Article

Morphological Variations of Bats, Cynopterus in Mt. Duasudara Nature Reserves, North Sulawesi, Indonesia

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Abstract: Bats belong to family pteropodidae evenly distributed in Indonesia. Genus *Cynopterus* has intraspecific morphological diversity based on their characteristics, one of which is food-feeding bat of *Cynopterus* (Chiroptera: Pteropodidae). This study aims identify the morphological variations and the effect of sex of *Cynopterus* bats in the Nature Reserves of Mt. Duasudara, North Sulawesi. The study site is inhabited by 7 major vegetations, such as moss forest, submontane, lowland forest, casuarina, coastal forest, bushes, and reeds at the position of 0-1,351 m above sea level. Results found 337 individuals, 84 *C. brachyotis*, 112 *C. luzoniensis*, and 141 *C. minutus*, respectively. Moreover, sex, in fact, affected the skull characters and the external parts of *C. brachyotis*, *C. luzoniensis,* and *C. minutus*. Descritptive statistics and ANOVA of 18 skull characters and 7 external body parts of 30 adult specimens indicated species had no sexual dimorphism in FL of *C. brachyotis*, FA of *C. luzoniensis,* and GSL, CCL, SV, and FA of *C. minutus*. In addition, *Cynopterus bracyotis*, *C. minutus,* and *C. luzoniensis* are morphologically different in GSL, CCL, SV and FA. Based on GSL, ZB, MSF, LIW, C^1-C^1 and FA. *C. luzoniensis* and *C. brachyotis* that are close to *C. minutus,* are correct identification. Moreover, *C. luzoniensis* separated from other *Cynopterus* was based on two functions, function 1 describes 70.6% of total variance and function 2 covers 29.4% of total variance. Higher data variance in function 1 than that in function 2 reflects that various morphological differences involving skull and external body sizes are crucial in grouping species of genus *Cynopterus*.

Keywords: *Cynopterus*, Morphology, Nature Reserves, Mt. Duasudara, North Sulawesi

Introduction

Nature Reserves of Mt. Duasudara is one of the most important conservation properties currently available in North Sulawesi under the agency Tangkoko Conservation Forest Management Unit. This region holds also endemic animals, such as black monkey (*Macaca nigra*), spectral tarsier (*Tarsius spectrum*), Sulawesi bear cuscus (*Ailurops ursinus*), maleo (*Macrocephalon maleo*), knobbed hornbill (*Rhyticeros cassidix*), collared kingfisher (*Halcyon chloris*, *Cittura cyanotis*) and several bat species (Kinnaird and O'Brien, 1996).

The survey of the Wildlife Conservation Society (WCS, 1999-2003) reported at least 10 species of bats in 6 types of vegetation in the Nature Reserves of Tangkoko-Duasudara, *Rousettus celebensis, R. amplexicaudatus, Cynopterus brachyotis, Thoopterus nigrescens, Nyctimene cephalotes, Macroglossus minimus, Megaderma spasma, Rhinolopus sp., Myotis sp., and Taphozous sp.* Four years later, 8 species of bats in 4 types of vegetation were reported (Lengkong, 2009).

Cynopterus is a bat family distributed in Asia. In Indonesia, its members are widely distributed in Kalimantan, Sumatra, Java, Mollucca, and Sulawesi. *Cynopterus* has claws on the second finger, fangs have a posterior bulge, 4 medium-sized upper molars, a short muzzle, a big tube-like nose, medium and straight ears, big round eyes, an undeveloped inter-thigh skin membrane, a short tail, and thick hairs. In most members, the lust season is indicated by reddish brown-colored shoulder hair. These members have a brown color and a white line on the ear margin, except *C. nusatenggara*.

Several biologists (Hutson, 1993; Koopman, 1970; Flannery, 1995; Payne *et al.*, 1985) claimed that *C. minutus* and *C. luzoniensis* are subspecies of *C.*

