Identification of Twelve Murid Rodent Genera in Thai-Malaysian peninsula (Rodentia: Muridae)

การจำแนกสกุลของหนู (Rodentia: Muridae) ในคาบสมุทรไทย-มาเลย์

Uraiporn Pimsai (อุไรพร พิมสาย)* Dr. Chutamas Satasook (ดร. จุฑามาส ศตสุข)**
Dr. Paul J. J. Bates (ดร. พอล เจ เจ เบทส์)*** Dr. Sara Bumrungsri (ดร. สาระ บำรุงศรี)****

ABSTRACT

Identification of murid rodents is essentially difficult by broad variations in morphological characters. This study aims to examine diagnostic characters for identification of twelve genera of murid rodent in Thai-Malaysian peninsula. Specimens of murid rodents were directly collected from the field by live traps, and supplemented with specimens from CTNRC, TISTR and NHM, London. We examined external, cranial and dental characters of these rodents. We found that tail color (monocolor or bicolor), tail length/head and body length, head and body length, and pelage pattern can be used to differentiate between genera of these rodents. Moreover, the size of tympanic bulla, the shape and position of incisive foramina, the position of the posterior of the bony palate relative to M^3, skull-sized, and cheekteeth pattern are very useful for such classification. However, no single character is able to identify these murid rodents, and a combination of these characters is needed for effective classification at generic level of murid rodents in the Thai-Malaysian peninsular region.

บทคัดย่อ

การจำแนกชนิดหนูมีความยากเนื่องจากลักษณะภายนอกที่ผันแปรสูง การศึกษานี้มีวัตถุประสงค์เพื่อตรวจสอบลักษณะที่ใช้ในการจำแนกหนูในระดับสกุลทั้ง 12 สกุลในคาบสมุทรไทย-มาเลย์ ตัวอย่างที่ใช้ในการศึกษาจากการออกภาคสนามโดยการดักจับด้วยกรง และตัวอย่างเพิ่มเติมจากสถาบันวิจัยวิทยาศาสตร์และเทคโนโลยีแห่งประเทศไทย และตัวอย่างจากพิพิธภัณฑ์ธรรมชาติวิทยา กรุงลอนดอน สหราชอาณาจักร ทำการศึกษาโดยการตรวจสอบลักษณะภายนอก กะโหลกและฟันของหนู 12 สกุล จากผลการศึกษาพบว่า สีของหาง (สีเดียว หรือสองสี) สัดส่วนของความยาวหางต่อหัวและลำตัว ความยาวของหัวและลำตัว และลักษณะของขน สามารถใช้ในการจำแนกหนูในแต่ละสกุลได้ นอกจากนี้ ขนาดของ bulla รูปร่างและตำแหน่งของ incisive foramina ตำแหน่งของกระดูก bony palate เมื่อเปรียบเทียบกับตำแหน่งฟันกรามบนซี่ที่สาม ขนาดของกะโหลก และรูปแบบของฟันกราม ก็ยังเป็นประโยชน์อย่างมากในการจำแนกหนูในระดับสกุล อย่างไรก็ตามการจำแนกหนูในระดับสกุลในคาบสมุทรไทย-มาเลย์นี้ไม่สามารถใช้เฉพาะลักษณะใดลักษณะหนึ่ง ต้องใช้หลายลักษณะร่วมกัน

Key words: Cranial character, Murid rodent, Thai-Malaysian peninsula

คำสำคัญ: ลักษณะกะโหลก หนู คาบสมุทรไทย-มาเลย์

*Student, Master of Science in Department of Biology, Faculty of Science, Prince of Songkla University, and Scientist, Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University, Songkhla, Thailand

**Associate Professor, Department of Biology, Faculty of Science, Prince of Songkla University, and Director, Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University, Songkhla, Thailand

*** Director, Harrison Institute, Bowerwood House, St. Botolph's Road, Sevenoaks, Kent, TN13 3AQ, United Kingdom

****Assistant Professor, Department of Biology, Faculty of Science, Prince of Songkla University, Songkhla, Thailand

Introduction

Rodents are the most diverse of the 28 Orders of mammals. According to Musser and Carleton (2005), they include 2277 extant species and represent about 42% of all currently recognized mammal species. Not only it is geographically widespread but also our understanding of its natural diversity is increasing rapidly. Corbet and Hill (1980) recognized 1591 species. Two years later Honacki et al. (1982) included 1719 species, which in turn became 2015 species in Wilson and Reeder (1993). The figure of 2277 in Musser and Carleton (2005) represents a 32% increase (558 species) in just 32 years of research and publication.

