An Identification Guide to the Rodents of Viet Nam

Darrin Lunde*

and Nguyen Truong Son**

*Collections Manager, Dept. of Mammalogy, American Museum of Natural History
** Department of Zoology, Institute for Ecology and Biological Resources, Ha Noi

Center for Biodiversity and Conservation • American Museum of Natural History

Ellen V. Futter, President • Lewis W. Bernard, Chairman, Board of Trustees

Direct correspondence to:

Darrin Lunde
Department of Mammalogy
The American Museum of Natural History
Central Park West at 79th St.
New York, New York 10024 USA
email: lunde@amnh.org

Direct requests for copies to:

Center for Biodiversity and Conservation
The American Museum of Natural History
Central Park West at 79th St.
New York, New York 10024 USA
Telephone: (212)769-5742
Fax:(212)769-5292
email: biodiversity@amnh.org

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Table of Contents

PART 1 Identification Guide to Viet Nam Rodents

PART 2 Notes on how to Collect, Prepare and Maintain Rodent Specimens

Authorship and Acknowledgments

This identification guide is the product of a collaboration between the Institute for Ecology and Biological Resources, Ha Noi (IEBR) and the American Museum of Natural History (AMNH). The text and skull illustrations are the work of the senior author. Eric Stiner assisted with the layout and production of the final draft and Nguyen Truong Son assisted with research at IEBR.

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Cal Snyder organized several successful field projects to Viet Nam and was always available for assistance at the American Museum. I am particularly grateful to Dr. Guy Musser for providing insights on Viet Nam rodents, and Dr. John Wahlert for commenting on several manuscripts. John Wahlert also taught me how to draw rodent skulls.

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The hospitality and friendship of many residents of Viet Nam encouraged my work but I cannot thank them all here. Most of all I thank my wife Sakiko and daughter Sakura for tolerating my absence during fieldwork and marathon work weeks at the American Museum.

Finally, it seems appropriate to note here that an excellent guide to the rodents of Viet Nam was recently published in Vietnamese by Dr. Cao Van Sung and Mr. Nguyen Minh Tam MSc. I am a newcomer to the study of Viet Nam rodents, whereas the collective experience of the aforementioned Viet Nam rodent experts is more than I can ever hope to achieve. This being said, the present work is not intended to supercede this previous work, but rather aims to complement it.

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INTRODUCTION

Rodents are important agricultural pests, seed dispersers, disease vectors and sources of food for wildlife and humans. At least 60 species of rodent occur in Viet Nam; however, the differences between species are often subtle, and many are difficult to identify without the benefit of comparative specimens.

This guide is based on the study of hundreds of specimens available in the collections of the Institute for Ecology and Biological Resources (IEBR, Ha Noi) and the American Museum of Natural History (AMNH, New York) and is intended to aid the preliminary identification of species when comparative collections are not available.

This is not a field guide, nor is it a comprehensive taxonomic reference. This identification guide provides descriptions of the most trenchant characteristics useful for identifying all rodent species currently known from Viet Nam (Appendix I). Accounts are organized by genus under the following headings:

Identification. Characteristics useful for identifying Viet Nam rodent genera are described. External characteristics are presented first, followed by cranial characteristics (when relevant). For genera with only one species in Viet Nam this section also serves as the species account.

Viet Nam Species. Species occurring in Viet Nam are diagnosed. Descriptions are for Viet Nam populations, and the user is warned that populations of some species exhibit considerable morphological variation beyond the borders of Viet Nam. Approximate ranges of external measurements and weights of adult individuals are summarized from original specimen tags and field notes and/or reliable published accounts. Summary statistics of cranial measurements are provided for selected species (Appendix II). The following abbreviations are used to indicate measurements (millimeters) and weights (grams):

Head and body length (HB): tip of nose to dorsal inflection point of tail.

Tail length (T): dorsal inflection point of tail to tip of last tail vertebra.

Hind foot length (HF): heel to tip of claws.

Ear length (E): inside of ear from lower notch to outermost margin of pinna.

Weight (Wt.):Whole body weight of adults.

Taxonomic Notes. Taxonomic and distributional uncertainties, and areas for further research are discussed. In particular we noted differences of taxonomic opinion between the present work and three frequently referenced works covering Viet Nam rodents: Van Peenen *et al.* (1969); Cao Van Sung (1984a); and Dang *et al.* (1994). We use this section to mention systematic revisions and other publications containing more detailed taxonomic information.

Conservation Status. For the majority of Viet Nam rodents conservation status is unknown. The CITES and IUCN status are stated where applicable.

Generalized distribution maps are provided at either the genus or species level. We did not include smaller islands in our range maps, but the faunistic composition of some of the coastal islands of Viet Nam was recently discussed by Kuznetsov (2000). Skull illustrations are provided for most genera. These give the user a simplified view of the overall size and shape of the skull as well as some of the more trenchant cranial characters; however, these cannot substitute for comparisons with series of actual specimens.

Specimens are crucial to the study of rodents, yet many species are under-represented in zoological collections. This is particularly true for collections in Viet Nam, where these resources are in the greatest demand. For this reason a section covering specimen collection, preparation, and basic collections management techniques is provided.

Order Rodentia

Rodents are distinguished by the single pair of ever-growing, chisel-like upper and lower incisor teeth at the front of the mouth. The incisors are used for gnawing and enable rodents to gain access to a wide range of hard and otherwise inaccessible foods. Gnawing maintains a chisel edge at the tips of the incisors because the anterior side of each incisor is covered with hard enamel that wears down more slowly than the softer dentine behind it.

Inside the mouth are the cheekteeth, which are used for chewing. The cheekteeth consist of molars, and in some genera, premolars. The cheekteeth are separated from the incisors by a long gap, the diastema, which allows maximum use of the incisors in manipulating food. The diastema is present because rodents lack canine teeth and at least the first two premolars typically found in mammals. In many species the inner surfaces of the cheeks can be brought together across the diastema in order to close off the inside the mouth when the incisors are in use.

The two basic functions of rodent teeth, gnawing and chewing, cannot be performed at the same time because, when the cheek teeth are in position for grinding, the incisors do not meet. The highly movable lower jaw must therefore be pulled forward in its channel-like articular fossa to achieve gnawing. The story of the evolution of rodents is very much that of how the skull and jaw musculature adapted to achieve both effective gnawing and chewing.

Sciurognathi and Hystricognathi

Rodents can be divided into two major kinds based on the morphology of the lower jaw: Sciurognathi and Hystricognathi. In sciurognathous rodents the angular process of the mandible is ventral to the incisor alveolus and body of the mandible, whereas in hystricognathous rodents the angular process is lateral to the incisor alveolus and body of the mandible. Sciurognathous rodents include all members of the Families Sciuridae and Muridae. Hystricognathous rodents include all members of the Family Hystricidae.

The angular process of the jaw functions as the attachment point for the large masseter muscle, which is used both to pull the lower jaw up to occlude lower with upper molars for chewing, and to protrude the lower jaw so that lower incisors meet the upper

incisors for gnawing. The masseter muscle is divided into lateral parts that arise on the lateral side of the zygomatic arch and medial parts that arise on the medial side of the arch. Sciurognathous and hystricognathous rodents can be further divided into three morphological groups based on how the masseter attaches to the rostrum of the skull: sciuromorph (squirrel-like); myomorph (mouse-like); and hystricomorph (porcupine-like).

Sciuromorph, Myomorph and Hystricomorph

The skulls of sciuromorphs have a small infraorbital foramen through which no part of the masseter muscle passes. The anterior part of the lateral masseter muscle extends forward over the infraorbital foramen to attach to the side of the rostrum.

The skulls of myomorphs are similar to sciuromorphs in that a portion of the lateral masseter also extends forward to attach on an extended zygomatic plate or on the dorsal part of the rostrum, but they differ in having a slightly larger infraorbital foramen through which a portion of the medial masseter muscle passes to attach on the rostrum.

The skulls of hystricomorphs have very large infraorbital foramen through which part of the *medial* masseter passes to attach on the rostrum.

“Sciuromorph”, “myomorph” and “hystricomorph” describe convenient anatomical groupings within the two major rodent kinds (Sciurognath and Hystricognath). In Viet Nam these three morphological groups are represented by members of three rodent families: Sciuridae (sciuromorph), Muridae (myomorph), and Hystricidae (hystricomorph).

Key to Families and Diagnosis of Subfamilies[1] (SKINS)

1a. Most of body covered with quills	Family Hystricidae
1b. Body without quills	2
2a. Tail bushy, covered with long hairs	Family Sciuridae
(Diurnal squirrels without gliding membranes	Subfamily Sciurinae)
(Nocturnal squirrels with gliding membranes	Subfamily Pteromyinae)
2b. Tail not covered with long hairs	Family Muridae
(Tail measures more than one-third of head and body	Subfamily Murinae)
(Tail measures one-third or less of head and body	Subfamily Rhizomyinae)

Key to Families and Diagnosis of Subfamilies[1] (SKULLS)

1a. Skull with large infraorbital foramina (fig. 1a)	Family Hystricidae
1b. Skull with small infraorbital foramina (fig. 1b)	2
2a. Skull with postorbital processes (fig. 2a)	Family Sciuridae
(Squamosal foramina large (except *Ratufa*) (fig. 3a)	Subfamily Sciurinae)
(Squamosal foramina minute (fig. 3b)	Subfamily Pteromyinae)
2b. Skull without postorbital processes (fig. 2b)	Family Muridae
(Incisors not pro-odont (fig. 4a)	Subfamily Murinae)
(Incisors pro-odont (fig. 4b)	Subfamily Rhizomyinae)

[1] Excludes the Murid subfamilies Platacanthomyinae and Arvicolinae, which are represented in Viet Nam by two species restricted to a few mountain tops in northern Viet Nam.

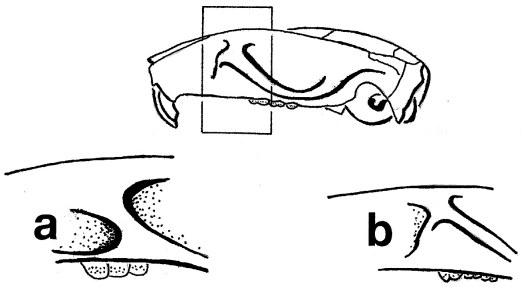


Figure 1. Infraorbital foramina large (a) or small (b).

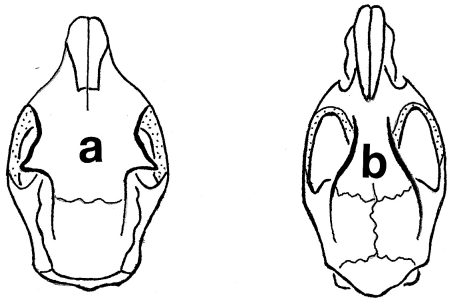


Figure 2. Postorbital process present (a) or absent (b).

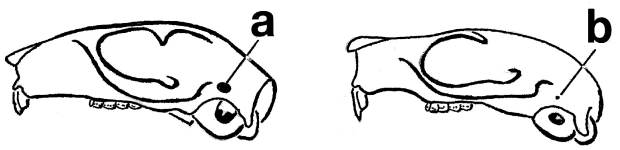


Figure 3. Squamosal foramina large (a) or minute (b).

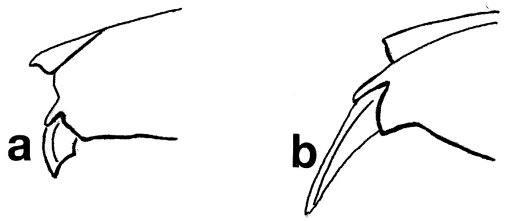


Figure 4. Incisors not pro-odont (a) or pro-odont (b).

Family Sciuridae

Squirrels have a bushy tail, a large rounded head and large eyes. The forefeet have four long toes with sharp claws and a short thumb with a small nail. The hind feet have five long toes with sharp claws. The skull is domed; infraorbital foramen very small; postorbital processes present; incisive foramina usually short in length and considerably anterior to the cheek teeth; jugal in contact with lacrimal bone; cheek teeth rooted and with prominent cusps; last premolar minute or absent; tibia and fibula not fully fused. There are two subfamilies: 1) the Sciurinae (diurnal squirrels without a gliding membrane). 2) the Pteromyinae (nocturnal squirrels with a gliding membrane extending along each flank between the fore- and hind-limbs). "Tree shrews" (*Tupaia* sp.) superficially resemble squirrels, but do not have enlarged chisel-like incisors (among other differences).

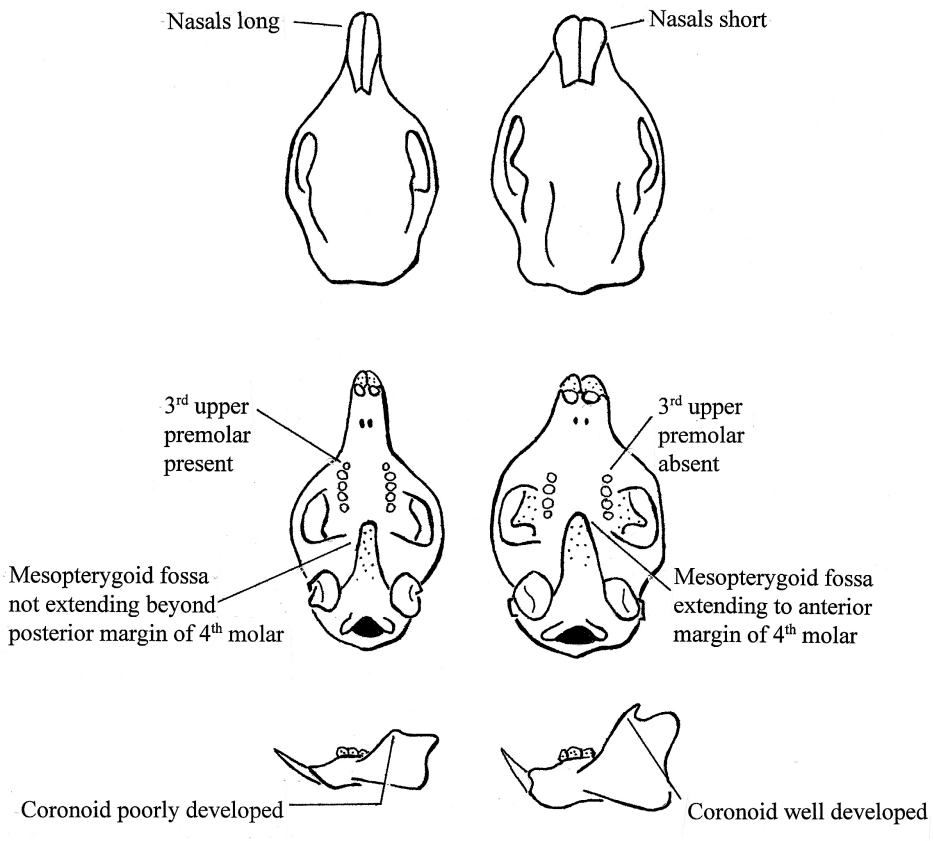


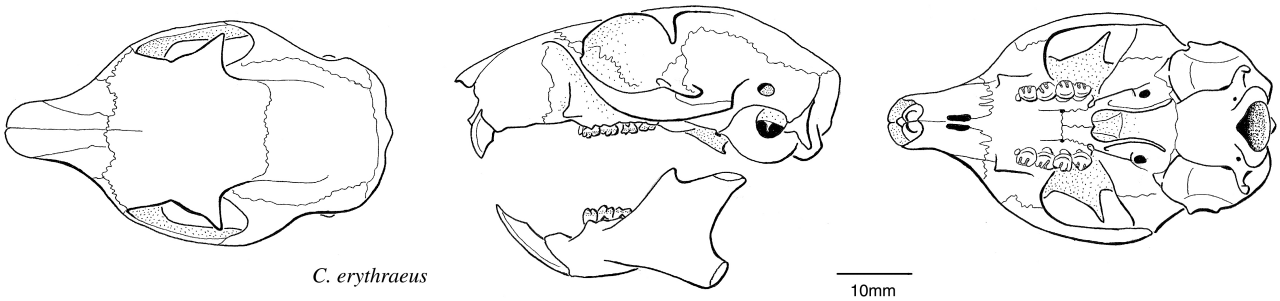
Figure 5. Cranial characters (Sciurinae).