brachyotis and not seperate species. However, Kitchener (1991); Maharadatunkamsi, (2013) said that *C. nusatenggara* is different from *C. brachyotis* since their body size and skull are different from those of *C. brachyotis*, except the width size of the zygomaticus bone (ZB) in males and skull width (BCW) and C^1-C^1 in females. Maryanto (2002) who measured 12 male *R. celebensis* in Zoologicum Bogoriensis Museum and 4 male *R. linduensis* of Sulawesi based on FA, GSL, ZB, CBL, and POW sizes, found that nearly all skull and teeth characters of *R. linduensis* are smaller than *R. celebensis*. Lengkong (2009) who studied bats in the Natural Preserve of Duasudara Mt., Sulawesi, found that species of genus *Rousettus* have different skull and external body characters and do not have sexual dimorphism in GSL, ZB, CBL, C^1-C^1, RAP, SV, FL, FA, TIB, and HF of *R. celebensis*, M^3-M3, SV, FL, and TIB of *R. amplexicaudatus*, and MSF of *R. tangkokoensis*. A new species was also found, *R. tangkokoensis,* separated from *R. amplexicaudatus* and *R. celebensis* in hair color, wing attachment, arm length, and posorbital width, and had data variance based on 2 significant functions to separate the species of genus *Rousettus*. Genus *Cynopterus* has interspecific morphological variations. This study aims to identify the morphological variations of genus *Cynopterus* bats in the Nature Reserves of Mt. Duasudara, North Sulawesi.

Materials and Methods

Study Site

This study was conducted from November 2023 to August 2024 in the Natural Preserve of Duasudara Mt, North Sulawesi (Figure 1) covering 7 major vegetations, such as moss forest, submontana, lowland forest, casuarina, coastal forest, bushes, and reeds at 0 -1.351 m above sea level. Sample collection used 2 units of 12×3.6 m mist nets set at 1 and 3 m above the land.

Methods

The number of samples collected was 337 individuals of adult bats caught in the Nature Reserves of Mt. Duasudara. Thirty individuals were preserved in 70% alcohol and their skulls were removed as specimens (Table 1). Measurements of skulls, jaws, and teeth were done on 18 skull characters and 7 external body characters of adult individuals at 0.1 cm accuracy (Figure 2). Figure 4. shows the three species in this study.

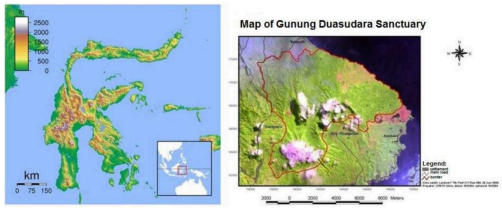

Fig. 1: Study site of the genus Cynopterus bat in Duasudara Mt. Sanctuary

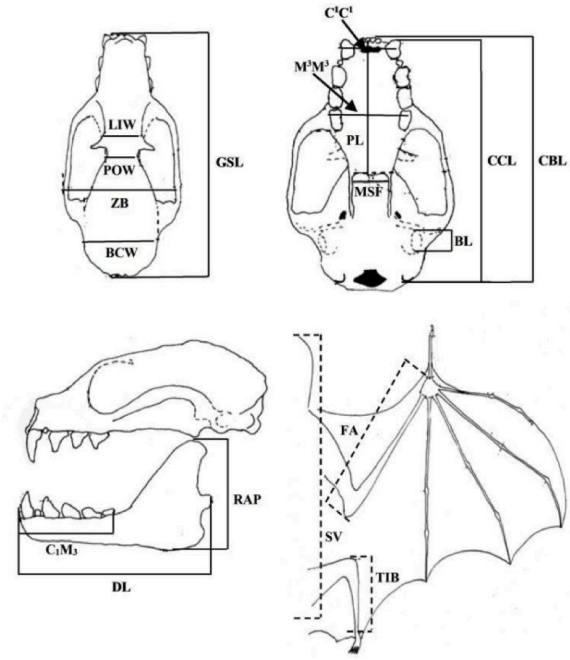

Fig. 2: Measurements of skull and external body of genus Cynopterus

North Sulawesi

The skull characters measured were Greatest Skull Length (GSL), Zygomatic Breadth (ZB); Least Interorbital Width (LIW), Postorbital Width (POWl), Braincase Width (BW), Bullae Length (BL), mesopterygoid fossa Width (MFW), Palatal Length (PL), Condylobasal Length (CBL), Condylocaninus Length (CCL), distance between upper canine and first upper molar (C^1-M^2), distance between outside upper canine (C^1-C^1), distance between outside first upper molar (M^2-M^2), Dentary Length (DL), ramus angular process (RAP), distance between lower canine and second lower molar (C_1-M_2), distance between outside lower canine (C_1-C_1), distance between outside first lower molar (M_2-M_2).

The external body characters measured were Snot-Vent length (SV), Face length (F,), Forearm (FA), Tibia (TIB), Foot Length (FL), Ear (E). and Tail (T).