According to Francis (2008), 22 genera of murid rodent are present in mainland South-East Asia. Twelve of these live in Thai-Malaysian peninsula, namely: *Bandicota, Berylmys*, *Chiropodomys*, *Hapalomys, Lenothrix, Leopoldamys*, *Maxomys, Mus*, *Niviventer, Pithecheir, Rattus,* and *Sundamys*.

Morphologically, all rodents contain the unique characters: a single pair of upper and lower incisors, these are large, chisel-edged and ever-growing. These are separated by a long diastema (without canines) from a compact row of three to five cheek-teeth. The incisors are probably adapted primarily to feed on seeds (Corbet and Hill, 1992). Within the rodents the Murinae are distinguished by the presence of a tail, which is usually moderately long to very long, covered with scales and only sparsely haired and having only 3 cheek-teeth (molars), which are used for chewing. The patterns of the cusps on the teeth vary from many separate cusps to parallel ridges (Francis, 2008).

The taxonomy and identification of rodents are very difficult at the generic and especially at the specific level because of morphological variation through development, and color variation of pelages (mammalian coat) between individuals (Lu et al., 2012). Confidential identification requires analysis of bio-information eg. – external, cranial and dental morphology and metrics (size). The size and shape of cranial are important to diagnose to genus, including the positive and relative length of the incisive foramina and bony palate. The size and shape of teeth, especially the pattern of cusp on the molars, are also important for identification (Francis, 2008). This morphometric approach should be supported by using molecular and cytological techniques for the best identification.

Previously, several papers had reviewed the characters of a number of Southeast Asian murine genera, often taking contradictory views on their taxonomy. Corbet and Hill (1992) published a subsequent monograph on the mammal fauna of Southeast Asia. This text book provides dichotomous and character matrix keys, a comprehensive list of synonyms, subspecies, and distribution maps. It included 12 genera of Murid rodent from the Thai - Malay peninsula.

With particular reference to the current mammal fauna of Thailand, Marshall (1988) in Lekagul and McNeely (1988) provides short descriptions; photographs of external, cranial and dental characters; some measurements (mostly external); some ecological information; and simple geographic distribution maps for 25 genera (69 species) including 36 species and 8 genera of murid rodents.

Waengsothorn et al. (2009) published information about the rodent specimens in the ‘Centre for Thai National Reference Collections

(CTNRC)'. They identified and mapped geographical areas of Thailand that have been well studied and surveyed in the past. They suggested priority areas for field research in the future.

Rodents are important because they represent a high proportion of the diversity and mammal biomass within the region. Moreover they play an important role in the food web, both of consumers and prey. In addition, they help spread pollen (Aplin et al. 2003) and disperse and bury seeds (Jensen and Nielsen, 1986; Lunde and Son, 2001).

This work is important from a scientific, economic and medical perspective. We need to be able to identify rodents, and especially murid rodents, with precision. Yet, despite the extensive literature, dating back over many years, it is still difficult to find simple, well illustrated keys that provide a description of discriminating characters that can be used by a range of end-users such as – student, professional zoologists, palaeontologists, as well as those involved in agriculture and medicine.

From above information, this study seeks to investigated the diagnose characters of the murid rodents for identified in genera level in Thai-Malaysian peninsula.