TABLE 1. Differential Diagnosis of Diurnal Squirrels (Sciurinae) of Viet Nam

Genus	**External Description**	**Mammae**	**Nasal Bones** (fig. 5)	**3rd upper premolar** (fig. 5)	**Posterior margin of bony palate** (fig. 5)	**Coronoid process of mandible** (fig. 5)
Callosciurus	medium sized (HB 187-230), without dorsal stripes, tail about as long as head and body (T 160-267)	2 pairs	short	present	level with posterior margin of 4th molar	well developed
Dremomys	medium sized (HB 196-228), without dorsal stripes, tail shorter than head and body (T 125-165), underside of tail red	3 pairs	long	present	level with posterior margin of 4th molar	well developed
Menetes	medium sized (HB153-184) with two light stripes on each side of body, tail shorter than head and body (T 139-167).	3 pairs	long	present	level with posterior margin of 4th molar	poorly developed
Ratufa	large sized (HB 362-470), black, without dorsal stripes, tail longer than head and body (T 85-110)	3 pairs	short	absent	level with posterior margin of 3rd molar	well developed
Tamiops	small sized (HB 95-164), with dorsal stripes, tail about as long as head and body (T 75-122)	3 pairs	short	present	level with posterior margin of 4th molar	well developed

Callosciurus

Identification: Medium-sized squirrels without dorsal stripes. Tail about as long as length of head and body. Females of species occurring in Viet Nam have only two pairs of mammae (Moore and Tate 1965 p. 100). Skull: nasals short, not exceeding the least interorbital breadth; minute third upper premolar present; posterior margin of bony palate level with posterior margin of 4th molars; coronoid process of mandible well developed. Species can be distinguished by bacula morphology (Corbet and Hill 1992). Occurs in lowland and montane forests.

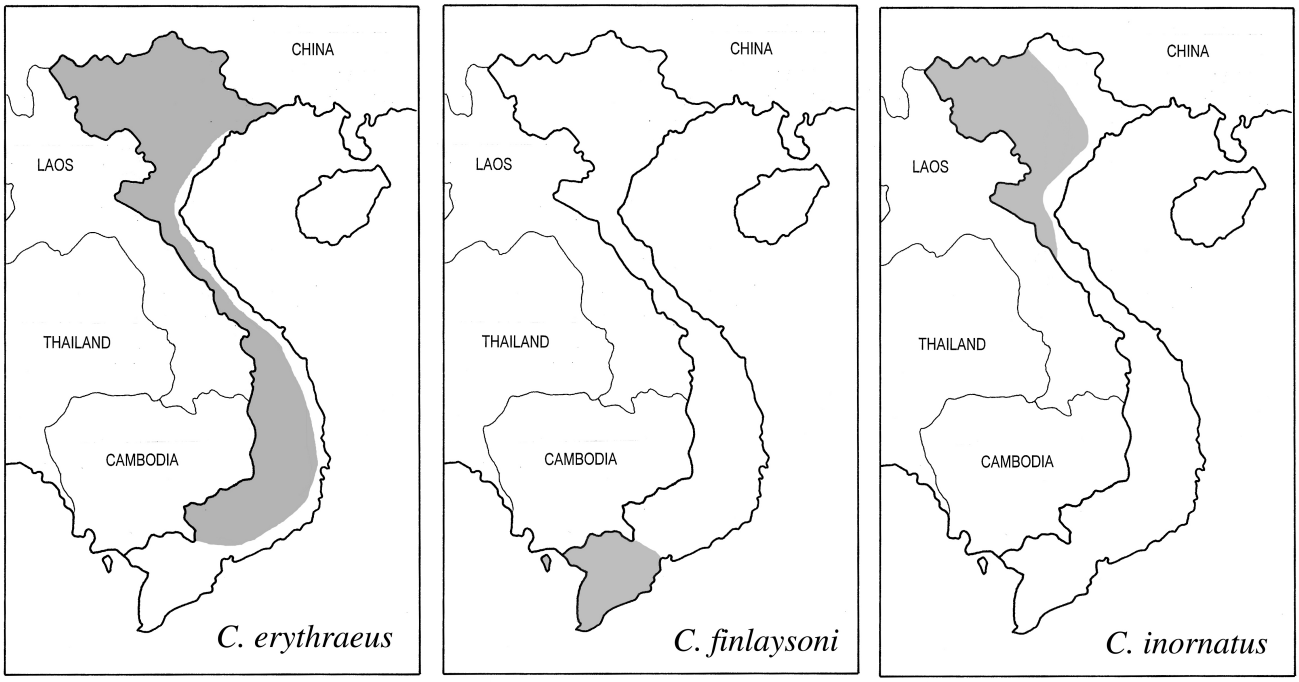


Viet Nam Species:

C. erythraeus - (HB 205-230, T 210-267, HF 54-58, E 22, Wt. 270-350). Dorsum grizzled olivaceous-brown, lacks flank stripes although individuals from southern Viet Nam may have a pale patch on each thigh. Bushy tail colored as dorsum both above and below, sometimes black toward the tip. Ventrum pale red (southern Viet Nam) to deep reddish brown (northern Viet Nam), individual hairs of ventrum usually solid red, not banded. Baculum long and thin. Specimens from northern Viet Nam (*Callosciurus erythraeus hendeei*) are darker, with black hands and feet. Specimens from southern Viet Nam (*Callosciurus erythraeus flavimanus*) are lighter, with more orange colored hands, feet, ears and face. Duckworth *et al.* (1994) reported this species from mountains, foothills and adjacent lowland areas but considered it rare in extensive lowland areas.

C. finlaysonii - (HB 200-230, T 160-210, HF 40-49). An extremely variable form ranging from all white to all red to all black with many combinations in between. Dorsum usually dark reddish-brown with admixtures of greyish-white. Ventrum usually orange-red. Tail usually greyish-white. Baculum long and thin. In Viet Nam the species is known from the extreme southern tip of the mainland and the islands of Phu Quoc and Con Son. Duckworth *et al.* (1994) reported this species from forest and scrub, mainly along the plains of wide lowland rivers.

C. inornatus - (HB 187-226, T 191-224, HF 45-49). Dorsum grizzled olivaceous-brown, lacks flank stripes. Bushy tail colored as dorsum both above and below, often black toward the tip. Ventrum grey, individual hairs banded dark and light grey. Baculum short and robust. In Laos, Duckworth *et al.* (1994) reported this species from scrub, degraded evergreen forest and pristine evergreen forest.



Taxonomic Notes:

1) *Callosciurus flavimanus* is often recognized as a distinct species (Dang *et al.*,(1994); Cao Van Sung (1984a); Van Peenen *et al.* (1969); Moore and Tate (1965)). However, we follow Corbet and Hill (1992) in including *flavimanus* as a southern form of *C. erythraeus.* We (DPL & NTS) examined a large series of *C. erythraeus* in the IEBR Zooligical Museum, and these showed a gradual intergradation between the northern dark-handed form (*hendeei*) and the southern pale-handed form (*flavimanus*).

2) Ellerman and Morrison-Scott (1951) included *inornatus* (northern Viet Nam and Laos) as a subspecies of *C. pygerythrus*, but Moore and Tate (1965 p. 211-212) discussed the specific distinctness of *inornatus*. Cao (1984a) apparently followed Ellerman and Morrison-Scott (1951) in reporting specimens of *C. pygerythrus* from Viet Nam but, following Moore and Tate (1965), these should be recognized as a distinct species: *C. inornatus*. We examined specimens collected by Cao Van Sung in the IEBR Zoological Museum and they are clearly *C. inornatus* as diagnosed in the account above. *C. pygerythrus* occurs from central Nepal to northern Myanmar and is distinguished from *C. inornatus* by its red ventrum and seasonally characteristic light patch on the side of each hip. Dang *et al.* (1994) reported *C. inornatus* Grey, 1867 from Viet Nam but unfortunately included *pygerythrus* Geoffroy, 1831 (an older name) as a junior synonym. We follow Moore and Tate (1965) in recognizing *C. inornatus* as a distinct species, and treat all records of *C. pygerythrus* from Viet Nam as representing *C. inornatus*.

3) Dang *et al.* (1994) reported *Callosciurus notatus* from Viet Nam, but the species is not otherwise reported from north of the isthmus of Kra (10° N latitude). The most distinguishing feature of *C. notatus* is the presence of a pale brown stripe superimposed on a black stripe along each flank. See the taxonomic note of *Sundasciurus hippurus* for a comment on the Viet Nam record of *C. notatus*.

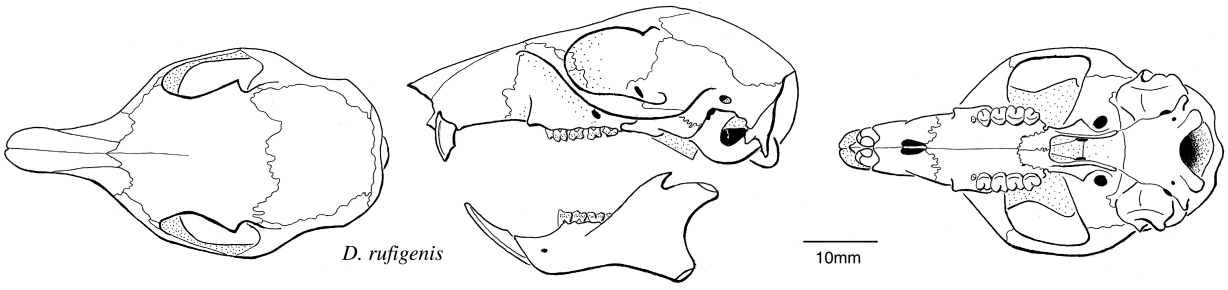
4) Cao Van Sung (1984a) and Dang *et al.* (1994) reported *Callosciurus nigrovittatus*

from Viet Nam but Corbet and Hill (1992 p.292) remarked that the single record seemed improbable as the species is not otherwise known from north of the isthmus of Kra. The most distinguishing feature of *C. nigrovittatus* is the presence of a pale orange stripe superimposed on a bold black stripe along each flank. See the taxonomic note of *Sundasciurus hippurus* for a comment on the Viet Nam record of *C. nigrovittatus*.

Conservation Status: *Callosciurus pygerythrus* IUCN Red List Vulnerable. As recognized by IUCN, *C. pygerythrus* apparently includes *inornatus*, but see taxonomic note #2 for why these two taxa should be recognized as distinct species. Duckworth *et al.* (1994) suggested that *C. inornatus* should perhaps be assigned to the IUCN status category "Insufficiently Known."

Dremomys

Identification: Medium-sized squirrels without dorsal stripes. Tail equal to or somewhat shorter than length of head and body, ventral side of tail with red markings. There is a small, sometimes inconspicuous pale patch behind each ear. Females with three pairs of mammae. Skull: nasals long, roughly equal to, or slightly longer than the least interorbital breadth; minute third upper premolar present; posterior margin of bony palate level with posterior margin of 4th molars; coronoid process of mandible well developed. Most often observed on the ground, although they sometimes climb through dense vegetation and up small trees to about six meters. Moore and Tate (1965) reported *D. rufigenis* "only in the mountains and hills" but Duckworth *et al.* (1999) reported the species as common in many lowland areas.

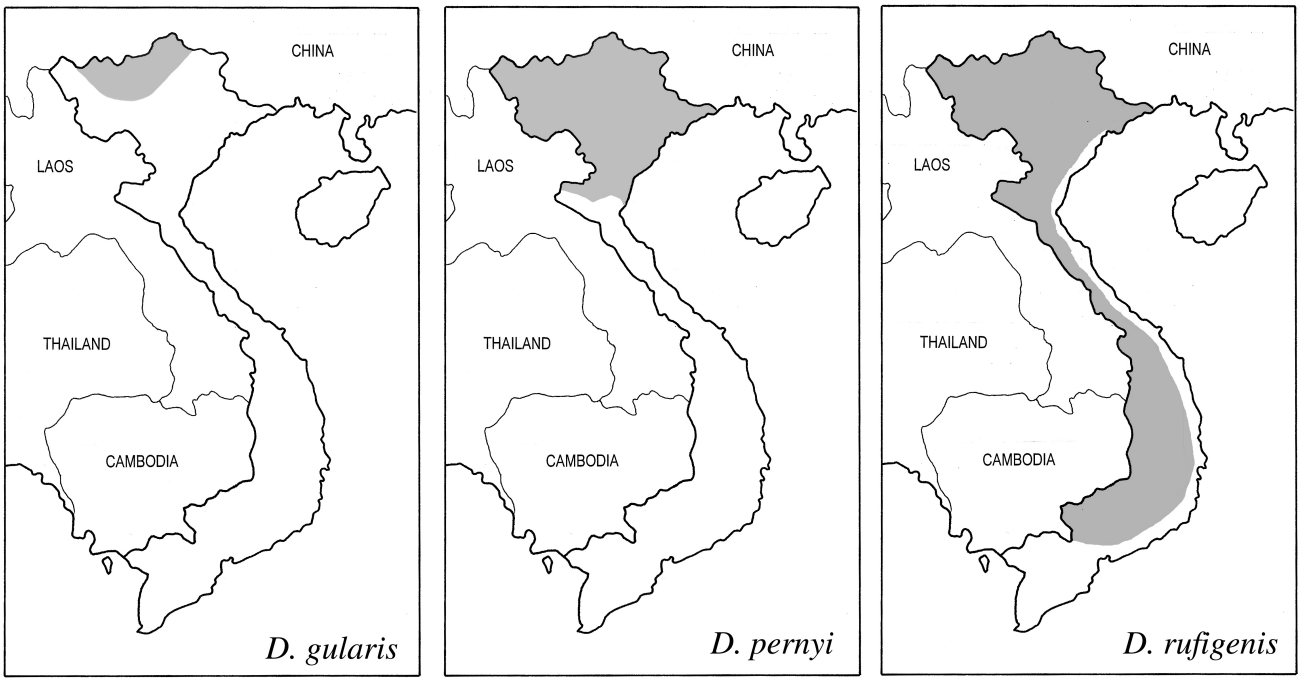


Viet Nam Species:

D. gularis - (HB 187-230, T 145-180, HF 42-50, E 23-26) Dorsum grizzled olivaceous-brown. Ventrum dark grey. Entire ventral side of tail red. Extensive red marks on the throat and neck.

D. pernyi - Dorsum grizzled olivaceous brown. Ventrum greyish white. Red coloration on underside of tail limited to anal region. Lacks red marks on cheeks and throat.

D. rufigenis - (HB 196-228, T 125-165, HF 52-54, E 24-25, Wt. 275-335). Dorsum grizzled olivaceous-brown. Ventrum greyish white. Entire ventral side of tail red. Red marks on cheeks, but not throat.

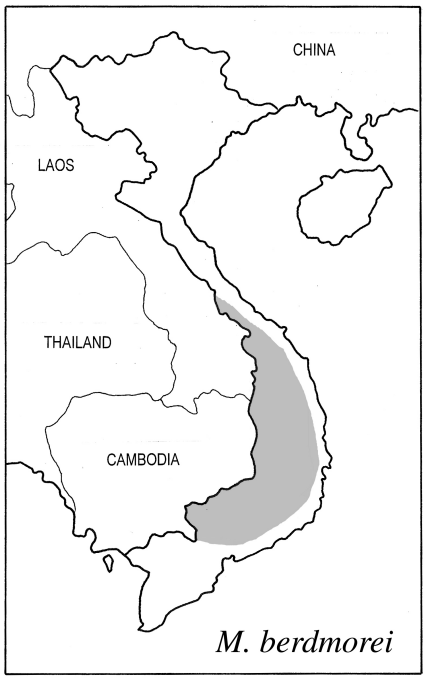


Taxonomic Notes:

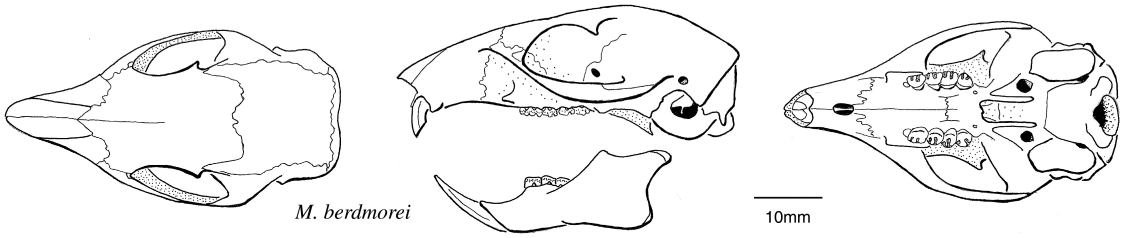
1) We follow Corbet and Hill (1992) in recognizing *D. gularis* as a distinct species.

2) Dao Van Tien (1969) discussed the existence of two subspecies of *Dremomys pernyi* in Viet Nam and provided measurements, a distribution map, and detailed descriptions for each. Briefly, *D. pernyi pernyi* occurs in Cao Bang Province, and has red patches behind the ears and a yellowish-white ventrum, whereas *D. pernyi flavior* occurs throughout the remainder of the species' range in Viet Nam, and has white patches behind the ears and a greyish-white ventrum.