The sex effect with species was analyzed using a Multiple regression analysis (MRA) on 18 skull characters and 7 external body characters. The Discriminant Function Analysis (DFA) was accomplished by integrating most of the skull characters and all external body characters using species as a priority group. The interspecific relationship in the discriminant function was quite similar in skull and external body characters.

The Discriminant Function Analysis (DFA) can also identify the important characters in separating species or groups. The non-significant characters were removed, because the use of too many characters can yield

unsatisfactory results known as overfitting. Since it is not possible to use all characters, only 6 characters (GSL, ZB, MSF, LIW, C^1-C^1 dan FA) are used to minimize the Wilk's Lamda values.

Results and Discussion

Table (1) shows the sample size, mean, standard deviation, maximum, and minimum of several skull and external body characters of *Cynopterus* measured. It indicates that *C. brachyotis* statistically has the largest skull characters among the three species of *Cynopterus* in the present study. For instance, mean characters of GSL (28.71), ZB (18.27), BL (2.96), PL (14.13), CCL (26.92), C^1-M^2 (9.24), C^1-C^1 (5.87), M^2-M^2 (8.63), DL (21.02), RAP (11.50), C_1-C_1 (3.90), M_2-M_2 (7.74), SV (65.56), F (26.18), FA (63.32), TIB (23.45), FL (15.41), E (16.11) and T (12.08). *C. minutus* has the smallest skull size, but this species has bigger external characters than *C. brachyotis* and *C. luzoniensis*. These characters are LIW (6.37) and POW (7.87). *C. Luzoniensis* has bigger BCW, MSF, and C_1-M_2 than *C. brachyotis* and *C. Minutus,* 12.24, 4.39, and 9.87, respectively. According to Suyanto *et al.* (2021), the measurements of 12 males of *R. celebensis* in the Zoologicum Bogoriensis Museum and 4 males of *R. linduensis* from Sulawesi based on body size FA, GSL, ZB, CBL, and POW, show that nearly all skull and teeth characters of *R. linduensis* are smaller than *R. celebensis*.

Table 1: Skull and External body characters

Species		GSL	ZB	LIW	POW	BCW	BL	MSF	PL	CBL	CCL
C. *brachyotis*	N	10	10	10	10	10	10	10	10	10	10
	Min	27.00	16.20	4.50	5.10	11.20	2.20	4.00	12.20	26.00	26.60
	Max	30.00	19.90	6.40	7.50	12.60	3.90	4.60	15.70	28.80	28.00
	X	28.71	18.27	5.80	6.67	12.03	2.96	4.23	14.13	27.63	26.92
	SD	1.03	1.06	0.58	0.75	0.43	0.62	0.19	1.13	1.07	0.92
C. *luzoniensis*	N	10	10	10	10	10	10	10	10	10	10
	Min	26.00	16.00	5.30	6.10	11.40	2.30	3.70	12.70	23.40	21.90
	Max	29.20	19.20	6.40	8.50	13.10	4.90	5.10	15.00	28.00	27.50
	X	27.76	17.71	5.77	7.10	12.24	2.92	4.39	13.89	26.45	25.43
	SD	1.00	1.03	0.38	0.84	0.58	0.76	0.39	0.84	1.40	1.48
C. *minutus*	N	10	10	10	10	10	10	10	10	10	10
	Min	24.80	15.30	5.00	6.50	11.50	2.30	3.10	12.40	24.30	23.90
	Max	28.90	19.00	8.00	8.90	12.80	3.20	4.00	13.70	28.10	27.60
	X	27.04	16.97	6.37	7.87	12.04	2.89	3.74	13.12	26.01	25.44
	SD	1.45	1.19	0.97	0.76	0.41	0.26	0.28	0.45	1.28	1.27

Species		C^1-M^2	C^1-C^1	M^2-M^2	DL	RAP	C_1-M_2	C_1-C_1	M_2-M_2
C. *brachyotis*	N	10	10	10	10	10	10	10	10
	Min	8.50	4.70	7.90	19.20	10.50	7.70	3.10	6.80
	Max	10.00	7.10	9.40	25.90	15.70	11.00	5.80	8.50
	X	9.24	5.87	8.63	21.03	11.50	9.66	3.90	7.74
	SD	0.57	0.68	0.56	1.90	1.53	1.28	0.78	0.64
C. *luzoniensis*	N	10	10	10	10	10	10	10	10
	Min	7.90	4.50	7.80	18.60	8.00	7.80	3.20	7.20
	Max	9.80	6.10	8.90	20.60	10.80	10.60	3.80	8.20
	X	8.97	5.51	8.26	19.71	9.69	9.87	3.59	7.67
	SD	0.62	0.46	0.39	0.82	0.87	0.86	0.20	0.28
C. *minutus*	N	10	10	10	10	10	10	10	10
	Min	8.60	5.20	7.70	16.80	7.10	9.00	3.20	6.70
	Max	9.30	5.80	8.40	21.30	11.10	10.40	4.00	7.30
	X	8.98	5.55	8.05	18.91	8.90	9.75	3.67	7.06
	SD	0.25	0.19	0.21	1.47	1.28	0.43	0.27	0.19