Methodology

The specimens of murid rodents used in this study were collected from the field (deposited in the collections of the Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University, Thailand (PSUZC)) and supplemented with specimens from Centre for Thai National Reference Collections (CTNRC), Thailand Institute of Scientific and Technological Research (TISTR) and Natural History Museum, London. All external, cranial and dental measurements were taken using digital calipers. Skulls were extracted and skin were prepared for voucher specimens. All measurements are in millimeters. The following measurements were taken (Figure 1): Head and body length (HB), Tail length (T), Hind foot length (HF), Greatest Skull Length (GSL), Zygomatic Breadth (ZB), Interorbital Breadth (IB), Length of Rostrum (LR), Breadth of Rostrum (BR), Breadth of Braincase (BB), Height of Braincase (HBC), Breadth of Zygomatic plate (BZP), Length of Nasals (LN), Length of Diastema (LD), Incisive foramina to M^1 (IF-M^1), Post Palatal Length (PPL), Palatal Length (PL), Length Incisive Foramina (LIF), Breadth Incisive Foramina (BIF), Length of Tympanic Bullae (LB), Length of maxillary toothrow (LM^{1-3}). The definitions of the measurements are followed Musser (1979), Lin and Shiraishi (1992), Lunde and Son (2001), Musser et al. (2006) and Nicolas et al. (2008).

Some characters were categorised such as tail and pelage. Tail can be categorised into two states: 1) Monocolor: all tail is same color; 2) Bicolor: have two color in the tail such as dark color on upper tail and pale color in lower tail or dark color at base of tail and pale color at tip of tail. The dorsal pelage has three types of fur (Figure 2): 1) Hair: soft and not very long (2A); 2) Spine: very hard and similar length with hair (2B); 3) Guard hair: harder and longer than hair and black color (2C). Moreover, the size of tympanic bulla was calculated in proportion to skull length (LB/GSLx100%). For tympanic bulla were categories in 3 groups: 1) Small is tympanic bulla less than 13% of GSL; 2) Medium is tympanic bulla between 13-16% of GSL; 3) Large is tympanic bulla larger than 18% of GSL. The skull size was categories in 3 groups: 1) Small is GSL less than 25 mm; 2) Medium is GSL between 25-50 mm; 3) Large is GSL larger than 50

mm. In addition number of cusps on M^1 was categories in 3 groups (Figure 3): 1) Simple is less than 3 cusps in M^1 (3A); 2) Less complex is 4-6 cusps in M^1 (3B); 3) Complex is more than 7 cusps in M^1(3C).

Results and Discussion

Various characters were found useful in identification of these 12 genera of murid rodents. They were summarized in Table 1 for external morphology and in Table 2 for skull and dental characters. These tables were provided for end-user such as agriculturist, paleontologist and biologist.

For external character (Table 1, 3), the tail color (monocolor, bicolor) which is the most useful diagnostic character and could be classified the murid rodent in two groups such as monocolor (*Bandicota*, *Hapalomys*, *Mus*, *Pithecheir*, *Rattus* and *Sundamys*) and bicolor (*Berylmys*, *Chiropodomys*, *Lenothrix*, *Leopoldamys*, *Maxomys* and *Niviventer*). Proportional length of the tail when compare of head and body length is the useful characters and could be divided in 3 groups that is tail shorter than head body length (*Bandicota* and *Mus*), tail about equal to head and body length (*Berylmys*, *Maxomys* and *Rattus*), tail longer than head and body length (*Chiropodomys*, *Hapalomys*, *Lenothrix*, *Leopoldamys*, *Niviventer Pithecheir*, *Rattus* and *Sundamys*). Moreover, dorsal pelage texture (Figure 2) (pelage with spiny hairs, pelage with long guard hairs, pelage without spiny and guard hairs) is also can use to identified murid rodent. In addition, head and body length can grouping in 3 groups: Large -HB over 200 mm (*Bandicota*, *Berylmys*, *Lenothrix*, *Leopoldamys* and *Sundamys*); Medium- HB between 100-200 mm (*Hapalomys*, *Maxomys*, *Niviventer*, *Pithecheir* and *Rattus*); Small-HB under 100 mm (*Chiropodamys* and *Mus*) were found to be diagnostic characters. This result consistent with Lekagul and McNeely (1988) who suggested that tail color and proportional length of the tail are useful diagnostic character. The pelage texture and head and body length was not valuable for identification at generic level because the variation between species within the genera was greater than variation between genera.