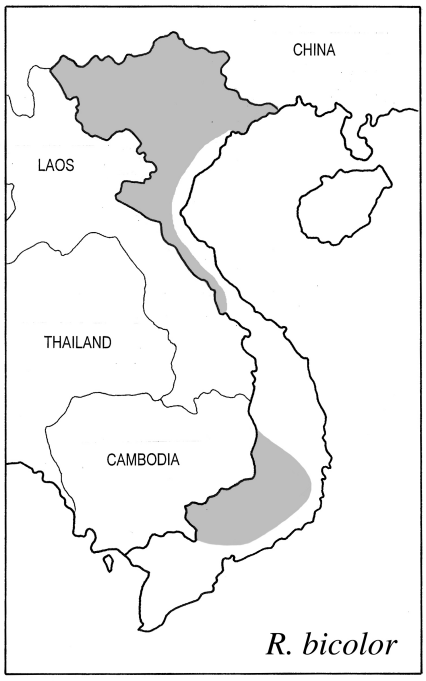
Menetes berdmorei



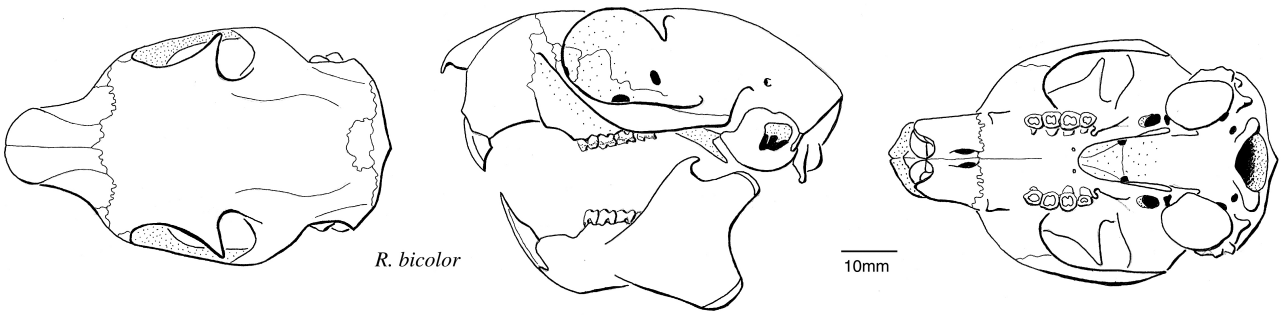
Identification: (HB 153-184, T 139-167, HF 40-44, E 17-20). Medium-sized ground squirrels with longitudinal dorsal stripes. Dorsum grizzled yellow-brown to red-brown, with two pale stripes on each side of the body; two dark stripes are sometimes present dorsal to the two paler stripes. A single mid-dorsal stripe is sometimes present. Ventrum buffy white. Individuals from wet localities tend to have a redder dorsum whereas individuals from drier localities tend to have more muted markings (Moore and Tate 1965 p. 296). Females with three pairs of mammae. Skull: nasals long, roughly equal to or slightly longer than the least interorbital breadth; minute third upper premolar present; posterior margin of bony palate level with posterior margin of 4th molars; coronoid process of mandible poorly developed. Common along forest edges and cultivated areas; uncommon in deep forest. Occurs up to about 1,200 m. Behaviorally similar to *Tupaia*.



Ratufa bicolor



Identification: (HB 362-470, T 455-510, HF 85-110). A very large, long-tailed squirrel of the forest canopy. Dorsum solid black (or very dark brown), cheeks and sides of neck boldly contrasting pale yellowish white with distinctive dark patches below each eye. Ventrum pale yellow. Tail entirely black. Females have three pairs of mammae (two abdominal, one inguinal). Skull: nasals short, much shorter than least interorbital breadth; third upper premolar absent; posterior margin of bony palate level with posterior margin of 3rd molars; coronoid process of mandible well developed. *Ratufa* are much larger than any other species of diurnal squirrel in Viet Nam. *Callosciurus* are smaller and sit with their tail bent up over their heads, whereas *Ratufa* perches with its tail down. Giant squirrels infrequently descend to the ground and are most often seen making agile leaps through tree tops. They sometimes occur in pairs. Reported to occur up to 1,400 m in Laos (Duckworth *et al.*, 1994).



Taxonomic Notes:

1) Two subspecies occur on the mainland of Viet Nam. The northern subspecies (*Ratufa bicolor hainana*) is distinguished by a solid black or dark brown dorsal pelage, ear tufts, pale cheek patches that extend above the anterior-most corners of the eyes and the absence of pale flash marks on the dorsal surfaces of the forelimbs. The southern subspecies (*Ratufa bicolor smithi*) is distinguished by a dorsal pelage with pale tipped hairs, the absence of ear tufts, white cheek patches that do not extend above the anterior-most corners of the eyes and the presence of pale flash marks on the forelimbs.

The two mainland subspecies are separated by a hiatus in central Viet Nam. A third Viet Nam subspecies: *Ratufa bicolor condorensis* is restricted to Condore Island.

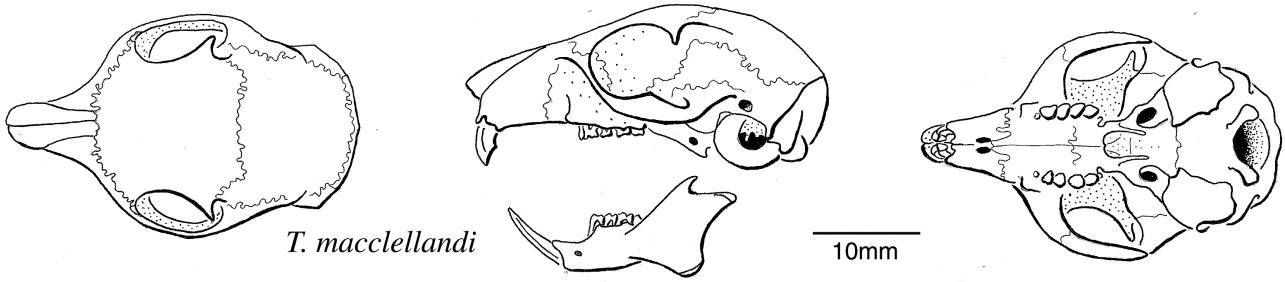
2) Corbet and Hill (1992 p.279) suggested that the single record of *Ratufa affinis* from southern Viet Nam (Cao Van Sung, 1984a) is probably based on a misidentified *R. bicolor smithi.* Compared to *Ratufa bicolor smithi*, *Ratufa affinis* is smaller with pale brown upper parts, dark brown hands and feet and with pale marks on the thighs. See the taxonomic note of *Sundasciurus hippurus* for a comment on the Viet Nam record of *R. affinis*

3) See Dao Van Tien (1967) for a taxonomic and geographic review of *Ratufa bicolor*.

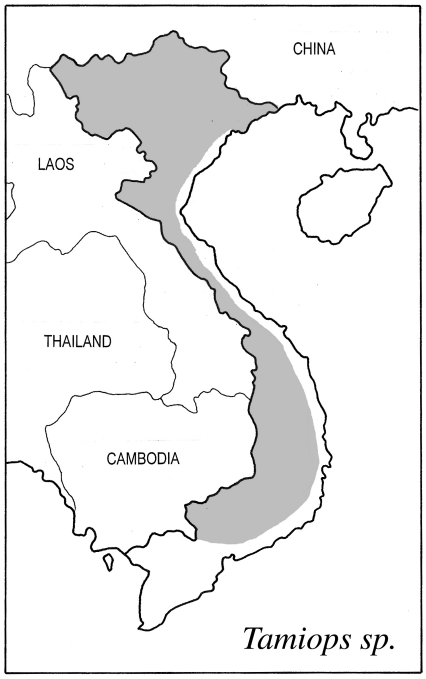
Conservation Status: CITES Appendix 2.

Tamiops

Identification: Small squirrels with longitudinal dorsal stripes. Dorsum grizzled tawny yellow-brown with four variably discernable light stripes separated by darker stripes. Face with a prominent light stripe beneath the eye which may or may not be continuous with the lateral light stripe of the back. Ears with tufts of white hairs. Tail equal to or slightly shorter than length of head and body. Ventrum grey-based buff. Seasonal pelage changes occur but are incompletely understood. Females with 3 pairs of mammae (one pectoral two inguinal). Skull: nasals short, much shorter than least interorbital breadth; minute third upper premolar present; posterior margin of bony palate level with posterior margin of 4th molars; coronoid process of mandible well developed. Occur in all types of forests, secondary growth and villages from sea level to the highest elevations in Viet Nam.



Viet Nam Species:



Tamiops sp.

Tamiops macclellandi - (HB 95-128, T 75-122, HF 23-31, E 11-15). Medial pair of light stripes faint, lateral pair bright. Pale stripe under eye continuous with lateral light stripe on back. Pelage short. Reported from the Red River valley of northern Viet Nam.

Tamiops maritimus - (HB 102-139, T 80-115, HF 25-30, E 9-17). Medial pair of light stripes faint, lateral pair more distinct but not as bright as in *T. macclellandi*; pale stripe under eye not continuous with outer light stripe on back. Pelage short. Reported from lower elevations in northern Viet Nam and at higher elevations in southern Viet Nam.

Tamiops rodolphi - (HB 117-120, T 104-120, HF 28-30). All four light stripes of equal intensity. Pale stripe under eye faintly continuous with lateral light stripe. The black middorsal stripe is sometimes divided into two thin mid-dorsal lines. Pelage short. Reported from southern Viet Nam.

Tamiops swinhoei - (HB 115-164, T 80-116, HF 31). Similar to *T. maritimus* but all four light stripes faint. Pale stripe under eye not continuous with barely discernable lateral light stripe of back. Usually larger than the other three species, with a long fluffy pelage. Occurs at high altitudes in extreme northern Viet Nam.

Taxonomic Note: See Dao (1970) for a detailed review of the forms of *Tamiops* occurring in Viet Nam. Dao (1970) treated all of the above forms as subspecies of *macclellandi*, but later (Dang *et al.*, 1994) followed Moore and Tate (1965) in recognizing each as a distinct species. We follow Corbert and Hill (1992) in regarding most of the above four species as difficult to define and therefore tentative. Only *T. rodolphei* is readily distinguished by its four especially bright dorsal stripes. Collections of specimens should be made during both wet and dry seasons in order to demonstrate seasonal pelage changes. When seasonal differences are well established, species limits can be more accurately defined.

Conservation Status: Duckworth *et al.* (1994) considered *T. rodolphei* of conservation concern on account of its limited range.

Sundasciurus hippurus

Identification: A medium-sized squirrel. Head, shoulders, and fore-limbs grey; back rufous; tail black (*S. hippurus hippurus*), or dark brown with a red tip (*S. hippurus ornatus*).

Taxonomic Note: Cao and Dao (1990) discuss two specimens of this species. One was described as a new subspecies: *Sundasciurus hippurus ornatus* Cao and Dao (1990). The

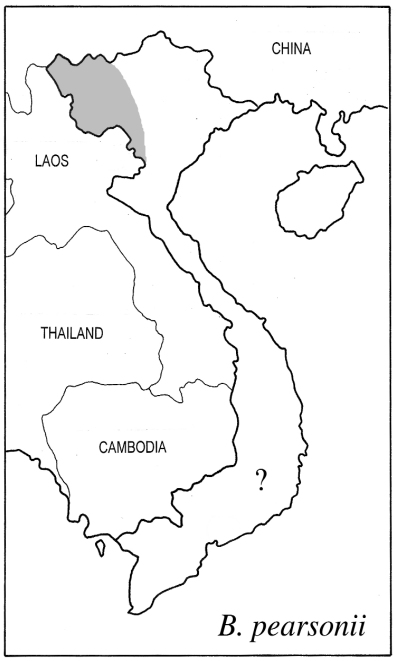
type and only known specimen of this subspecies was collected in Minh Hai Prov., in the extreme southernmost part of Viet Nam, and consists of a mounted skin with no skull. The other specimen was indentified as *Sundasciurus hippurus hippurus* and consists of a mounted specimen collected at "Saigon" in 1870. We question the validity of the "Saigon" records of *Sundasciurus hippurus*, as well as those of *Callosciurus nigrovittatus*, *Callosciurus notatus*, and *Ratufa affinis*. These species are not otherwise known from north of the Isthmus of Kra, and the Viet Nam records are all based on a small number of specimens (including taxidermy mounts) in the Hungarian Natural History Museum that were apparently procured in "Saigon". We do not necessarily doubt the identifications of the Hungarian Museum specimens, rather we question the authenticity of the locality "Saigon". These specimens may have been obtained from animal dealers in Saigon who procured the animals from further south.

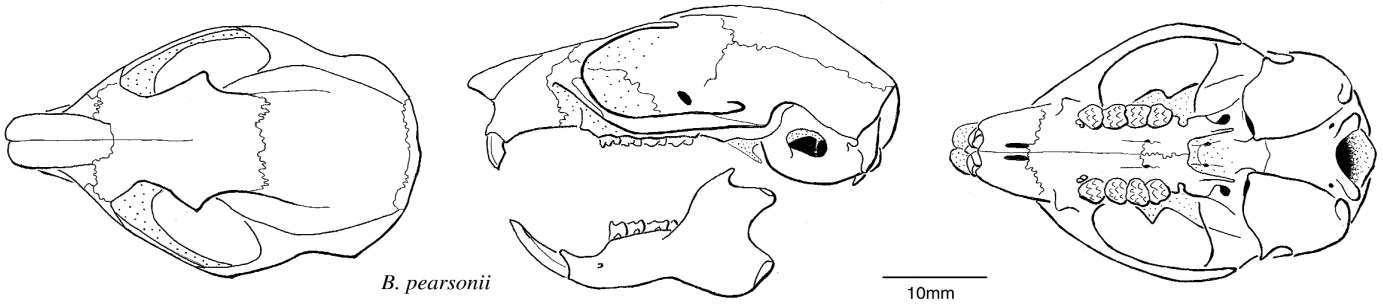
Conservation Status: This species probably extirpated from Viet Nam. See Dao and Cao (1990)

Subfamily Pteromyinae - Nocturnal Gliding Squirrels

Belomys pearsonii

Identification: (HB 165-212, T 143-167, HF 36-42, E 18-22). Medium sized gliding squirrels with soft dense fur and a tuft of long fine black hairs at the base of each ear. Hairs of dorsum dark brown with light brown tips; gliding membrane with white fringe. Cheeks grey. Ventrum creamy white. Tail bushy, not flattened and feather-like. Dorsal surfaces of hands and feet dark brown. Females with three pairs of mammae. Inhabits montane forests. Arboreal.



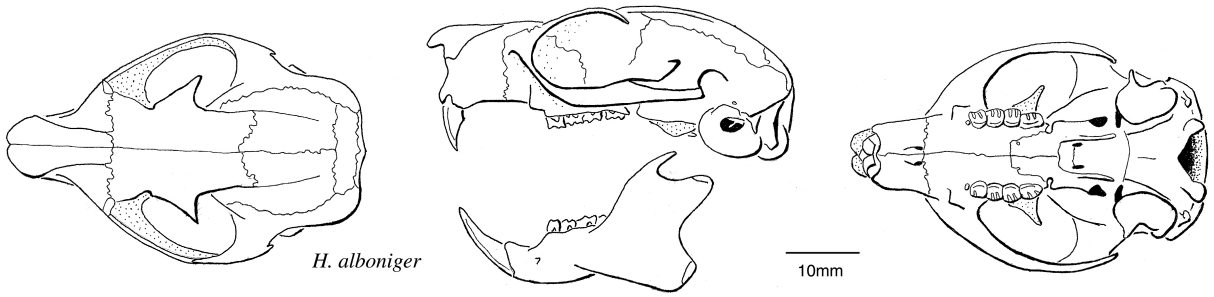


Taxonomic Note: Corbet and Hill (1992) synonomized *Belomys* with *Trogopterus* but we recognize *Belomys* as a distinct genus.

Conservation Status: IUCN Red List Lower Risk, near threatened.

Hylopetes

Identification: Small- to medium-sized gliding squirrels with soft dense fur. Tail hairs extending laterally such that the tail appears feather-like. Females with three pairs of mammae. Arboreal.