Species		SV	F	FA	TIB	FL	E	T
C. *brachyotis*	N	84	84	84	84	84	84	84
	Min	50.90	22.30	59.00	21.10	12.30	12.60	4.80
	Max	73.40	30.00	67.00	25.70	17.80	25.90	16.80
	X	65.56	26.18	63.32	23.45	15.41	16.11	12.08
	SD	3.93	1.85	1.76	0.95	1.12	1.74	1.95
C. *luzoniensis*	N	101	101	101	101	101	101	101
	Min	52.10	20.10	56.00	19.40	10.20	12.10	5.60
	Max	68.80	30.00	65.00	34.90	18.80	18.00	14.80
	X	61.16	24.80	60.83	22.30	15.08	15.15	11.16
	SD	3.87	2.06	2.17	1.76	1.39	1.26	2.07
C. *minutus*	N	138	138	138	138	138	138	138
	Min	23.40	20.70	52.00	19.10	11.40	11.20	6.50
	Max	71.40	29.50	63.00	24.70	23.40	18.30	14.40
	X	63.05	24.47	60.95	22.68	15.03	14.84	11.56
	SD	5.09	1.63	1.82	1.00	1.47	1.37	1.66

The significant influence of sex on the skull and external body characters was recorded in *C. brachyotis* (FL) ($p<0.001$), *C. luzoniensis* (FA) ($p<0.001$), and *C. minutus* (GSL, CCL, SV, and FA) ($p<0.01$, $p<0.05$). Therefore, most skull and external body characters are affected by sex, so both the skull characters and the external body characters are involved in sexual dimorphism (Table 2). Lengkong (2009) found that in Mt. Duasudara Nature Reserve, Sulawesi, bat species of the genus *Rousettus* had significant differences ($p<0.05$) based on skull and external body characters and are not sexually dimorphic in the size of GSL, ZB, CBL, C^1-C^1, RAP, SV, FL, FA, TIB, and HF (*R. celebensis*), M^3-M^3, SV, FL, and TIB (*R. amplexicaudatus*), and MSF (*R. tangkokoensis*). Furthermore, the high values of skull and external body characters indicate the interspecific differences of the bats.

Table 2: ANOVA of skull and external body characters of Cynopterus based on sex

Character	*C. brachyotis*	*C. luzoniensis*	*C. minutus*
a. Skull			
GSL	3.71	1.05	13.69**
ZB	0.00	2.65	3.62
LIW	0.21	0.47	0.02
POW	0.20	0.30	0.00
BCW	0.08	0.71	1.55
BL	0.20	0.45	0.03
MSF	0.15	0.87	2.68
PL	2.76	1.22	2.88
CBL	2.86	0.82	5.26
CCL	2.49	0.60	5.89*
C^1-M^3	1.27	0.75	0.30
C^1- C^1	0.01	0.86	1.92
M^3-M^3	0.95	0.14	1.68
DL	1.41	0.25	3.94
RAP	1.19	0.06	3.56
C_1-M_3	0.19	0.20	0.02
C_1-C_1	0.25	0.05	0.03
M_3-M_3	0.19	0.48	1.30
b. External body			
SV	2.61	1.66	4.10*
F	2.96	0.52	0.64
FA	0.62	15.80***	5.39*
TIB	2.62	1.31	1.57
FL	0.36	0.13	2.44
E	0.47	0.10	0.74
T	2.11	1.39	0.64

** = p<0.05, ** = p<0.01, and *** = p<0.001*

ANOVA indicates that sex significantly affects one external character of the forearm (FA) of *C. luzoniensis* ($p<0.001$). It is affected by 2 skull characters (GSL and CCL) and 2 external body characters (SV and FA) of *C. minutus* ($p<0.01$, $p<0.05$). Thus, most of the skull characters and the external body characters are not influenced by sex. Neither skull characters nor external body parts of the three species are included in sexual dimorphisms (Table 2).