For cranial character (Table 2, 3) the most useful skull character for the identification of genera proved to be the relative size of the tympanic bulla (Figure 4, Table 3) [LB/GSLx100%]. These genera could be divided into three groups based on size of bulla relative to the length of the skull that is large tympanic bulla (>18% of GSL) such as *Bandicota*, *Hapalomys*, *Pithecheir* and *Rattus*); medium-sized tympanic bulla (between 13-16% of GSL) such as *Berylmys*, *Chiropodomys*, *Mus* and *Sundamys*); small tympanic bulla (< 13% of GSL) such as *Lenothrix*, *Leopoldamys*, *Maxomys* and *Niviventer*. The shape and position of the incisive foramina (Fig. 4) were also very useful features in discriminating at a generic level. The position of the posterior border of the foramina relative to the first upper molar was particularly important, that is between M^1-M^1 (*Mus*, *Niviventer* and *Rattus*), posterior lies in line with the anterior border of M^1(*Bandicota*, *Chiropodamys*, *Niviventer* and *Rattus*), posterior border lies in front of the anterior border of M^1(*Berylmys*, *Chiropodamys*, *Hapalomys*, *Lenothrix*, *Leopoldamys*, *Maxomys*, *Pithecheir* and *Sundamys*). Furthermore the position of the posterior border of the bony palate (Fig. 4) relative to M^3 can also be used as an additional diagnostic character such as posterior margin of palate is situated between M^3-M^3 (*Berylmys*, *Lenothrix*, *Maxomys* and *Pithecheir*), posterior palate is in line

with M^3-M^3 (*Berylmys*, *Hapalomys*, *Leopoldamys*, and *Niviventer*), posterior palate extends beyond the posterior border of M^3-M^3 (*Bandicota*, *Chiropodamys*, *Mus*, *Niviventer*, *Rattus* and *Sundamys*). The size of the skull is also good character for genera level: large skull (*Bandicota*, *Berylmys*, *Leopoldamys* and *Sundamys*), medium-sized skull (*Hapalomys*, *Lenothrix*, *Maxomys*, *Niviventer*, *Pithecheir* and *Rattus*), small skull (*Chiropodamys* and *Mus*). For dental character (table 2, 3) the cheekteeth vary in complexity and form between the different genera in which some are very complex whereas others have a simple pattern and could be divided in 3 group (Figure 3); 1.)simple-less than 3 cusps in M^1 (*Bandicota*, *Berylmys*, *Leopoldamys* and *Sundamys*), 2.) less complex – 4-6 cusps in M^1 (*Maxomys*, *Mus*, *Niviventer* and *Rattus*), 3.) complex-more than 7 cusps in M^1 (*Chiropodomys*, *Hapalomys*, *Lenothrix* and *Pithecheir*). However, tooth wear can obscured the original cusp pattern of the teeth and makes the identification of older individuals of many genera problematical. The pattern of cusps on the teeth is important for identification, especially for identified in genera of murid rodent (Francis, 2008).

As a result, no single character is able to identify these murid rodents in the Thai-Malaysian peninsular region, hence a combination of these characters is needed. The diagnostic character of external morphology, skull and teeth are proposed for understood and are accessible by a wide range of end-users including taxonomists, ecologists, conservationists, and agriculturalists. The species study should be done in the future for more understanding about Murid rodent in this region.

Conclusion

Various characters can be used for identification of twelve genera of Murid rodent in Thai-Malaysian peninsula, but a single character only cannot be used to distinguish all genera. A combination of characters is more effective in classification of these rodents. The matrix table of diagnostic character are made for being accessible by a wide range of end-users including taxonomists, ecologists, conservationists, and agriculturalists.

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References

Aplin, KP., Brown, PR., Jacob, J., Krebs, CJ., and Singleton, GR. 2003. Field Methods for Rodent Studies in Asia and the Indo-Pacific. Australian Centre for International Agricultural Research, Canberra. 223 pp.

Corbet, GB., and Hill, JE. 1980. A wopld list of mammalian species. Bristish Museum (Natural History), London, 226 pp.

Corbet, GB., and Hill, JE. 1992. The Mammals of the Indomalayan Region. Natural History Museum Publications and Oxford University Press. 488 pp.

Francis, CM. 2008. A field guide to the mammals of Thailand and South-east Asia. New Holland Publishers (UK) Ltd. 392 pp.

Honacki, JH., Kinman, KE.,and Koeppl, J W. 1982. Mammal species of the World. A taxonomic and geographic reference. Allen Press and the Association of Systematic Collections. Lawrence, Kansas, USA. 694 pp.