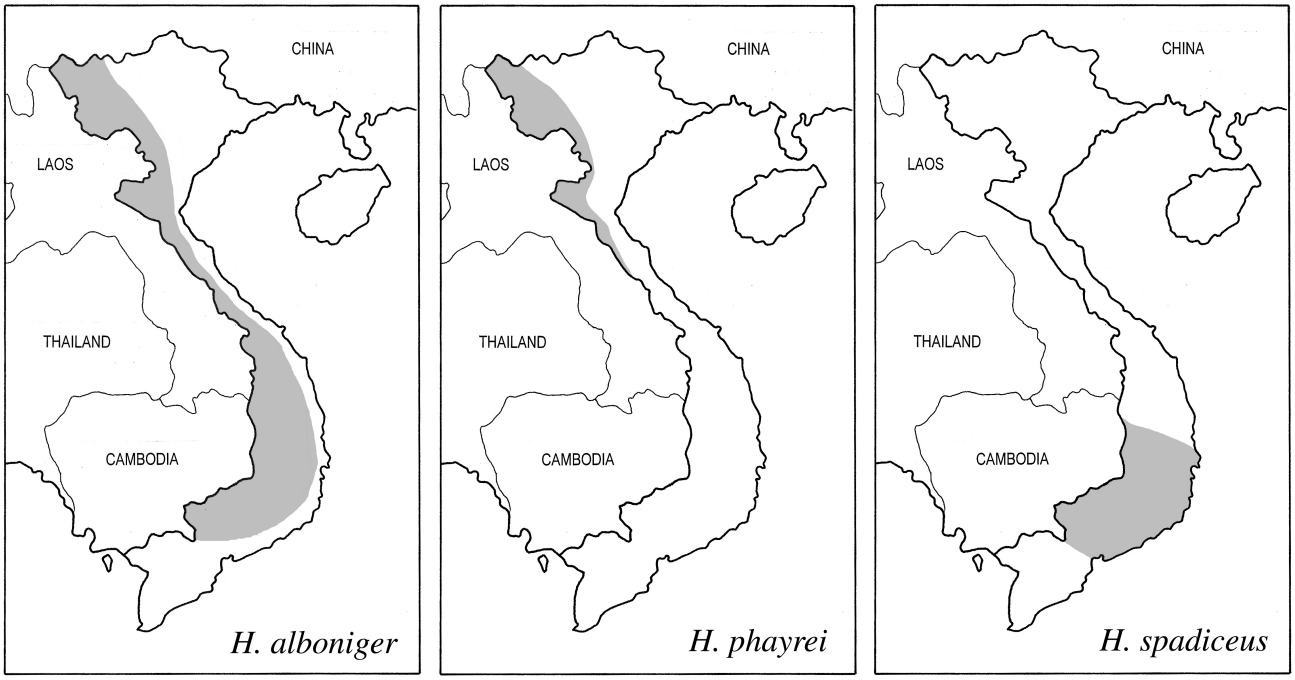


Viet Nam Species:

Hylopetes alboniger - (HB 175-247, T 172-227, HF 39-45, E 30-36). Medium-sized gliding squirrels. Hairs of dorsum dark brown with light brown tips; gliding membrane with white fringe. Cheeks grey. Eyes encircled in black rings. Ventrum grey with creamy white patches. Ventral surface of tail slightly flattened, dorsal surface of tail only slightly flattened. Dorsal surfaces of hands and feet dark brown, digits of hind feet white. Baculum a curved rod with a distal crest, which spirals from the left side at the distal tip of the rod to the ventral surface at mid-shaft, length 11-13 mm (Thorington *et al.,* 1996).

Hylopetes phayrei - (HB 144-167, T 128-157, HF 31-34, E 23-25). Medium-sized gliding squirrels, (but smaller than *H. alboniger*). Hairs of dorsum dark greyish brown with light brown tips; gliding membrane with white fringe. Cheeks white. Ventrum creamy white. Both dorsal and ventral surfaces of tail flattened and feather-like.

Hylopetes spadiceus - (HB119-137, T 92-118, HF 19-29). Small-sized gliding squirrels. Hairs of dorsum dark grey with orange tips. Head and cheeks orange. Ventrum greyish white. Tail orange at base. *H. spadiceus* closely resembles *H. lepidus* but is distinguished by its larger size, larger bullae, and brighter coloration. In *H. spadiceus* the orange coloration of the head tends to extend on to the cheeks beneath the eye while *H. lepidus* has mostly grey cheeks. Baculum a short straight rod only 1 mm in length (Thorington *et al.,* 1996).

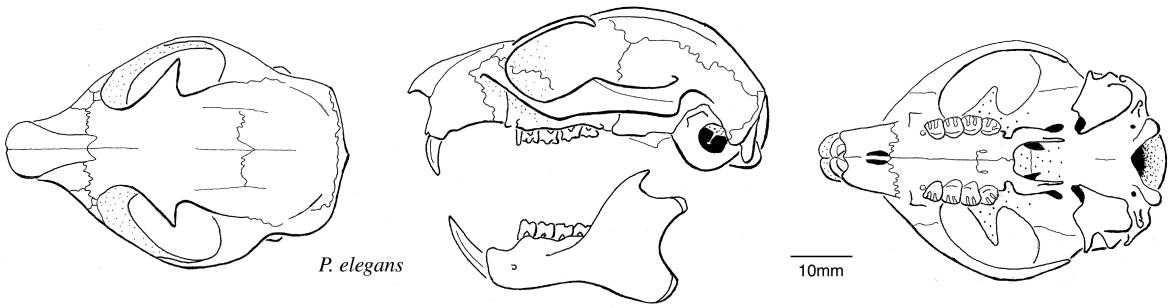


Taxonomic Note: Cao Van Sung (1984a) reported a single specimen of *lepidus* from Viet Nam (Phu Quoc Island); however, Thorington *et al.* (1996) restricted the name *lepidus* (with a type locality in Java) to animals from Borneo and Java, and recognized *H. platyurus* as the species from north of the Isthmus of Kra. It is not clear if the specimen reported by Cao Van Sung (1984a) represents typical *platyurus* or *lepidus* (sensu Thorington, *et al.* 1996).

Status: *H. alboniger* IUCN Red List Endangered.

Petaurista

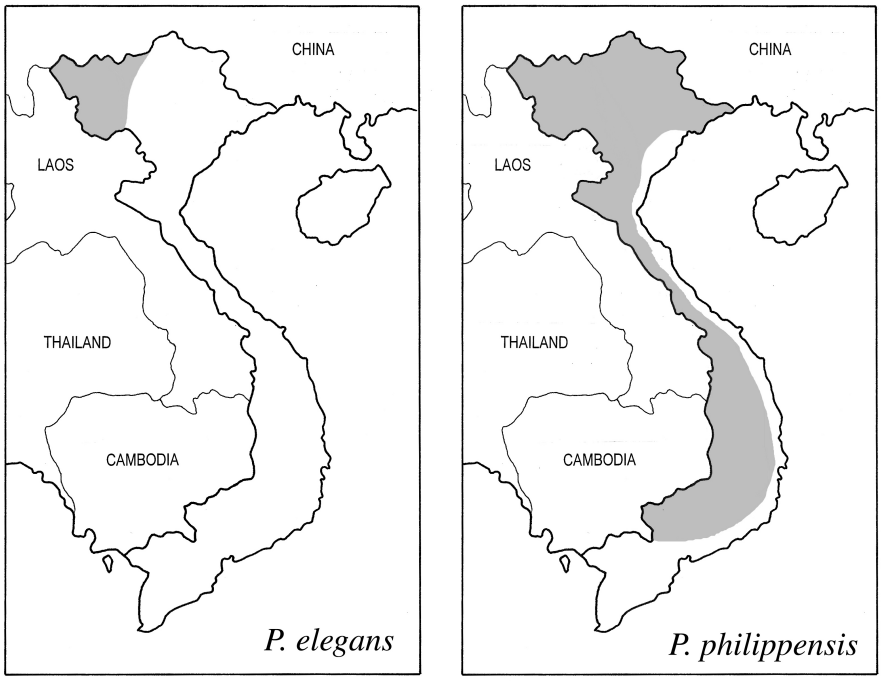
Identification: Large gliding squirrels with shor,t broad heads, long, soft fur and long, bushy tails that are not flattened and feather-like. Tail equal to or longer than combined length of head and body. Females with three pairs of mammae. Usually occupies the forest canopy. Gliding is the predominant mode of long-distance locomotion and glides of over 100 meters have been recorded (Ando and Shiraishi, 1993). The tail usually hangs below the animal during feeding, or folded over the back when the animal has all 4 limbs available for support (Muul and Liat, 1978).



Viet Nam Species:

Petaurista elegans - (HB 326-365, T 310-364, HF 52-66, E 32-38). Large gliding squirrels (but smaller than *P. philippensis*). Hairs of dorsum brown-grey, tipped with orange; cheeks and top of head grey. Dorsal surface of gliding membrane, ears, hands and feet orange. Ventrum yellowish white, underside of gliding membrane tinged with orange.

Petaurista philippensis - (HB 405-540, T 400-691, HF 72-87, E 40-47). Very large gliding squirrels. Hairs of dorsum dark reddish brown tipped with white. Both dorsal and ventral surface of gliding membrane, hands, feet, and tail dark reddish brown, almost black; hairs without white tips. Eyes encircled by dark brown hairs, ears dark brown with bright orange tips. Ventrum sparsely furred, red brown in color, throat and chin brown.



Taxonomic Note: Askins (1977), Cao Van Sung (1984a), Dang *et al.* (1994), and Van Peenen *et al.* (1969) included *philippensis* as a subspecies *P. petaurista,* but we follow Corbet and Hill (1992) in recognizing *P. philippensis* as a species that is distinct from *P. petaurista*. *Petaurista petaurista* (sensu Corbet and Hill, 1992) does not occur in Viet Nam.

Conservation Status: Muul and Liat (1978) have reported that *Petaurista* has been able to survive where primary forest has been almost completely cut over, provided scattered fruit trees are left within gliding distance.

Family Muridae

Viet Nam Murids include typical mice and rats, bamboo rats, the Chapa tree mouse and Pere David's vole. The forefeet have four toes and a short thumb; the hind feet have five toes and usually six plantar tubercles, but these may be reduced or lost in some species. Skull with medium-sized infraorbital foramina that are large dorsally for the transmission of muscle, and narrow ventrally for passage of nerves and blood; post-orbital processes absent; the maxillary root of the zygomatic arch is flattened to form a "zygomatic plate" at the anterior root of the zygomatic arch for muscle attachment. The jugal is not in contact with the lacrimal bone. Last premolar absent in Viet Nam species.

Viet Nam species belong to four subfamilies: 1) the Murinae, or typical rats and mice, are characterized especially by the pattern of the upper molars in which the cusps form three longitudinal rows; 2) the Rhizomyinae, or "bamboo rats," are adapted for burrowing and have short limbs, large feet with strong claws, small ears and eyes and short tails. The skulls of bamboo rats are flat in profile, with wide zygomatic arches and nasals that do not project beyond the incisors; 3) the Platacanthomyinae, or tree mice are characterized by two enlarged posterior palatine foramina between the first upper molars. In Viet Nam this subspecies is represented by a single rarely collected species (*Typhlomys chapensis*) restricted to a few mountain tops in northernmost Viet Nam; 4) the Arvicolinae are likewise represented in Viet Nam by a single species of vole (*Eothenomys melanogaster*) restricted to higher elevations in extreme northern Viet Nam.

TABLE 2a. Differential Diagnosis of Rats

(See Musser 1981, fig. 18 for illustrations of cranial character states)

Character	***Rattus***	***Bandicota***	***Berylamys***
Size	medium (HB 115-233)	medium-large (HB 145-328)	large (HB 200-285)
Upper parts	grey-brown, without spines	shaggy grey-brown, without spines	grey-brown, without spines
Under parts	grey, not sharply demarcated from upper parts	grey, not sharply demarcated from upper parts	white, sharply demarcated from upper parts
Tail	monocolored or bicolored	monocolored brown	usually monocolored brown, sometimes paler below
Mammae	4-6 pairs	6 pairs	4-5 pairs
Squamosal roots of zygoma (fig. 6)	low on braincase	low on braincase	low on braincase
Incisive foramina (fig. 6)	extend past front margin of molars	extend to level of first molars	extend to level of first molars
Posterior Margin of Palate (fig. 6)	posterior to last molars	posterior to last molars	level with last upper molar
Pterygoid fossa (fig 6)	perforated by foramina	not perforated by foramina	not perforated by foramina
Mesopterygoid fossa (fig. 6)	narrower than palate	narrower than palate	narrower than palate
Bullae (fig. 6)	relatively large	relatively large	relatively large
Coronoid of denary (fig. 6)	well developed	well developed	well developed

TABLE 2b. Differential Diagnosis of Rats

(See Musser 1981, fig. 18 for illustrations of cranial character states)

Character	***Leopoldamys***	***Maxomys***	***Niviventer***
Size	large (HB 214-262)	medium (HB 146-227)	small (HB 120-189)
Upper parts	red-brown to grey-brown, sleek, not spiny.	warm orange, spiny.	red-brown to grey-brown, spiny.
Under parts	white or cream, sharply demarcated from upper parts.	white or cream, sharply demarcated from upper parts.	white or cream, sharply demarcated from upper parts.
Tail	not sharply bicolored.	brown above, pale below often all white toward tip.	often brown above, pale below.
Mammae	4 pairs	4 pairs	4 pairs
Sqamosal roots of zygoma (fig. 6)	high on braincase	high on braincase	high on braincase
Incisive foramina (fig. 6)	oblong, ending before the first molars	short and wide, ending well in front of the first molars	oblong, ending before the first molars
Posterior Margin of Palate (fig. 6)	at level of last molars	at level of last molars	at level of last molars
Pterygoid fossa (fig. 6)	not perforated by foramina	not perforated by foramina	not perforated by foramina
Mesopterygoid fossa (fig. 6)	as wide as palate	as wide as palate	as wide as palate
Bullae (fig. 6)	relatively small	relatively small	relatively small
Coronoid of denary (fig. 6)	small	small	small

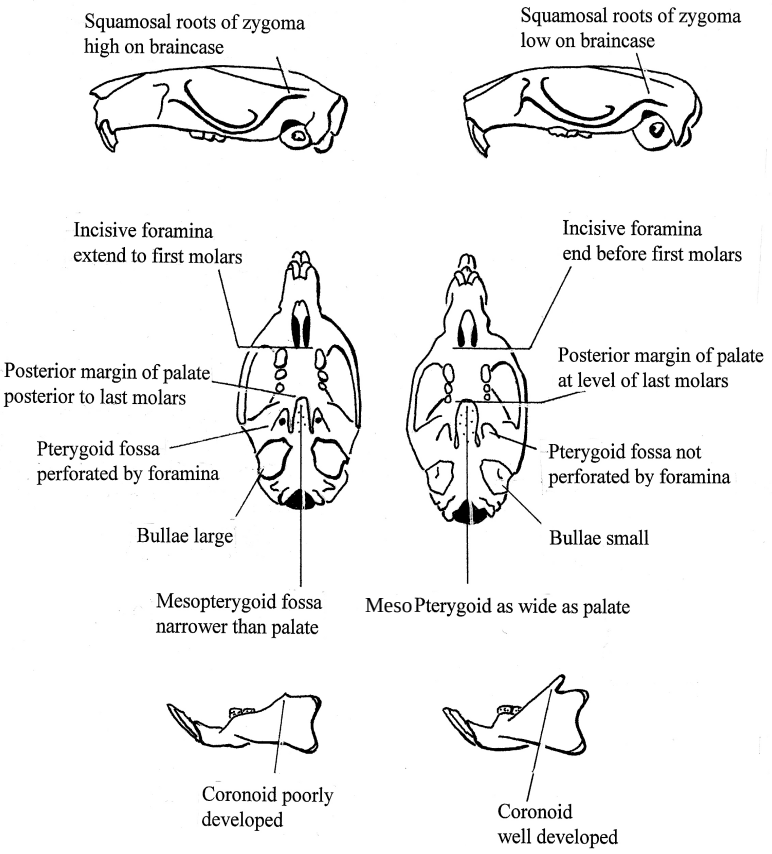
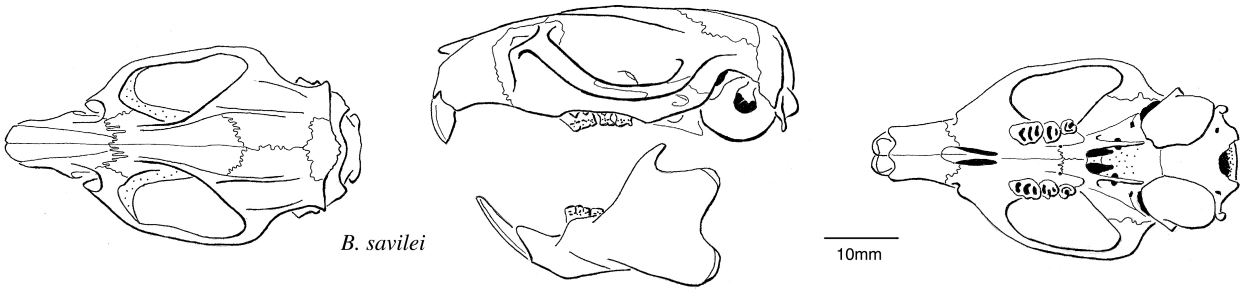


Figure 6. Cranial Characters (Murinae)

Bandicota

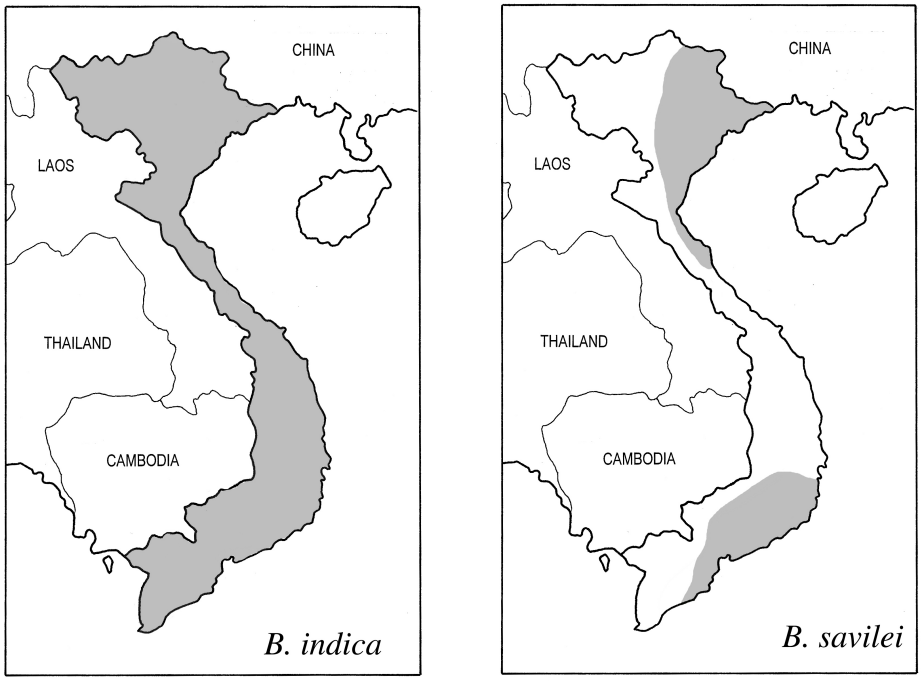
Identification: Medium to large sized rats. Dorsum drab grey-brown to almost black, pelage coarse but not spiny. Ventrum somewhat paler than dorsum; not sharply demarcated from dorsum. Tail mono-colored brown to almost black. *Bandicota savilei* may be confused with *Rattus norvegicus* externally but can be distinguished by its wider upper incisors (greater than 4mm across both insisors). Females with 6 pairs of mammae (1 pectoral pair, 2 postaxillary pairs, 1 abdominal pair, 2 inguinal pairs). Skull: squamosal roots of zygoma set low on braincase; incisive foramina extend to the level of the first molars; posterior margin of palate posterior to last molars; pterygoid fossa not perforated by foramina; mesopterygoid fossa narrower than palate; bullae relatively large; coronoid process of dentary well developed. These fierce rats occur in tall grass, agricultural areas and other modified habitats where they dig complex burrows. A larger and a smaller species occur in Viet Nam.