DFA was carried out using the representatives of *C. brachyotis*, *C. minutus, and C. luzoniensis*. In the early stage, DFA was accomplished on all skull characters and external body characters that are not influenced by sex.

The morphological profiles of *Cynopterus brachyotis*, *C. luzoniensis* dan *C. minutus* based on GSL, ZB, MSF, LIW, C^1-C^1, and FA (Fig. 3) indicate that *C. luzoniensis* had closer similarity to *C. brachyotis* than *C. minutus*. *C. brachyotis* and *C. minutus* also had very low similarity.

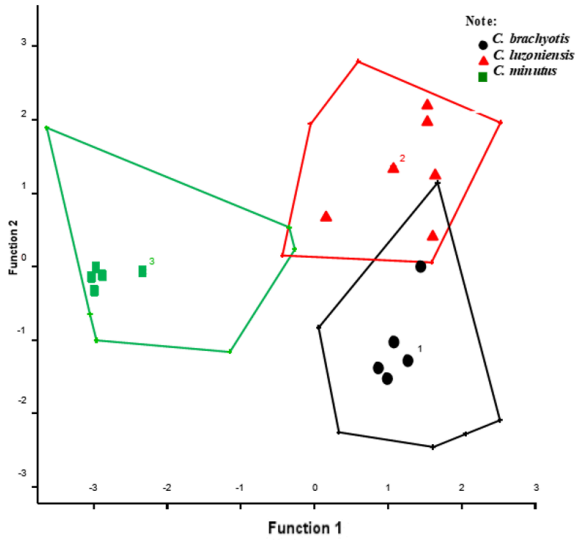

Fig. 3: Morphological variation profiles of 3 species of Cynopterus based on discriminant analysis using 6 selected characters

Based on Table (3), function 1 explains 70.6 of % variance and function 2 explains 29.4 of % variance. It reflects that the data variance in function 1 is higher than that in function 2. The morphological differences among the three *Cynopterus* species can be based on 6 skull size and external body size. The 6 important characters are capable of separating the members of genus *Cynopterus*. Due to the very close similarity of morphological variance between *C. brachyotis* and *C. minutus*, the identification is correct.

Table 3: Standard and unstandard discriminant function coefficients of Cynopterus

Character	Function 1	Function 2
GSL	-.312 (-.264)	1.628 (1.380)
ZB	.555 (.508)	-1.805 (-1.651)
MSF	1.079 (3.608)	-.305 (-1.022)
LIW	-1.121 (-1.632)	.228 (.333)
C^1-C^1	.545 (1.117)	.727 (1.491)
FA	.253 (.093)	1.001 (.368)
Eigen Value	3.022	1.260
Constan	-18.674	-37.917
Variance explained (%)	70.6	29.4

Table (3) demonstrates that function 1 covers 70.6% of the total variance and function 2 covers 29.4% of the

total variance. Higher data variance in function 1 than that in function 2 indicates that various morphological differences related to skull size and external body size are important characters to separate the species of genus *Cynopterus*. These morphological groups are considered to have different specifications, so they have different skull and external body characters.

Fig. 4: Bat species (a) Cynopterus brachyotis, (b) Cynopterus luzoniensis, and (c) Cynopterus minimus

Species Systematics

- Class: Mammal
- Order: Chiroptera
- Suborder: Megachiroptera
- Family: Pteropodidae Gray, 1821
- Genus: Cynopterus Cuvier, 1824

Cynopterus Brachyotis Muller, 1838

Paratype

Ten specimens were collected in submontana forest vegetation, dataran rendah, casuarina, coast, bushes, and reeds in the Nature Reserves of Mt. Duasudara, North Sulawesi, Indonesia. The specimens were preserved in 70% alcohol. They are listed below:

- HL 111338 (Field no. CB-20), adult male, testis swollen, body weight of 32 g, collected at 15 m above sea level $01^0$32’883” N, $125^0$12’543” E)
- HL 111339 (Field no. CB-497), adult female, nipples swollen with no bite marks, body weight of 35 g, collected at 514 m above sea level ($01^0$30’872’ N, $125^0$13’516' E)
- HL 111340 (Field no. CB-541), adult male, testis slightly swollen, body weight of 32 g, collected at 150 m above sea level ($01^0$30’779’ N, $125^0$13’543' E)
- HL 111341 (Field no. CB-63), adult female, pregnant, body weight of 33 g, collected pada ketinggian 30 mdpl ($01^0$33’978’ N, $125^0$09’577' E)
- HL 111342 (Field no.CB-640), adult male, testis unswollen, body weight of 28 g, collected at 250 m above sea level ($01^0$32’897’ N, $125^0$09’651' E)
- HL 111343 (Field no. CB-1082), adult male, testis unswollen, body weight of 25 g, collected at 106 ($01^0$30’764’ N, $125^0$14’115' E)
- HL 111344 (Field no. CB-993), adult male, testis swollen, body weight of 32 g, diperoleh at 514 m above sea level ($01^0$30’872’ N, $125^0$13’516' E)
- HL 111345 (Field no. CB-1170), adult male, testes slightly swollen, body weight of 30 g, collected at 55 m above sea level ($01^0$33’429’ N, $125^0$09’359' E)
- HL 111346 (Field no. CB-1101), adult female, nipples swollen with bite marks), body weight of 39 g, collected at 696 m above sea level ($01^0$29’431’ N, $125^0$10’568' E)
- HL 111347 (Field no. CB-1052), adult male, testes slightly swollen, body weight of 30 g, collected at 341 m above sea level ($01^0$30’621’ N, $125^0$13’209' E)

Distribution

They were found in the Nature Reserves of Mt. Duasudara, North Sulawesi, Indonesia.

Diagnosis

C. brachyotis belongs to a small-sized species, but has bigger external body characters (ZB, CBL, CCL, C^1-M^3, DL, SV, FA, and HF) than *C. luzoniensis* and for all external body characters, bigger GSL, BL, C^1-C^1, M^3-M^3, RAP, FL, TIB, EAR, and TAIL than *C. luzoniensis* and *C. minutus*, bigger LIW than *C. luzoniensis* and bigger MSF than *C. minutus*.

Description

All bats were directly described in the Nature Reserves of Mt. Duasudara. *C. brachyotis* was compared with *C. luzoniensis* and *C. minutus* specimens.

Animal Fur

The back fur, chest to belly, is brownish grey with much yellow color, neck is dark orange, but does not reach the left and right body part in adult males, the upper head is dark brownish grey, does not have dense fur to around thigh and no wing attachment on the back side and wings have no fur.

External Body

C. brachyotis has longer nose length to anus (SV), arm length under the wing (FA), sole length (HF), face length (FL), tibia length (TIB), ear length (EAR) and tail (TAIL) than *C. minutus* and *C. luzoniensis.*

Skull

C. brachyotis has a longer skull (GSL) and wider zygomaticus (ZB) than *C. luzoniensis* and *C. minimus*; longer *condylobasal* (CBL) and *condylocaninus* (CCL) than *C. luzoniensis* and *C. minutus*; wider *interorbital* (LIW) than *C. luzoniensis*; longer *bula* (BL) than *C. luzoniensis* and *C. minutus*; wider *fossa mesopterygoid* (MSF) than *C. minutus*; longer *palatal* (PL) than *C. luzoniensis* and *C. minutus.*

Teeth and Dentary

C. brachyotis has larger outer distance between the side of canine teeth and upper molars (C^1-M^3) and

dentary length (DL) than *C. luzoniensis* and *C. minutus*; the outer distance between the upper left and right canine teeth (C^1-C^1) and the widest outer distance between the upper left and right molars (M^3-M^3) are bigger than *C. luzoniensis and C. minutus*; the outer side distance between the lower left and right canine (C_1-C_1) of *C. brachyotis* is bigger than that of *C. minutus* and *C. luzoniensis*; the widest outer distance between the left and right molars (M_3-M_3) is bigger than *C. minutus*.

Biology

Fourty-seven adult male bats have varied reproductive conditions (22 small testes, 22 medium-sized testes, and 3 big testes), 37 adult females have varied reproductive conditions (3 small breasts, 7 big breasts with no bite marks, 15 big breasts with bite marks, and 12 pregnant).

Habitat

Eighty-four bats were caught in bat nets at 1 m and 3 m above the land of moss forest, submontana, lowland, casuarina, beach, bushes, and reeds in the rainy season and dry season.

Cynopterus Luzoniensis Peters, 1861

Paratipe

Ten specimens were collected from submontane forest vegetation, lowland, casuarina, beach, bushes, and reeds in the Nature Reserves of Mt. Duasudara, North Sulawesi, Indonesia. Skull and dentary were separated. The specimens were preserved in 70% alcohol.