Jensen, TS., and Nielsen , OF. 1986. Rodents as seed dispersal in a heath-oak wood succession. Oecologia. 70: 214–221.

Lekagul, B., and McNeely, JA. 1988. Mammals of Thailand. (2nd Edition). Darnsutha Press. Bangkok, 758 pp.

Lin, LK., and Shiraishi, S. 1992. Skull growth and variation in the Formosan wood mouse, *Apodemus semotus*. Journal of the Faculty of Agriculture - Kyushu University. 37 (1): 51-69.

Lu, L., Chesters, D., Zhang, W., Li, G., Ma, Y., Ma, H., Song, X., Wu, H., Meng, F., Zhu, C., and Liu, Q. 2012. Small Mammal Investigation in Spotted Fever Focus with DNA-Barcoding and Taxonomic Implications on Rodents Species from Hainan of China. PLoS ONE 7(8): 13 pp.

Lunde, D., and Son, NT. 2001. An identification guide to the rodents of Vietnam. Centre for Biodiversity and Conservation. American Museum of Natural History Publication. 80 pp.

Marshall, JT., Jr. 1988. Family Muridae: Rat and Mice. pp. 396-487. *in* Mammal of Thailand (Lekagul, B. and McNeely, JA.,eds). Association for the Conservation of Wildlife, Sahakranbhat Co., Bangkok. 758 pp.

Musser, GG. 1979. Results of the Archbold Expeditions. No. 102. The species of *Chiropodomys*, arboreal mice of Indochina and the Malay Archipelago. Bulletin of the American Museum of the Natural History. 162: 377-445

Musser, GG., and Carleton, MD. 2005. *Maxomys*. pp. 1367-1373. *in* Wilson, D.E. and D.M. Reeder. Mammal species of the World: a taxonomic and geographic reference. (3rd Edition). The John Hopkins University Press, Baltimore. 2142 pp.

Musser, GG., Lunde, DP., and Son, NT. 2006. Description of a new genus and species of rodent (Murinae, Muridae, Rodentia) from the Tower Karst Region of Northeastern Vietnam. American Museum Novitates. 3517: 1-41

Nicolas, V., Wendelen, W., Barriere, P., Dudu, A., and Colyn, M. 2008. Morphometric Variation in *Hylomyscus alleni* and *H. Stella* (Rodentia: Muridae), and description of a new species. Journal of Mammalogy. 89 (1): 222-231.

Waengsothorn, S., Kenthao, A., Latinne, A., and Hugot, JP. 2009. Rodents within the Centre for Thai National Reference Collections (CTNRC), Past, Present and Future. Kasetsart Journal, Natural Sciences, 43(1): 118-124.

Wilson, DE., and Reeder, DM. 1993. Mammal species of the World: A Taxonomic and Geographic Reference. (2nd Edition). Smithsonian Institution Press, Washington and London.

Table. 1. Diagnostic characters of external morphology of 12 murid rodent genera in Thai-Malaysian peninsula. The table shown the tail color, tail length when compare with head and body length, dorsal pelage text and head and body length in each genera of murid rodent.

Genus	Tail Color	Tail length	Dorsal pelage texture	HB length
Bandicota	Monocolor	Tail < HB	with long guard hairs	Large (>200mm)
Berylmys	Bicolor with pale tip	Tail = HB	without spiny+guard hairs	Large (>200mm)
Chiropodomys	Bicolor with pale tip+tuft	Tail > HB	without spiny+guard hairs	Small (<100mm)
Hapalomys	Monocolor with small tuft	Tail > HB	without spiny+guard hairs	Medium (100-200mm)
Lenothrix	Bicolor with pale tip	Tail > HB	without spiny+guard hairs	Large (>200mm)
Leopoldamys	Bicolor with pale tip	Tail > HB	without spiny+guard hairs	Large (>200mm)
Maxomys	Bicolor with pale tip	Tail = HB	with spiny hairs	Medium (100-200mm)
Mus	Monocolor	Tail < HB	without spiny+guard hairs	Small (<100mm)
Niviventer	Bicolor	Tail > HB	with spiny hairs	Medium (100-200mm)
Pithecheir	Monocolor	Tail > HB	without spiny+guard hairs	Medium (100-200mm)
Rattus	Monocolor	Tail = HB or Tail> HB	with spiny hairs	Medium (100-200mm)
Sundamys	Monocolor	Tail > HB	with long guard hairs	Large (>200mm)