Viet Nam Species:

Bandicota indica - (HB 188-328; T 190-280; HF 46-60; E 25-33). Larger than *B. savilei*. Dorsum blackish brown with long dark guard hairs on midline of back; pelage coarser than *B. savilei*. Ventrum dark brownish grey, not sharply demarcated from dorsum. Hind foot relatively long.

Bandicota savilei - (HB 145-225; T 75-178; HF 33-40; E 20-30). Smaller than *B. indica*. Dorsum brown to brown grey; pelage softer than *B. indica*. Ventrum pale grey, not sharply demarcated from dorsum. Hind foot relatively short.



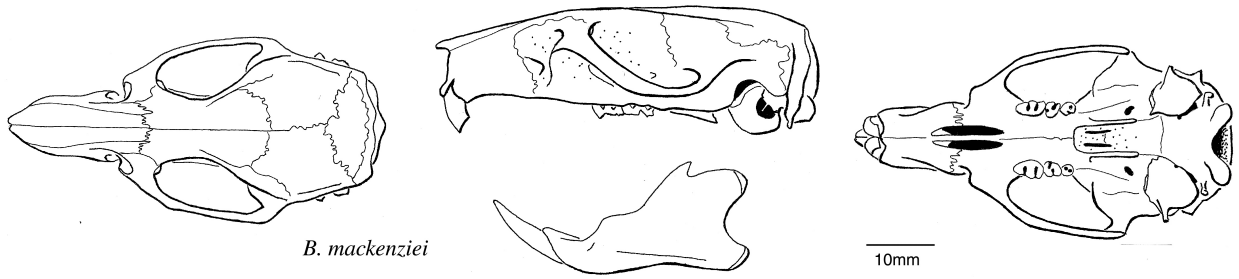
Taxonomic Notes:

1) Specimens of *B. bengalensis* reported from Viet Nam (Van Peenen *et al.*, 1969) are *B. savilei*. *Bandicota savilei* was long included in synonomy with *B. indica*, and the name *bengalensis* was consequentially applied to any smaller-bodied *Bandicota.* However, *Bandicota savilei* is a valid species that is distinct from *B. bengalensis*. See Marshall (1977a p. 426) and Musser and Brothers (1994 p. 10). *Bandicota savilei* occurs in Viet Nam but *Bandicota bengalensis* is apparently restricted to localities west of Laos. Two taxa described as subspecies of *B. bengalensis* (*hichensis* Dao, 1961 and *giarainensis* Dao and Cao, 1990) are appropriately associated with *B. savilei*.

2) See Musser and Brothers (1994) for a review of the genus *Bandicota*. The range map illustrated in Musser and Brothers (1994) shows only localities from which the authors examined specimens, and, although no records of *B. savilei* were indicated from northern Viet Nam, the holotype of *hichensis* Dao, 1961 is from northern Viet Nam and the authors state that *B. indica* and *B. savilei* most certainly occur in suitable habitats in northern Viet Nam. We follow Dang *et al.*(1994) in mapping *Bandicota savilei* from both northern and southern Viet Nam.

Berylmys

Identification: Large rats. Dorsum steel-grey, fades to grey-brown in old specimens, pelage smooth and stiff but not spiny. Ventrum pure white, sharply demarcated from dorsum. Skull: squamosal roots of zygoma set low on braincase; incisive foramina ending anterior to, or level with first molars; incisors white or pale orange; posterior margin of bony palate usually anterior to last upper molar; pterygoid fossa not perforated by foramina; mesopterogoid fossa narrower than palate; bullae relatively large; coronoid process of dentary well developed. Terrestrial. Occur in forest, scrub and sometimes around the margins of cultivated fields. *Berylmys* occur in low densities throughout their range and are infrequently captured.



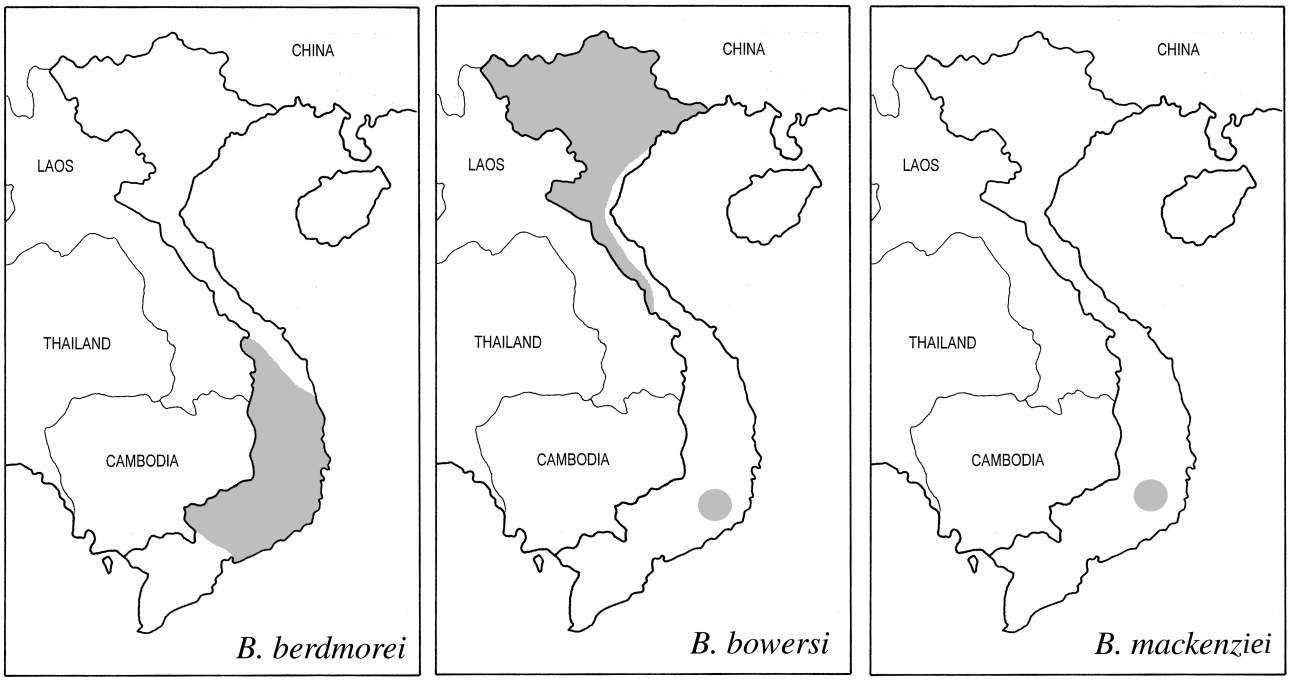
Viet Nam Species:

Berylmys berdmorei - (HB 199-208, T 149-192, HF 37-46, E 20-27, Wt. 177-300). Dorsum grey-brown. Ventrum white, sharply demarcated from dorsum. Tail shorter than length of head and body, dorsal surface dark brown, ventral surface paler brown but not sharply demarcated. Dorsal surfaces of hands and feet greyish white. Females with 5 pairs of mammae (1 pectoral pair, 2 postaxillary pairs, 2 inguinal pairs). Occurs in swampy forests and marshes from sea level to over 1,000 m.

Berylmys bowersi - (HB 240-285, T 260-310, HF 54-57, E 30-37). Dorsum grey-brown. Ventrum white, sharply demarcated from dorsum. Tail longer than length of head and body, dorsal surface dark brown, ventral surface paler brown but not sharply demarcated, tail tip sometimes white. Dorsal surface of hands and feet brown with white digits. Females with 4 pairs of mammae (1 pectoral pair, 1 postaxillary pair, 2 inguinal pairs).

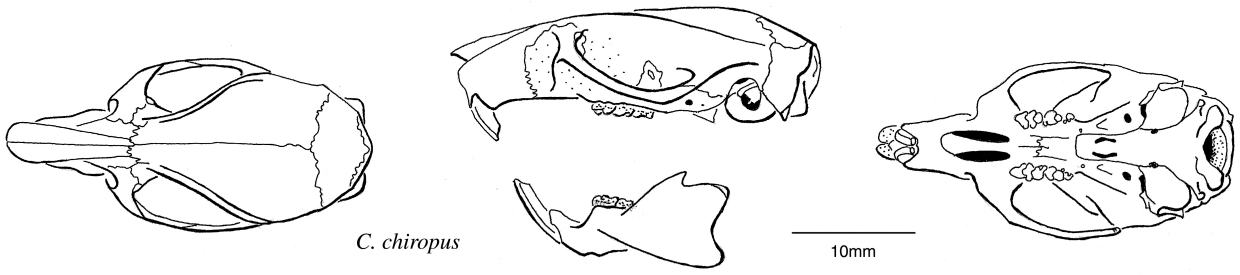
*Berylmys mackenz*iei - (HB 230-232, T 254-255, HF 51-53, E 33-35). Dorsum grey-brown. Ventrum white, sharply demarcated from dorsum. Tail longer than length of head and body, dorsal surface dark brown, ventral surface paler but not sharply demarcated, tail tip sometimes white. Dorsal surfaces of hands and feet brown with white digits. Females with 5 pairs of mammae. Probably lives in forests and is associated with habitats at higher elevations.

Taxonomic Note: *Berylmys mackenz*iei was not reported from Viet Nam by Cao Van Sung (1984a), Corbet and Hill (1992), Dang *et al.* (1994), and Van Peenen *et al.* (1969). The southern Viet Nam records of *B. mackenziei* mapped here are those indicated in Musser and Newcomb (1983 p. 374).

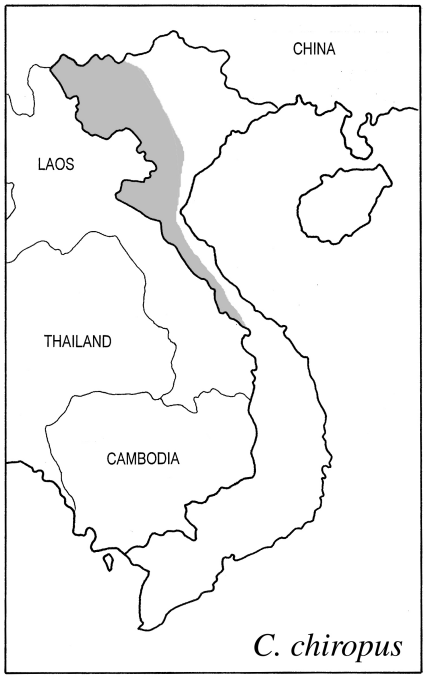


Chiromyscus chiropus

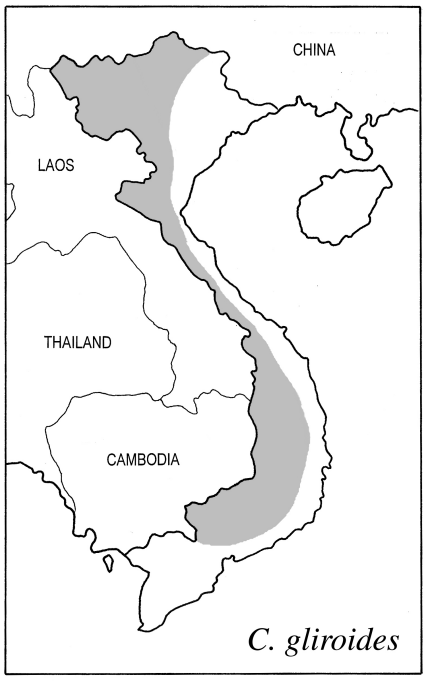
Identification: (HB 147-160, T 200-226, HF 27-29, E 19-20). Dorsum orange brown, head orange; eyes encircled in dark mask. Ventrum white, sharply demarcated from dorsum. Tail longer than length of head and body; bicolored, brown above, light brown below. Similar to *Niviventer langbianus* but differs in having a nail instead of a claw on the hallux and a skull with shelf-like postorbital and temporal ridges. Arboreal.



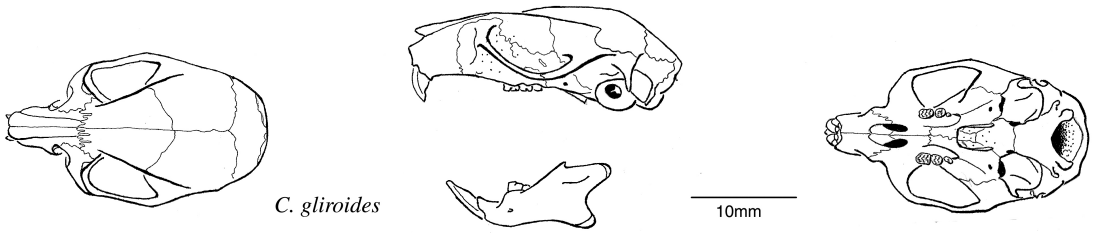
Taxonomic Note: See Musser (1981 p. 316-317) for a detailed description of the genus *Chiromyscus*. According to Musser (1981 p. 327) *Chiromyscus* and *Niviventer* are closely related, and that if it were not for the special arboreal derivations of the nails and the wide cranial ridging there would be no reason for not uniting *Chiromyscus* and *Niviventer* into one genus.



Chiropodomys gliroides



Identification: (HB 81-105, T 105-130, HF 19-21, E 15-19, Wt. 23-31). Small mice with a short rostrum, long vibrissae and large eyes that are encircled in a dark eye-mask. Pelage short and dense. Dorsum reddish brown, cheeks buffy. Ventrum white. Tail grey-brown, longer than length of head and body, not prehensile, densely covered in hairs that are short near the base of the tail and longer along the distal half and ending in a 4 to 5 mm long tuft. Tail never mottled or bicolored. Forefeet white to light brown; hind feet with a thin brown stripe extending from the ankle to the base of the digit; both fore- and hind feet are short and broad. The first digit of each forefoot is thick, stumpy, and bears a wide nail; the other digits are short and end in thick pads with thin claws. The stubby first digit of each hind foot is much shorter than the others and ends in a very large fleshy pad in which a nail is embedded; the other digits are slender and terminate in smaller pads that bear short, thin, sharp claws. Occurs in all kinds of primary and secondary tropical forests, especially where bamboo clumps, viney tangles, and strangler figs are present. Primarily arboreal, although they sometimes descend to the ground.



Taxonomic Note: See Musser (1979) for a revision of the Genus *Chiropodomys*.

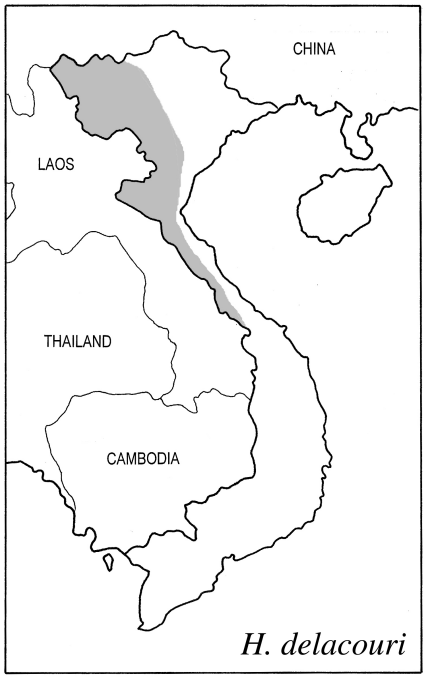
Dacnomys millardi

Identification: (HB 273, T 308, HF 55, measurements from Osgood (1932)). A large rat with a very long tail. The pelage is thick and short. Dorsum brown flecked with buff. Ventrum ranges from cream through greyish white to buffy grey. Dorsal surface of fore- and hind feet brown, each hind foot with 6 plantar pads. Females with four pairs of mammae (1 pectoral pair, 1 postaxillary pair, 2 inguinal pairs). Restricted to forested areas at higher elevations in extreme northwestern Viet Nam.