The specimens were:

- HL 111348 (Field no. CL-5), adult male, testes unswollen, body weight of 22 g, diperoleh pada ketinggian 14 mdpl ($01^0$32’262’ N, $125^0$12’281' E)
- HL 111349 (Field no. CL-185), adult female, nipples swollen with no bite marks, body weight of 29 g, caught at 1,037 m above sea level ($01^0$31’271’ N, $125^0$11’169' E)
- HL 111350 (Field no. CL-461), adult male, testes unswollen, body weight of 24 g, caught at 495 m above sea level ($01^0$30’779’ N, $125^0$13’543' E)
- HL 111351 (Field no. CL-526), adult male, tetes unswollen, body weight of 34 g, caught at 431 m above sea level ($01^0$30’511’ N, $125^0$13’098' E)
- HL 111352 (Field no. CL-249), adult female, pregnant, body weight of 14 g, caught at 157 m above sea level ($01^0$33’085’ N, $125^0$10’688' E)
- HL 111353 (Field no. CL-789), adult male, testes unswollen, body weight of 30 g, caught at 43 m above sea level ($01^0$33’882’ N, $125^0$09’533'E)
- HL 111354 (Field no. CL-955), adult male, testes slightly swollen, body weight of 27 g, caught at 697 m above sea level ($01^0$30’255’ N, $125^0$12’333' E)
- HL 111355 (Field no. CL-1176), adult male, testes unswollen, body weight of 21 g, caught at 64 m above sea level ($01^0$33’503’ N, $125^0$09’435' E)
- HL 111356 (Field no. CL-1121), adult male, testes unswollen, body weight of 27 g, caught at 232 m above sea level ($01^0$32’909’ N, $125^0$09’641' E)
- HL 111357 (Field no. CL-1112), adult female, nipples unswollen, body weight of 18 g, caught at 506 M above sea level ($01^0$29’917’ N, $125^0$09’959' E)

Distribution

Found in the Nature Reserves of Mt. Duasudara, Notrth Sulawesi, Indonesia.

Diagnosis

C. luzoniensis belongs to small-sized species, but has bigger ZB, CBL, M^3-M^3, DL, RAP and GSL than *C. minutus.* It also has bigger MSF than *C. brachyotis* and *C. minutus*; bigger PL than *C. minutus*; bigger BCW, C_1-M_3, M_3-M_3 and FL than *C. minutus* and *C. brachyotis*; It has bigger FL than *C. minutus* and bigger HF and EAR than *C. minutus.*

Description

All bats were described directly in the Nature Reserves of Mt. Duasudara. *C. luzoniensis* specimen was compared with *C. brachyotis* and *C. minutus.*

Animal Fur

The back fur is dark grey-colored, the chest to belly is grey, the adult male has dark orange neck down to the left and right body, the upper head is dark grey-colored and no wing attachment on the backside and the wings have no fur.

External Body

C. luzoniensis has larger face length (FL), sole and ear than *C. minutus*.

Skull

C. luzoniensis has bigger GSL ZB, CBL, BL and palatal (PL) than *C. minutus*, bigger *posorbital* (POW) than *C. brachyotis*, bigger *fossa mesopterygoid* (MSF) than *C. brachyotis* and *C. minutus.*

Teeth and Dentary

C. luzoniensis has the widest distance between the outer edge of left molar and right molar (M^3-M^3), longer *dentary* (DL) and wider *ramus angular* (RAP) than *C. minutus*; wider outer edge of canine tooth and lower molars (C_1-M_3) and widest outer edge between upper left molar and right molar (M_3-M_3) than *C. minutus* and .

Biology

Fifty adult male bats have varied reproductive conditions (46 testes unswollen, 3 testes slightly swollen, one testis swollen), 50 adult females have also varied reproductive conditions (37 nipples unswollen, 7 swollen

nipples with no bite marks, 5 swollen nipples with bite marks and one pregnant).

Habitat

One-hundred bats were caught using a bat net at 1 m and 3 m above the land in the moss forest, submontana, lowland, casuarina, coast, bushes and reeds in rainy and dry seasons.

Cynopterus Minutus Muller, 1861

Paratype

Ten spesimens were collected from submontane forest vegetation, lowland, casuarina, coast, bushes and reeds in the Nature Reserves of Mt. Duasudara, North Sulawesi, Indonesia. The skull and *dentary* tare separated, preserved in 70% alcohol.