Table. 2. Diagnostic characters of skull and dental of 12 murid rodent genera in Thai-Malaysian peninsula. The table shown the size of tympanic bulla when compare with Skull length (GSL), the position of posterior margin in incisive foramina, the position of posterior border of bony palate, the skull size and number of cusps in first upper molar (M^1) in each genera of murid rodent.

Genus	Tympanic bulla size	Position of posterior margin of incisive foramina	Position of posterior border of bony palate	Skull size	Cusp in M^1
Bandicota	Large (>18% of GSL)	in line with the anterior border of M^1-M^1	posterior to posterior borders of M^3-M^3	Large (GSL>50mm)	Simple (<3cusps)
Berylmys	Medium (13-16% of GSL)	anterior to the anterior borders of M^1-M^1	between or in line with M^3-M^3	Large (GSL>50mm)	Simple (<3cusps)
Chiropodomys	Medium(13-16% of GSL)	anterior to, or in line with the anterior borders of M^1-M^1	posterior to posterior borders of M^3-M^3	Small (GSL<25mm)	Complex (>7 cusps)
Hapalomys	Large (>18% of GSL)	anterior to the anterior borders of M^1-M^1	in line with posterior borders of M^3-M^3	Medium (GSL 25-50mm)	Complex (>7 cusps)
Lenothrix	Small (<13% of GSL)	anterior to the anterior borders of M^1-M^1	between M^3-M^3	Medium (GSL 25-50mm)	Complex (>7 cusps)
Leopoldamys	Small (<13% of GSL)	anterior to the anterior border of M^1-M^1	in line with posterior borders of M^3-M^3	Large (GSL>50mm)	Simple (<3cusps)
Maxomys	Small (<13% of GSL)	anterior to the anterior borders of M^1-M^1	between M^3-M^3	Medium (GSL 25-50mm)	Less complex (4-6 cusps)
Mus	Medium (13-16% of GSL)	between M^1-M^1	posterior to posterior borders of M^3-M^3	Small (GSL<25mm)	Less complex (4-6 cusps)
Niviventer	Small (<13% of GSL)	in line with the anterior borders of M^1-M^1 or between M^1-M^1	in line with, or posterior to, posterior borders of M^3-M^3	Medium (GSL 25-50mm)	Less complex (4-6 cusps)
Pithecheir	Large (>18% of GSL)	anterior to the anterior borders of M^1-M^1	between M^3-M^3	Medium (GSL 25-50mm)	Complex (>7 cusps)
Rattus	Large (>18% of GSL)	in line with the anterior borders of M^1-M^1 or between M^1-M^1	posterior to posterior borders of M^3- M^3	Medium (GSL 25-50mm)	Less complex (4-6 cusps)
Sundamys	Medium (13-16% of GSL)	anterior to the anterior borders of M^1-M^1	posterior to the posterior borders of M^3-M^3	Large (GSL>50mm)	Simple (<3cusps)

Table. 3. External and cranial measurements (in mm) of 12genera of murid rodent. The mean, standard deviation, minimum and maximum are given. Sample sizes are in parentheses.