Taxonomic Note: *Dacnomys* is rarely collected in Viet Nam. See Musser (1981 p. 314-316) for a more detailed description of the genus along with skull and toothrow photographs.

Hapalomys delacouri

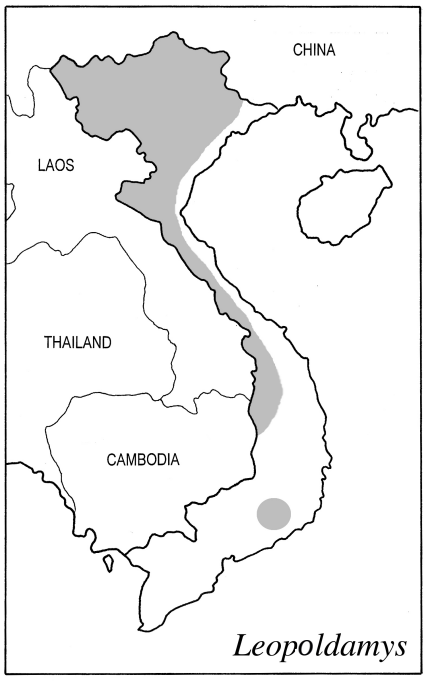
Identification: (HB 123-136, T 140-160, HF 22-24, E 14-15). Dorsum greyish brown or ochraceous brown, pelage soft and dense. Ventrum whitish. Tail longer than head and body, ending in a tuft of hairs. Ears conspicuously fringed with long vibrissae. Females with four pairs of mammae, (1 pectoral pair, 2 postaxillary pairs, 2 inguinal pairs). The hallux is fully opposable, with a nail rather than a claw. Skull: squarish, with a short rostrum. First and second lower molars with three rows of approximately equal-sized cusps. Lives in the internodes of bamboo which it enters through a round hole that it chews open. According to Medway (1964) the holes carved in bamboo by *Hapalomys* are 35 mm in diameter "ringed by a border about 1 cm wide from which the green outer skin has been stripped." The animals are excellent climbers (Medway, 1964). Occurs in tropical deciduous forests at elevations from 1,200 to 1,500 m.



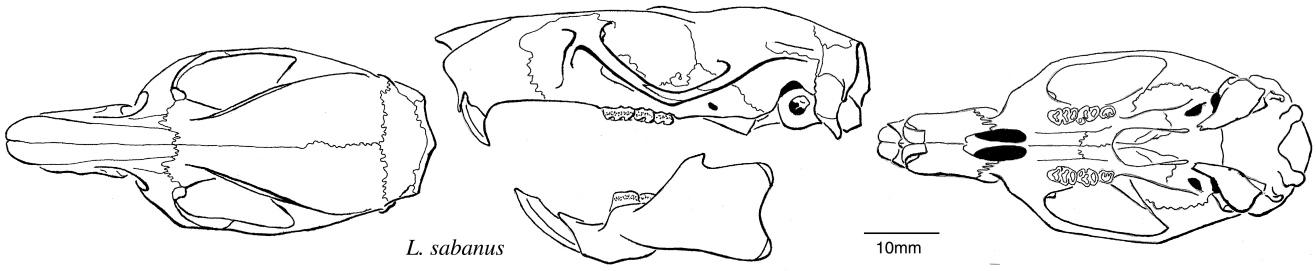
Taxonomic Note: See Musser (1972) for a review of the genus *Hapalomys*.

Conservation Status: IUCN Red List Lower Risk, near Threatened.

Leopoldamys



Identification: Large rats. Dorsum reddish brown to greyish brown. Ventrum white to creamy white, sharply demarcated from dorsum. Tail longer than combined length of head and body, not sharply bicolored, dorsal surface of tail brown, sometimes mottled brown and white towards the tip, ventral surface of tail pale brown or white. Hind foot long and slender, each with 6 plantar pads, front and hind feet with broad brown stripes on dorsal surface. Females with 4 pairs of mammae; (one pectoral pair, one postaxillary pair, and two inguinal pairs). Skull: long and narrow; squamosal roots of zygomatic arches set high on sides of braincase; incisive foramina ending before the first molars; posterior margin of bony palate at level of third upper molars; pterygoid fossa not perforated by foramina; mesopterygoid fossa as wide as palate; bullae relatively small, dentary with small coronoid process. Skull configurations similar among species (Musser 1981, fig. 15). A common terrestrial rat of lowland and montane forests.



Viet Nam Species:

Leopoldamys edwardsi - Pelage somewhat *shaggy*. Dorsum dull brown. Ventrum creamy white, sharply demarcated from dorsum. A montane evergreen forest species.

Leopoldamys sabanus - (HB 214-262, T 263-305, HF 47-51, E 28-33, Wt. 230-420). Pelage short and *sleek*, never shaggy. Dorsum warm brown. Ventrum creamy white, sharply demarcated from dorsum. Common in lowland evergreen forest and pre-montane forest to at least 1,200 m.

Taxonomic Notes:

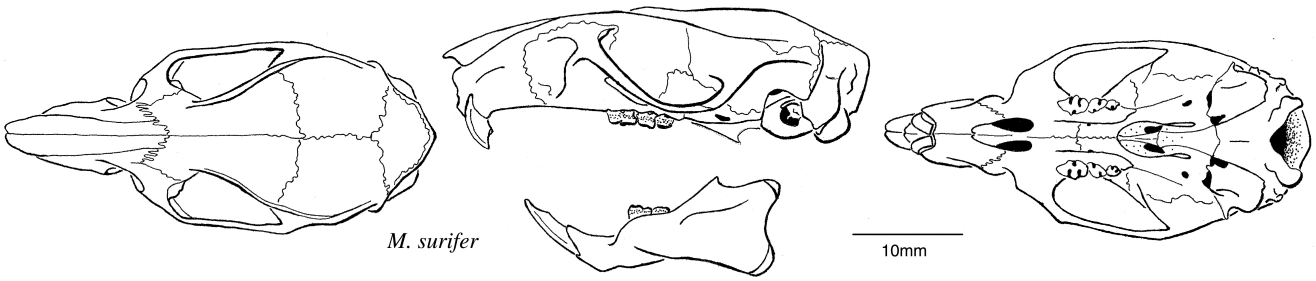
1) *Leopoldamys* requires taxonomic revision. The only morphological characters distinguishing *L. sabanus* and *L. edwardsi* seem to be size and pelage: *L. edwardsi* are

larger and tend to have a darker, coarser pelage. Musser (1981 p. 262-266) noted the existence of several cranial and pelage distinctions between populations of *L. edwardsi* from south of the Isthmus of Kra and those obtained from Northern Indochina and suggested that these two samples may represent different species. In addition, Musser (1981) noted appreciable morphological variation between samples of *L. sabanus* from north and south of the Isthmus of Kra.

2) Nguyen (1998) reported three specimens of *L. neilli* from Viet Nam, but we have not seen them. According to Marshall (1977a) *N. neilli* looks like a dwarf version of *L. edwardsi*. In Thailand, *L. neilli* occurs in limestone areas.

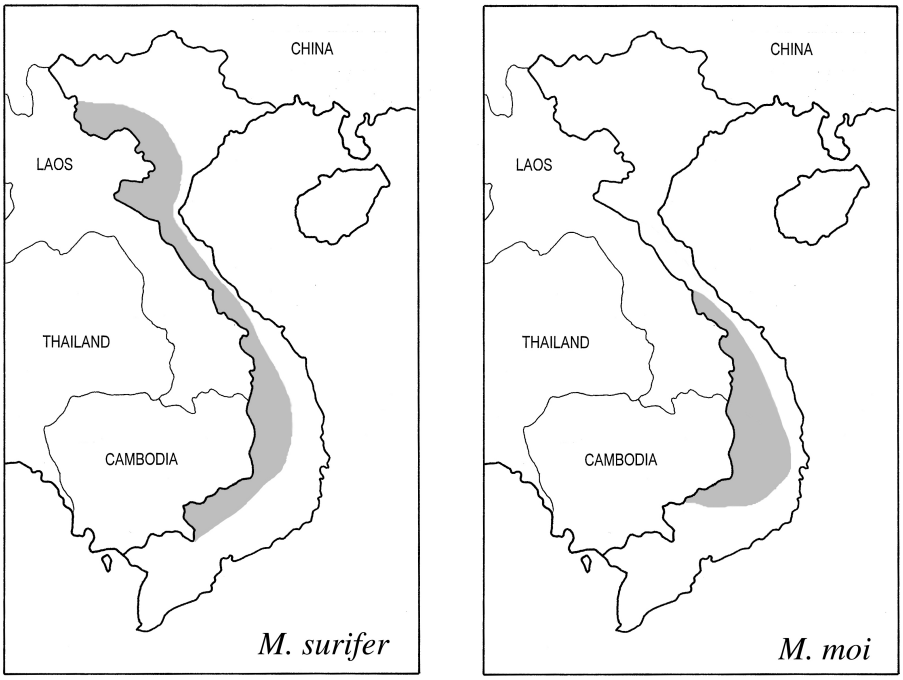
Maxomys

Identification: Medium-sized rats. Dorsum orange-brown with mixtures of black; the pelage of the more common species (*surifer*) is spiny. Ventrum white, sharply demarcated from dorsum. Tail about as long as length of head and body, bicolored, white below, brown above but becoming all white more or less half way along the length of the tail. Hind foot elongated, nearly five times as long as wide, dorsal surfaces of feet white or pale brown. Females with 4 pairs of mammae; (one pectoral pair, one postaxillary pair, and two inguinal pairs). Skull: squamosal roots of zygomatic arches set high on the side of the braincase; incisive foramina short and wide, ending well in front of the first molars; posterior margin of palate at level of posterior margin of third upper molars; pterygoid fossa not perforated by foramina; mesopterygoid fossa about as wide as palate; bullae relatively small; dentary with small coronoid process. Terrestial rats of tropical evergreen forests.



Maxomys moi - (HB 142-217, T 157-202, HF 37-44, E 22-27). Dorsal pelage dense and soft, not spiny, very bright orange. Ventrum white, sharply demarcated from dorsum. Usually five plantar pads on each hind foot, sometimes six. Compared to *M. surifer*, skull with longer incisive foramina, shorter molar toothrow and smaller teeth. First upper molar with three roots.

Maxomys surifer - (HB 155-206, T 153-208, HF 40-47, E 24-28). Dorsum orange-brown, but not nearly as bright orange as in *M. moi*. Pelage spiny. Ventrum white, sharply demarcated from dorsum. Six plantar pads on each hind foot. Compared to *M. moi,* skull with shorter incisive foramina, longer molar toothrow, and larger teeth with three or four roots on each first upper molar.



Taxonomic Notes:

1) Nguyen (1998) reported a single specimen of *M. rajah* from Viet Nam but we have not seen the specimen and the species is not otherwise known from north of the Isthmus of Kra.

2) See Musser (1979) for a review of the genus *Maxomys*.

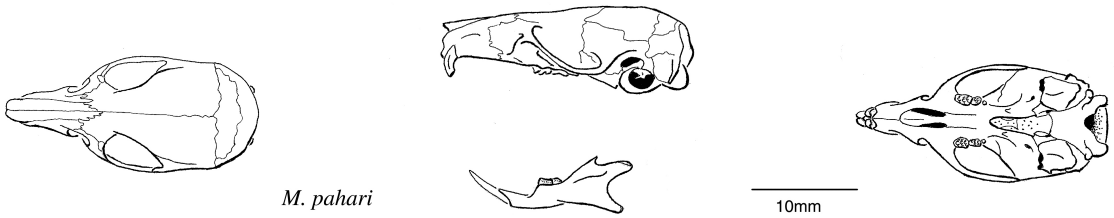
Micromys minutus

Identification: (HB 55-68, T 54-79, HF 14-16). Among the smallest of rodents. Dorsum brown. Ventrum yellowish brown. Occurs in tall grass, grain and rice fields. In Viet Nam this species is restricted to a few localities in the extreme northwest.

Conservation Status: IUCN near threatened.

Mus

Identification: Small-sized mice. Dorsum brown to dark blue grey. Ventrum white to dark grey. Tail about as long as length of head and body. All digits bear claws, hallux not opposable.



Viet Nam Species:

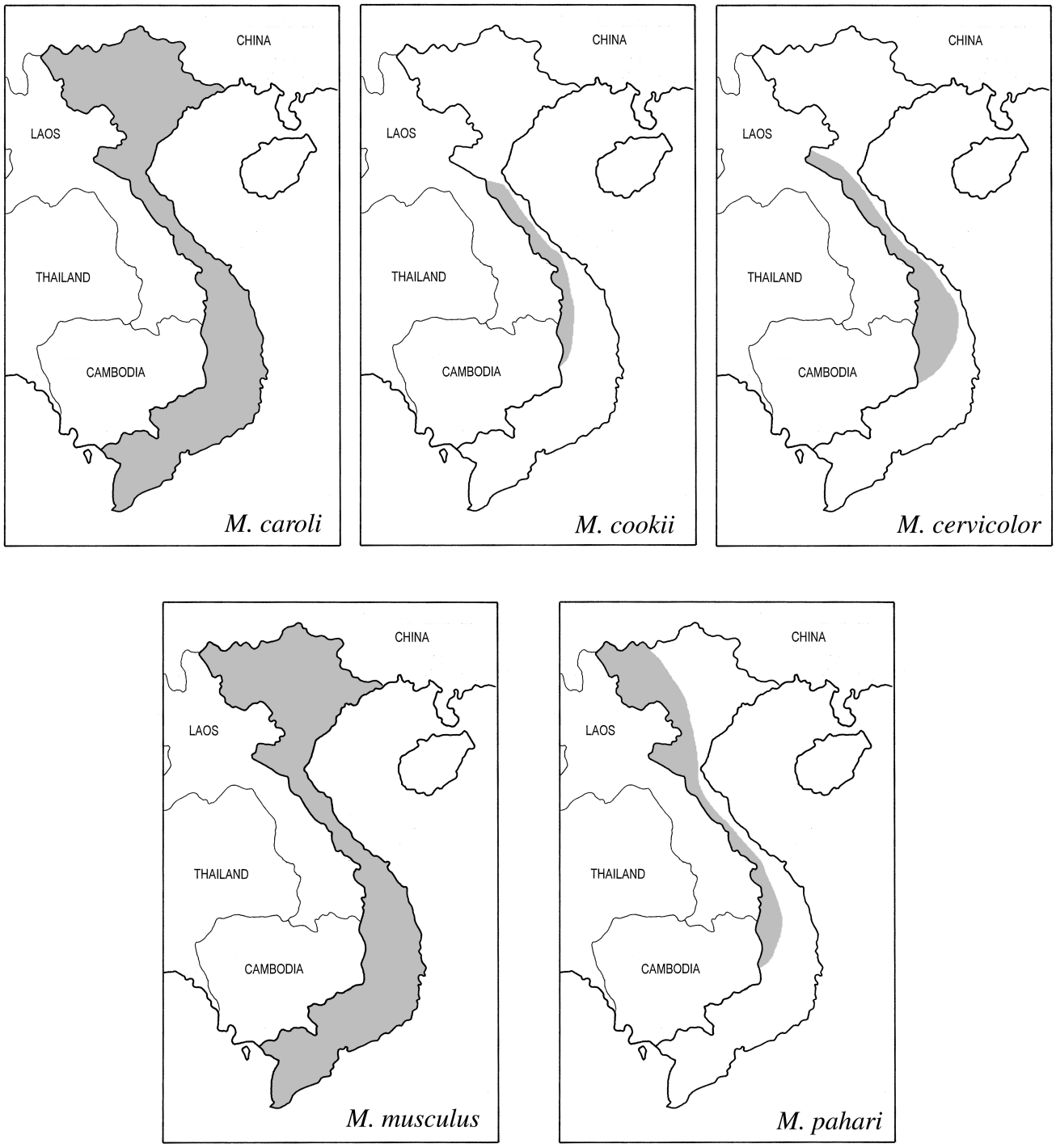
Mus caroli - (HB 76, T 78, HF 18, E 14, Wt. 12, values from Marshall (1977). Dorsum greyish brown, hairs stiff. Ventrum greyish white. Tail about as long as length of head and body, sharply bicolored black above, white below. Dorsal surface of hands and feet light brown. Upper incisors dark orange. Similar to *M. cervicolor* with which it is often sympatric but differs in having a longer sharply bicolored tail and brown feet (always white in *M. cervicolor*). Inhabits rice fields and other agricultural areas.