- HL 111358 (Field no. CM-469), adult female, nipples swollen, body weight of 34 g, caught at 514 m above sea level ($01^0$30’872’ N, $125^0$13’516' E)
- HL 111359 (Field no. CM-520), adult male, testes unswollen, body weight of 25 g, caught at 415 m above sea level ($01^0$30’872’ N, $125^0$13’516' E)
- HL 111360 (Field no. CM-548), adult male, testes unswollen, body weight of 18 g, caught at 171 m above sea level ($01^0$30’872’ N, $125^0$13’516' E)
- HL 111361 (Field no. CM-579), adult female, nipples slightly swollen, body weight of 33 g, caught at 696 m above sea level ($01^0$29’431’ N, $125^0$10’568'E)
- HL 111362 (Field no. CM-660), adult male, testes slightly swollen, body weight of 27 g, caught at 133 m above sea level ($01^0$30’641’ N, $125^0$13’858' E)
- HL 111363 (Field no. CM-709), adult female, nipples unswollen, body weight of 27 g, caught at 477 m above sea level ($01^0$31’980’ N, $125^0$10’734' E)
- HL 111364 (Field no. CM-793), adult male, testes slightly swollen, body weight of 26 g, caught at 43 m above sea level ($01^0$33’882’ N, $125^0$09’533' E)
- HL 111365 (Field no. CM-1070), adult female, nipples swollen with bite marks, body weight of 28 g, caught at 171 m above sea level ($01^0$30’872’ N, $125^0$13’516' E)
- HL 111366 (Field no. CM-1107), adult male, testes unswollen, body weight of 29 g, caught at 696 m above sea level ($01^0$29’431’ N, $125^0$10’568' E)
- HL 111367 (Field no. CM-1148), adult female, nipples slightly swollen, body weight of 28 g, caught at 43 m above sea level ($01^0$33’793’ N, $125^0$10’068' E)

Distribution

Found in Nature Reserve of Duasudara Mt., North Sulawesi, Indonesia.

Diagnosis

C. *minutus* is a small-sized bat that has bigger LIW and POW than *C. brachyotis* and *C. luzoniensis*; bigger BCW than *C. brachyotis*; bigger CCL, C^1-M^3, SV, FA, C_1-C_1, TIB and TAIL than *C. luzoniensis*; bigger C_1-M_3 than *C. brachyotis*.

Description

All bats were directly described in the Nature Reserves of Mt. Duasudara. *C. minutus* sepcimens were compared with *C. luzoniensis* and *C. brachyotis.*

Animal Fur

The back fur is slightly dark grey colored, chest to belly is grey with slight yellowness, neck is lightly orange and does not reach the lower body sides in adult males, the upper head is slightly dark grey, does not have dense fur down to the thigh and no wing attachment on the backside and the wings have no fur.

External

C. minutus has a long nose reaching the anus (SV) and longer wing forearm (FA), tibia (TIB) and tail (TAIL) than *C. luzoniensis.*

Skull

C. minutus specimen has Larger Interorbital Width (LIW) postorbital width than *C. brachyotis* and *C. luzoniensis,* smaller Bigger Braincase Width (BCW) and bigger skull length (CCL) than *C. brachyotis* and *C. luzoniensis.*

Teeth and Dentary

C. minutus has wider peripherial distance between canine tooth and upper molars (C^1-M^3) and wider distance between left and right upper canine tooth (C^1-C^1) than *C. luzoniensis*; wider outer distance between canine tooth side and lower molars (C_1-M_3) than *C. brachyotis*; wider distance between left and right lower canine teeth (C_1-C^1) than *C. luzoniensis.*

Biology

Seventy-two adult male bats have varied reproductive conditions (38 testes unswollen, 26 testes slightly swollen and one swollen testis); 66 adult female bats have also varied reproductive conditions (11 nipples unswollen, 8 nipples slightly swollen, 6 swollen nipples with no bite makrs, 26 swollen nipples with bite marks and 15 pregnant).

Habitat

One-hundred-thirty-eight bats were caught on the bat net at 1 m and 3 m above the land in moss forest, submontana, lowland, casuarina, coast, bushes and reeds in rainy and dry seasons.

Conclusion

Overall, this study confirms that morphological variation in Cynopterus is influenced by both species

identity and sex and that these differences are valuable for taxonomic identification and species differentiation.

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Author's Contributions

Hanry Jefry Lengkong: Participated in all experiments, coordinated the data-analysis and contributed to the writing of the manuscript.

Meis Jacinta Nangoy: Designed the research plan and organized the study and review the manuscript.

Ethics

This article is original and contains unpublished material. The corresponding author confirms to the other author and have read and approved the manuscript and no ethical issues involved.

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