Genus	Head and Body length	Tail length	Skull length	Tympanic bulla size	Number of cusps in M^1
Bandicota	266.1, 28.5 230.0-350.0 [17]	232.4, 29.3 146.0-275.0 [17]	58.03, 2.59 54.14-63.41 [19]	9.96, 0.60 8.60-10.96 [19]	3 cusps
Berylmys	256.2, 18.4 235.0-268.5 [3]	270.7, 14.3 255.0-283.0 [3]	55.06, 3.51 50.03-57.51 [4]	7.27, 0.24 7.06-7.58 [4]	3 cusps
Chiropodomys	81.0, 5.7 77.0-85.0 [2]	111.0, 8.5 105.0-117.0 [2]	24.49, 0.34 24.19-24.86 [3]	3.89, 0.36 3.61-4.29 [3]	9 cusps
Hapalomys	156.6[1]	187 [1]	39.3 [1]	8.3 [1]	9 cusps
Lenothrix	200.0 [1]	265.0 [1]	44.15 [1]	5.75 [1]	9 cusps
Leopoldamys	224.6, 16.1 190.0-252.0 [14]	328.5, 19.5 295.0-362.0 [14]	55.63, 2.52 51.00-61.29 [16	5.61, 0.31 5.17-6.18 [14]	3 cusps
Maxomys	169.6, 23.4 112.0-210.0 [45]	167.9, 23.4 109.0-219.0 [36]	43.07, 3.8 33.66-48.77 [46]	4.91, 0.2 4.47-5.63 [46]	5-6 cusps
Mus	80.0 [1]	75.0 [1]	22.73, 1.63 21.00-24.23 [3]	3.70 [1]	4-5 cusps
Niviventer	13.76, 10.0 115.0-153.6 [13]	180.6, 18.9 152.0-219.0 [12]	36.02, 1.58 33.21-39.59 [13]	4.40, 0.19 4.10-4.64 [8]	4-5 cusps
Pithecheir	168.5, 10.6 161.0-176.0 [2]	189.0, 2.8 187.0-191.0 [2]	39.95 [1]	9.8 [1]	8 cusps
Rattus	177.7, 56.4 100.0-350.0 [63]	170.2, 34.0 110.0-258.0 [60]	40.78, 8.20 28.23-59.07 [66]	7.00, 1.07 5.07-8.17 [64]	5-6 cusps
Sundamys	222.5, 11.9 215.0-240.0 [4]	270.0, 20.0 250.0-290.0 [3]	54.82, 2.01 52.24-56.68 [5]	7.55, 0.38 6.96-7.99 [6]	3 cusps