Mus cervicolor - (HB 83, T 58, HF 16, E 13, Wt. 15, values from Marshall (1977). Dorsum dark greyish brown. Ventrum greyish white. Tail shorter than length of head and body, bicolored brown above, pale below. Dorsal surface of hands and feet white. A rice field mouse, commonly occurs with *M. caroli.*

Mus cookii - (HB 96, T 83, HF 19.5, E 15, Wt. 23, values from Marshall (1977). A large species of *Mus*. Dorsum greyish brown, hairs stiff. Ventrum greyish white. Tail shorter than length of head and body, brown, somewhat paler below. Dorsal surface of hands and feet always white. Upper incisors pale orange. Looks like a larger version of *M. caroli* but with pale upper incisors and tail not sharply bicolored. Occurs in rice fields, brush and along the edges of forest.

Mus musculus - (HB 74, T 79, HF 16, E 12, Wt. 12, values from Marshall (1977). A human commensal. Dorsum dark greyish brown. Ventrum dark grey. Tail about as long as length of head and body, mono-colored brown. Dorsal surface of hands and feet dark. Never found very far from human settlements.

Mus pahari - (HB 88-103, T 88-90, HF 21-23, E 15-17, Wt. 21-24) A long-nosed, shrew-like mouse with small eyes and short ears. Dorsum dark blue-grey, spiny in adults. Ventrum silver grey. Tail longer than head and body, bicolored, dark brown above white below. Dorsal surface of hands and feet white. Occurs in primary and secondary forests.



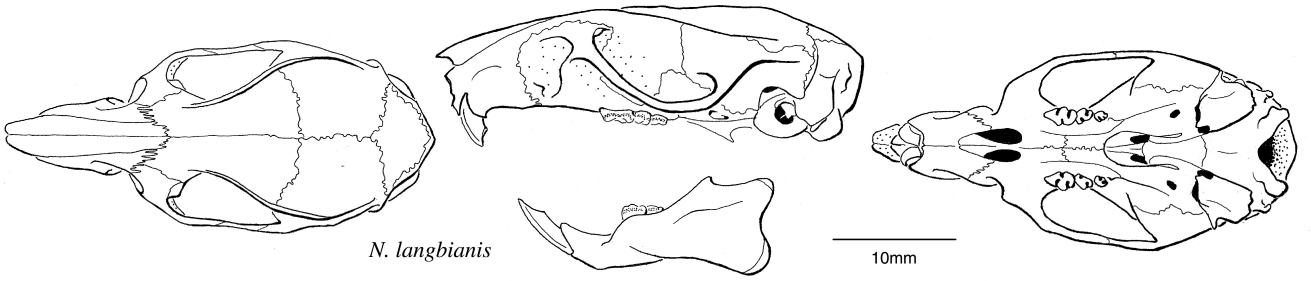
Taxonomic Notes:

1) Van Peenen *et al.* (1969) recognized *Mus kakhyensis*, as a valid species; however, we follow Musser and Carleton (1993) in regarding *kakhyensis* a synonym of *M. caroli*.

2) See Marshall (1977b) for a synopsis of the Asian species of *Mus*.

Niviventer

Identification: Medium-sized rats. Dorsum greyish brown to reddish brown, often spiny. Ventrum white or cream-colored, sharply demarcated from dorsum; specimens may discolor to a sulfur yellow when in contact with formalin. Tail longer than combined length of head and body, usually bicolored dark above, pale below. Hind foot short and broad in arboreal species, longer and narrower in more terrestrial species, all species have 6 plantar pads on each hind foot. Females with 4 pairs of mammae (1 pectoral pair, 1 postaxillary pair, 2 inguinal pairs). Skull: squamosal roots of zygomatic arches set high on the sides of the braincase; incisive foramina extend almost to the first molars; posterior margin of the bony palate at level of posterior margin of third upper molars; pterygoid fossa not perforated by foramina; mesopterygoid fossa as wide as palate; bullae relatively small; dentary with small coronoid process. Skull configurations similar among species. Common in most types of forests from sea level to above 1,000 m. They are cursorial, scansorial, or arboreal, depending on the species. When two or more species occur in sympatry they are usually ecologically isolated, with one species being primarily arboreal and the other primarily terrestrial.



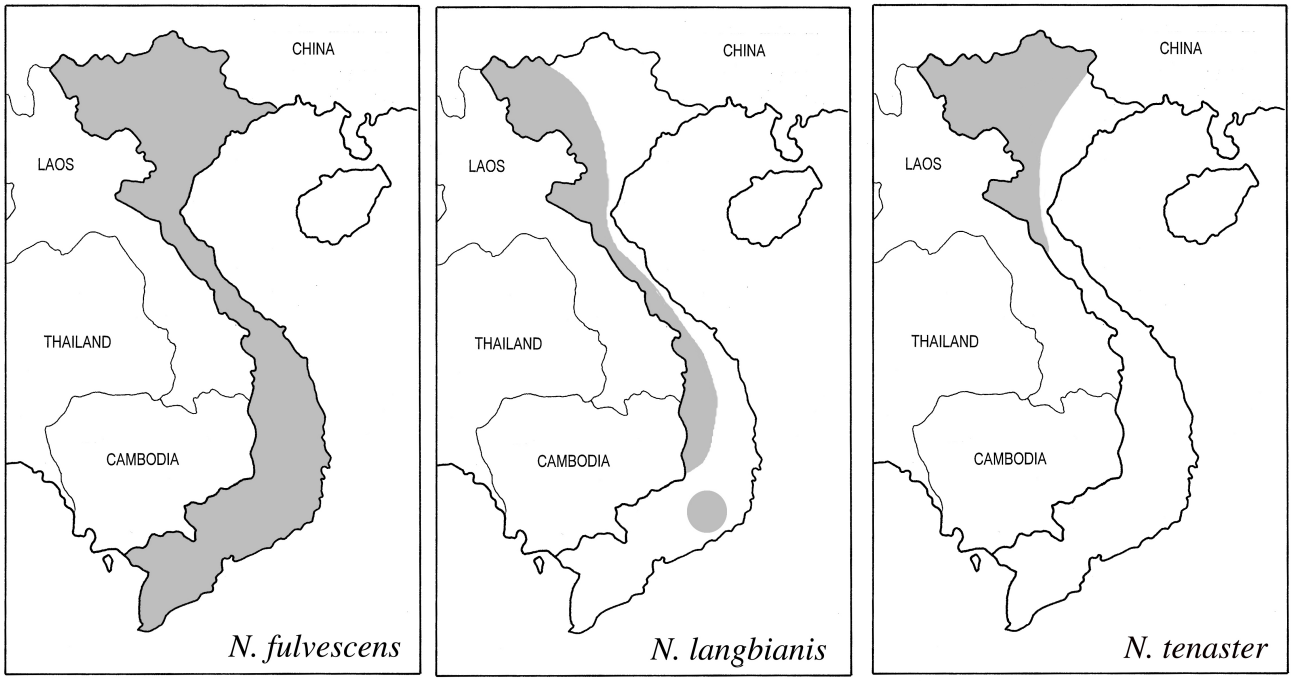
Viet Nam Species:

Niviventer confucianus- Dorsum brown, pelage long and soft, not spiny. Ventrum white, sharply demarcated from dorsum. Dorsal surface of tail brown, often with a pale tip, ventral surface paler. Occurs at higher elevations in moss forest in extreme northern Viet Nam.

Niviventer fulvescens - (HB 131-172, T 160-221, HF 30-34, E 17-23, Wt. 60-135). Dorsum reddish brown with dark brown spiny guard hairs. Ventrum white, sharply demarcated from dorsum. Dorsal surface of tail brown, ventral surface white to pale brown. Dorsal surface of hind foot pale brown to white, sometimes with a dark brown patch. Most often caught on the ground.

Niviventer langbianis - (HB 131-162, T 154-199, HF 29-33, E 19-22, Wt. 58-98). Dorsum yellowish to reddish brown with dark brown spiny guard hairs. Ventrum white, sharply demarcated from dorsum. Tail monocolored dark brown. Dorsal surface of hind feet pale brown to white, sometimes with a dark brown patch. Most often caught on vines and lianas.

Niviventer tenaster - (HB 120-189, T 174-234, HF 32-35, E 23-26, Wt. 53-140). Dorsum yellowish brown with dark brown spiny guard hairs. Ventrum white, sharply demarcated from dorsum. Dorsal surface of tail brown, often with a pale tip, ventral surface paler. Occurs above 1,000 m. Similar to *N. langbianis* but with a longer, bicolored tail.



Taxononomic Notes:

1) *Niviventer fulvescens* was described from a specimen collected in Nepal. Some authors have referred to populations occurring in southern Indochina as *N. bukit* and only those occurring farther north as *N. fulvescens*, but we follow Musser (1993 p. 634) in including *bukit* as a synonym of *fulvescens* "pending careful revision of the *fulvescens-bukit* complex."

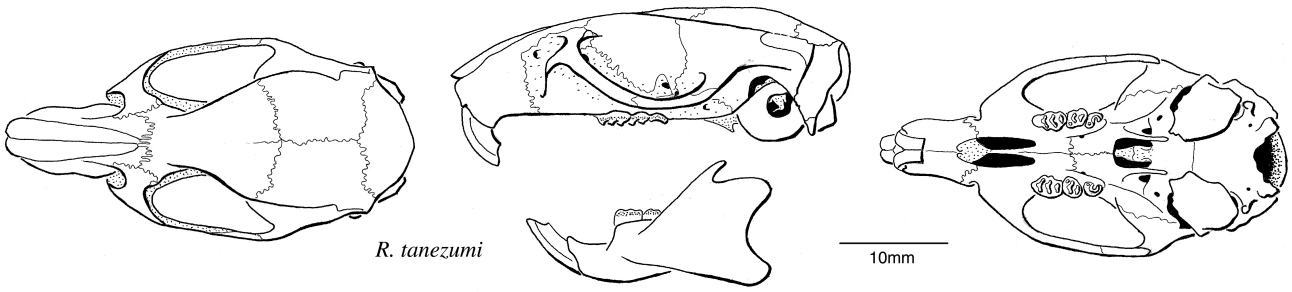
2) *Niviventer confucianus* and *N. fulvescens* are difficult to distinguish (see Musser 1981, figure 12). We recognize both *N. confucianus* and *N. fulvescens* but Musser and Carleton (1993 p. 633) noted that the geographic and elevational relationships between *N. confucianus* and *N. fulvescens* need to be resolved by careful taxonomic revision.

3) According to Musser (1981 p. 253) "there is no convincing evidence that the Nepalese populations of *N. niviventer* are the same [species] as those from farther east." Dang *et al.* (1994) and Cao Van Sung (1984a) reported *N. niviventer* from Viet Nam, but we follow Musser (1981), and Musser and Carleton (1993) in restricting *N. niviventer* to northeastern Pakistan, Nepal and northern India.

4) *Niviventer langbianis* was once considered a subspecies of *N. cremoriventer* but Musser (1973 p. 24) elevated *N. langbianis* to full species status and restricted *Niviventer cremoriventer* to localities south of the isthmus of Kra. *Niviventer cremoriventer* is still sometimes included in lists of Viet Nam mammals (Dang *et al.*, 1994), but see Musser (1981, p. 248-9) and Musser (1973, p. 33-41) for a description of the qualitative and quantitative features distinguishing *N. cremoriventer* and *N. langbianis*.

Rattus

Identification: Medium-sized rats. Dorsum grey brown, without spines. Ventrum grey, not sharply demarcated from dorsum. Tail monocolored or bicolored depending on species. Skull: squamosal roots of zygomatic arches set low on side of braincase; incisive foramina extend to, or slightly past the front margins of the molar tooth row; posterior margin of bony palate is posterior to last molars; ptergoid fossa perforated by large foramina; mesoptergoid fossa narrower than palate; bullae relatively large; coronoid process of dentary well developed.

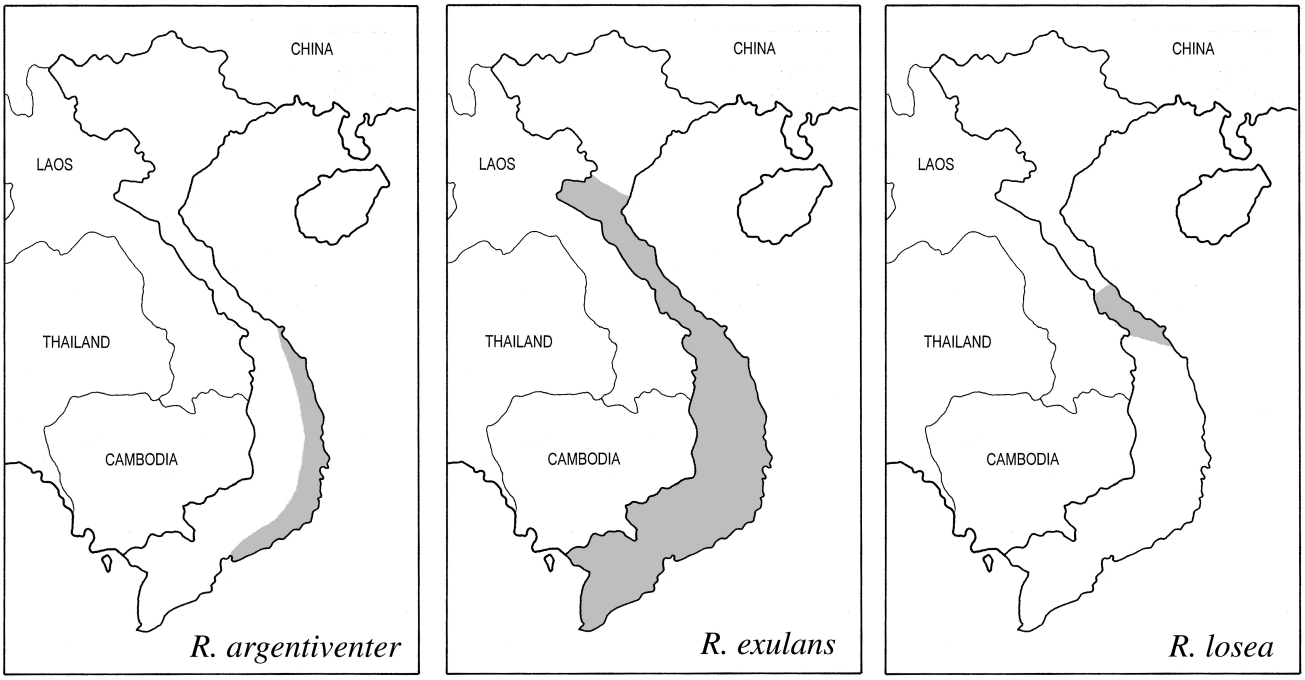


Viet Nam Species:

Rattus argentiventer - (HB 176-230, T 172-201, HF 35-40, E 20-24). Dorsum variegated yellow-brown speckled with black, giving the animal a distinctive salt and pepper effect; tufts of contrasting orange hairs are present in front of each ear (less conspicuous in adults). Ventrum silvery grey except for throat, axillary, and inguinal regions which are white. Tail dark brown above and below, usually equal to or slightly shorter than the length of head and body. Dorsal surfaces of front and hind feet colored as dorsum. Footpads with shallow striations typical of terrestrial species. Females with 6 pairs of mammae. Skull robust, with a short rostrum; incisive foramina terminate near the first lingual root of each first upper molar. A terrestrial inhabitant of rice fields and scrub, usually occurs below 1,000 m elevation.

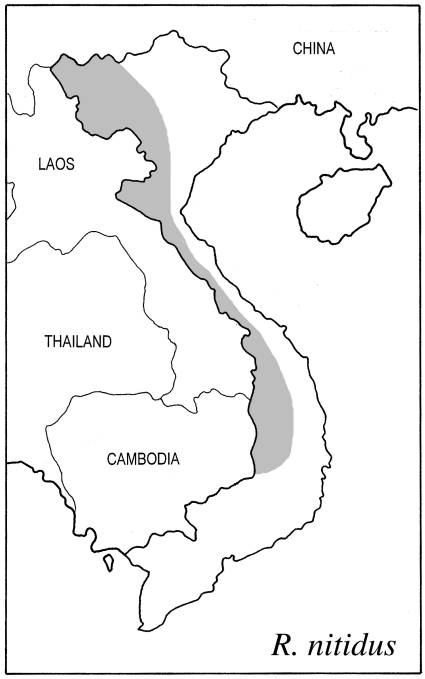
Rattus exulans - (HB 91-124, T 105-146, HF 21-26). A small *Rattus*. Dorsum greyish brown. Ventrum pale grey. Tail much longer than length of head and body. Females with 4 pairs of mammae (1 pectoral pair, 1 postaxillary pair, 2 inguinal pairs). Occurs in villages, cultivated areas, and secondary growth up to 3,000 m. A good climber.