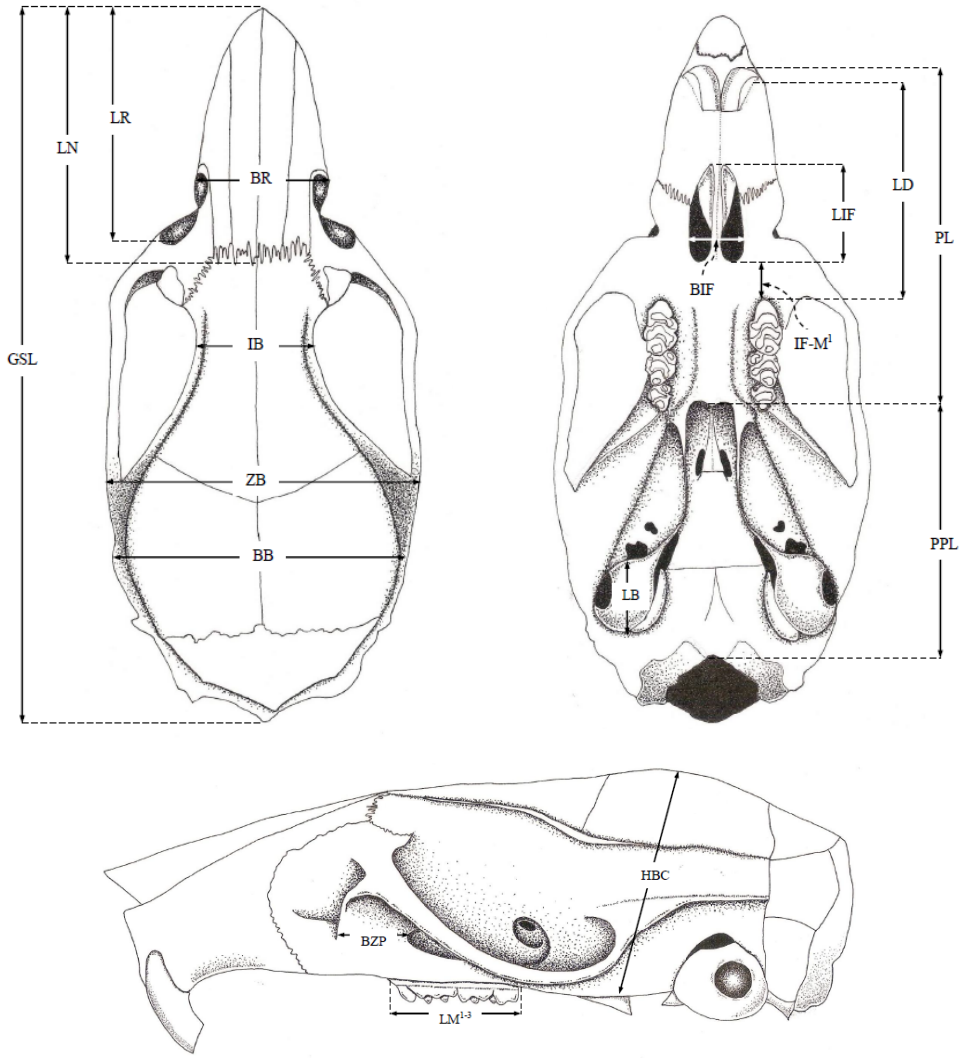

Figure1. Dorsal, ventral and lateral view of cranium *Maxomys surifer* showing limits of cranial measurements which are defined in the text.

Figure 2. Type of fur in the dorsal pelage: A. Hair: soft and not very long; B. Spine: very hard and similar length with hair; C. Guard hair: harder and longer than hair and black color.

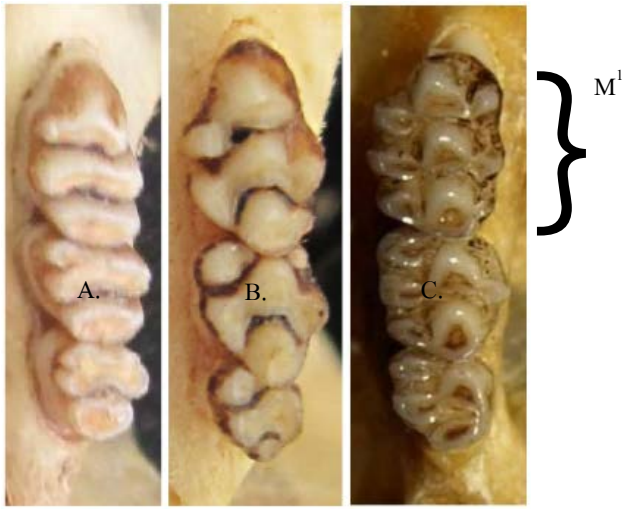

Figure 3. Number of cusps on M^1 was categories in 3 groups: A. Simple is less than 3 cusps in M^1; B. Less complex is 4-6 cusps in M^1; C. Complex is more than 7 cusps in M^1.

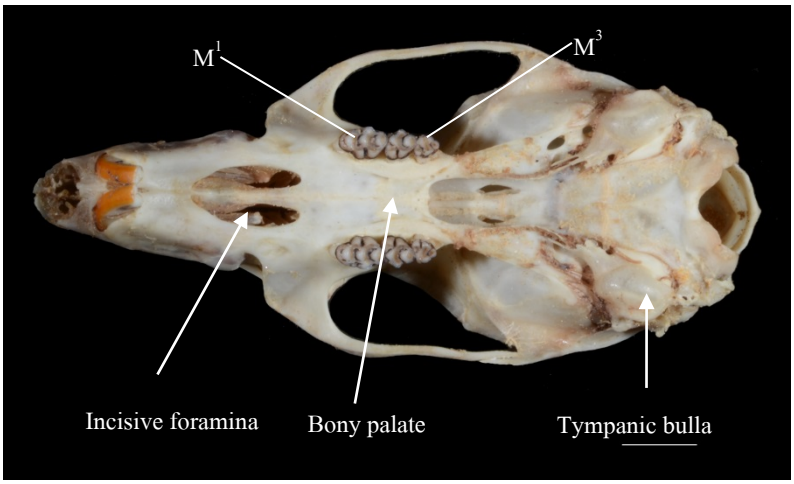

Figure 4. Ventral view of Skull of *Maxomys surifer* (PSUZC-MM2012.139) from Naratiwas, peninsula Thailand. Scale 5 mm. This view shown the position of first upper molar (M^1), third upper molar (M^3), Incisive foramina, Bony palate and Tympanic bulla.