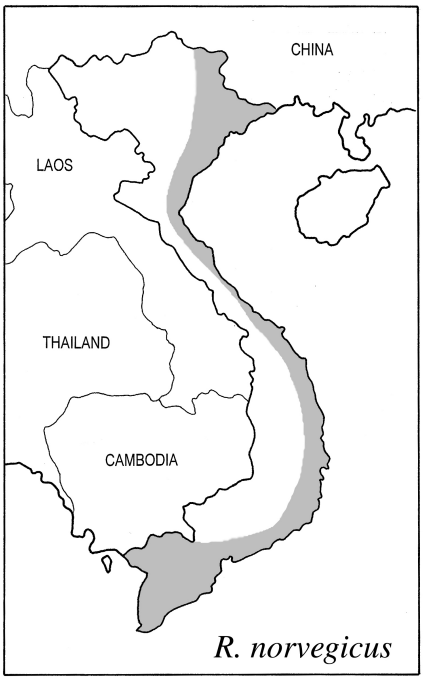
Rattus losea - (HB 131-166, T 143-161, HF 31-34, E 17-20). Dorsum bright buffy brown, pale yellow highlights scattered on sides, adult pelage long and slightly shaggy; narrow soft translucent spines occur throughout the dorsal fur. Ventrum greyish white except for the inguinal region and the underside of the chin, which are usually white. Tail shorter than head and body, brown, slightly paler below but not distinctly bicolored. Ears pale brown. Dorsal surfaces of hands and feet grey to greyish brown, hind foot long and narrow, 4 interdigital and two plantar pads with the shallow striations typical of terrestrial rats. Females with 5 pairs of mammae (1 pectoral pair, 1 postaxillary pair, 1 abdominal pair, 2 inguinal pairs). Similar to *Rattus rattus* but smaller, and with a tail that is never very much longer than length of head and body. A terrestrial species of the lowlands and middle altitudes to about 1,000 m. Often trapped in agricultural areas, scrub habitats and around houses.



Rattus nitidus - (HB 173-177, T 168-171, HF 37-38, E 21). Dorsum dark greyish brown, pelage short, thick and soft. Ventrum dull grey, not sharply demarcated from dorsum. Tail about as long as length of head and body, often shorter. Dorsal surfaces of hands and feet pearly white. Females with 3 pairs of mammae. Skull with long nasals and rostrum and small bullae. "The anterolabial cusp of each first upper molar, so well developed and conspicuous in most species of *Rattus*, is either absent or represented only by a low bulge in *R. nitidus*" (Musser and Holden, 1991 p. 381). A good climber.

Rattus norvegicus - (HB 233, T 201, HF 44). Dorsum greyish brown to almost black. Ventrum grey, often with a white chest patch. Tail always shorter than length of head and body, bicolored brown above, greyish below, not sharply demarcated. Dorsal surfaces of feet white. Females with 6 pairs of mammae. Skull: width across incisors less than 3.5mm (greater than 4mm in *Bandicota*) Terrestrial and amphibious. A non-native species introduced to cities and towns. Sometimes an important agricultural pest in rice fields.



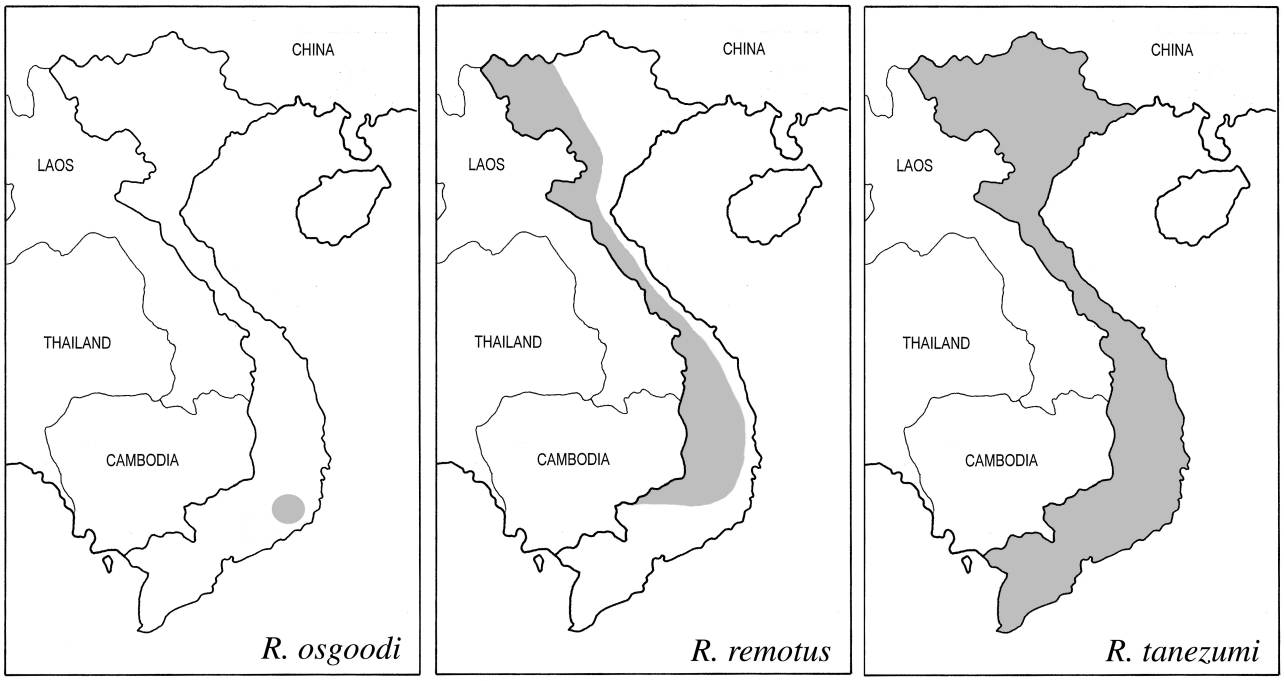


Rattus osgoodi - (HB 124-171, T 102-137, HF 26-37). A small *Rattus* (only *R. exulans* is smaller). Dorsum rich dark brown, darker along midline of back and rump, pelage long and dense, silky to the touch. Ventrum dark grey-brown, underside of chin and inguinal region dark grey. Tail shorter than length of head and body. Females with 5 pairs of mammae (1 pectoral pair, 1 postaxillary pair, 1 abdominal pair, 2 inguinal pairs). Similar to *R. losea* but smaller and with a shorter tail. Known only from the highlands of southern Viet Nam at altitudes above approximately 1,000 m. Terrestrial, probably occurs in dense shrubbery.

Rattus rattus - (HB 173, T 196, HF 34). Dorsum grey brown. Ventrum grey, not sharply demarcated from dorsum. Tail longer than length of head and body. Females with 5 pairs of mammae (1 pectoral pair, 1 postaxillary pair, 1 abdominal pair, 2 inguinal pairs). Terrestrial and scansorial, pads of hind feet large, with conspicuous transverse and semicircular lamellae characteristic of good climbers. In Viet Nam this species is restricted to ports and ships in harbor.

Rattus remotus - (HB 185, T 204, HF 36). Dorsum greyish brown, pelage long and thick with long guard hairs down the middle. Ventrum creamy white. Tail monocolored, much longer than the length of head and body. Upper surfaces of hand and feet dark brown. Females with 6 pairs of mammae. Often trapped in agricultural areas, scrub habitats and around houses.

Rattus tanezumi - Dorsum grey brown. Ventrum grey, not sharply demarcated from dorsum. Tail longer than length of head and body. Females with 5 pairs of mammae (1 pectoral pair, 1 postaxillary pair, 1 abdominal pair, 2 inguinal pairs). Terrestrial and scansorial, pads of hind feet large, with conspicuous transverse and semicircular lamellae characteristic of good climbers. This is the "Asian type" rat of the "*Rattus rattus* group." Often trapped in agricultural areas, scrub habitats and around houses.



Taxonomic Notes:

1) The genus *Rattus* once included several forms now recognized as distinct genera (see Misonne 1969; Musser 1981; Musser and Newcomb 1983; Musser and Holden 1991; Musser and Heaney 1992). Genera that were once lumped together within *Rattus* include: *Leopoldamys*, *Maxomys*, *Niviventer*, and *Berylmys*.

2) The genus *Rattus* can be sorted into five species groups, some of which may ultimately be recognized as distinct genera (Musser and Carleton 1993). Two *Rattus* species groups are represented in Viet Nam: the "*rattus* group" (*R. argentiventer*, *R. losea*, *R. remotus, R. nitidus*, *R. osgoodi*, *R. rattus*, *R. tanezumi)* and the "*norvegicus* group" (*R. norvegicus)*. (The affinities of *R. exulans* remain unresolved).

3) Two types of *Rattus rattus* can be recognized: the "European type" and the "Asian type." The Asian type is here recognized as a distinct species, *R. tanezumi*. Where the Asian type is indigenous, the European type (*Rattus rattus*) is restricted to ports and ships in harbor. See comments for *Rattus rattus* in Musser and Carleton (1993).

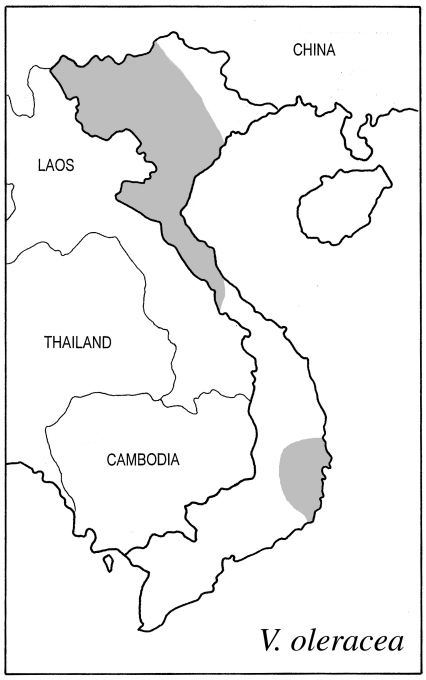
4) Musser and Heany (1985) considered *R. remotus* and *R. sikkimensis* synonymous but failed to recognize that *R. remotus* was the older name and thus had priority. Specimens of *R. sikkimensis* reported from Viet Nam are *R. remotus*.

5) We follow Musser and Carleton (1993) in including *koratensis* as a synonym of *R. remotus*; *hoxaensis* as a synonym of *R. argentiventer*; *exiguus* as a synonym of *R. losea*; and *germani, molliculus, flavipectus* and *sladeni* as a synonyms of *R. tanezumi*.

6) Musser and Newcomb (1985) mapped locality records of *R. losea* only from specimens that they actually examined, but stated that it likely occurs in northern Viet Nam. Tien (1960, 1961, 1978) indicates samples of *R. losea* from central and northern Viet Nam, and these literature records are reflected in our range map for *R. losea*.

7) See Musser and Newcomb (1985) for further discussion of Viet Nam *Rattus* and in particular *R. osgoodi* and *R. losea*.

Vandeleuria oleracea



Identification: (HB 61-79, T 104-113, HF 16-19, E 14.5-16, Wt. 20.9 g). A small arboreal mouse with a proportionally long tail. Dorsum uniform bright orange brown; lacks a dark mask around each eye. Ventrum white with ochraceous tinges, not sharply demarcated from dorsum. Great toe of hind feet opposable and thumb-like; fifth finger and fifth toe short and clawless (*Chiropodomys*, *Hapalomys*, and *Chiromyscus* have a pointed claw on the fifth digit). Tail almost twice as long as length of head and body, brown, not bicolored and well haired for its entire length, without a distinct terminal tuft. Females with four pairs of mammae (2 thoracic pairs and 2 inguinal pairs). Tate (1947) reported on a specimen from Ceylon captured alive up a tree. The animal was apparently kept alive and "proved to be nocturnal and strongly arboreal, using its long tail as a balancing organ as it ran out to the tips of slender twigs."

Subfamily Platacanthomyinae - Tree Mice

Typhlomys chapensis

Identification: (HB 80-98, T 117-135, HF 22) - Pelage short; dorsum grey dark grey to almost black; ventrum dull buffy; hands whitish; feet dusky, the sides of the toes whitish; tail long with distal brush of long hairs. Known only from Chapa in northern Viet Nam. Skull unlike any other Viet Nam rodent in that there are two large palatine foramina posterior to the incisive foramina.

Taxonomic Note: Originally described as a subspecies of *T. cinereus* but distinguished by its larger size (Musser and Carleton, 1993).

Conservation Status: IUCN Red List Critically Endangered

Subfamily Arvicolinae - Voles

Eothenomys melanogaster

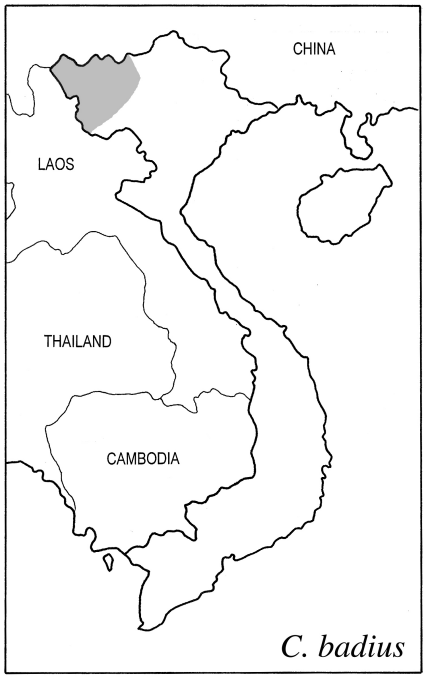
Identification: (HB 90-106, T 46-59, HF 16-20, E 11-13) A shaggy, thick-furred mouse with short legs and short ears which do not protrude above the fur of the head. Tail shorter than head and body, well covered with short hairs. Females with two pairs of mammae. The unrooted, ever-growing molars have flattened grinding surfaces and a complex zig-zag enamel pattern. Occurs at higher elevations in extreme northern Viet Nam. Feeds on grass.

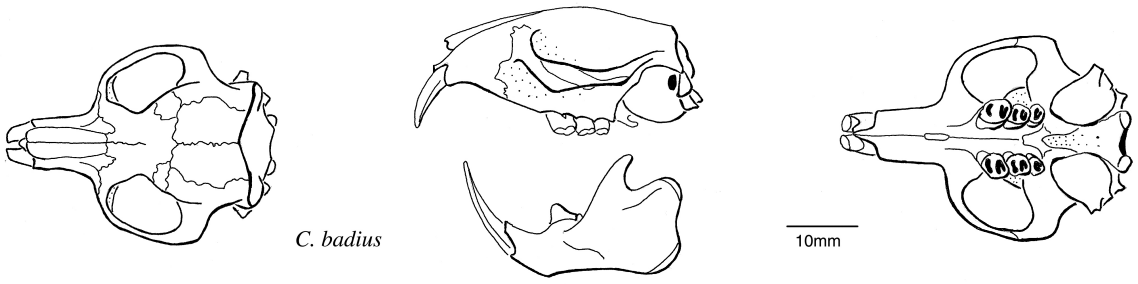
Taxonomic Note: Only nine specimens of this species have been collected in Viet Nam, all from Chapa (Osgood 1932). There is considerable variation among forms currently included in this species (Corbet 1978).

Subfamily Rhizomyinae - Bamboo Rats

Cannomys badius

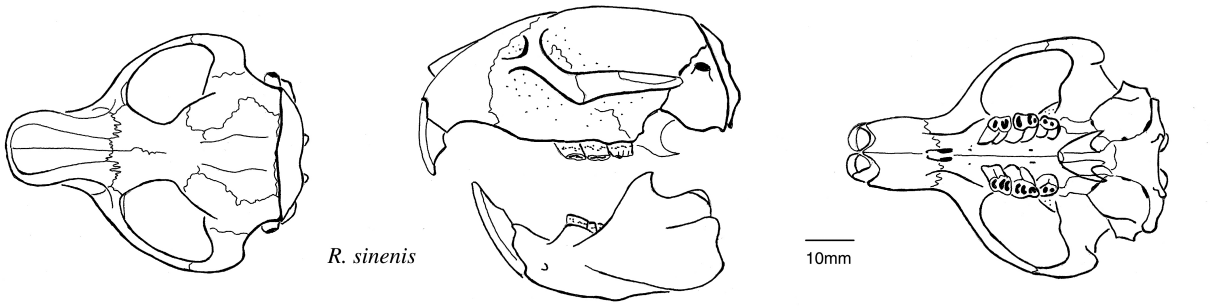
Identification: (HB 191-259, T 44-73, HF 30-35, E 8-11) A burrowing rodent with a stout body, short legs, a short naked tail and small eyes and ears. Dorsum and ventrum uniformly colored red-brown or dark grey. There are sometimes white bands on the top of the head and on the throat. *Cannomys badius* is smaller than *Rhizomys*, and has a shorter tail (usually less than 75 mm) and smooth footpads. Lesser bamboo rats live in deep burrows in both open areas and forests and emerge in the evening to feed on young shoots and roots.





Rhizomys

Identification: Burrowing rodents with stout heavy bodies, short legs, short naked tails, and small eyes and ears and granular foot pads. Females with 5 pairs of mammae (2 pectoral pairs and 3 abdominal pairs). Skull dorsally flattened, with marked postorbital constriction, broad zygomatic arches, and a triangular braincase; pro-odont incisors thick and blunt; molars flat crowned. Inhabit bamboo thickets above 1,200 m where they spend much of their time in extensive underground tunnels.



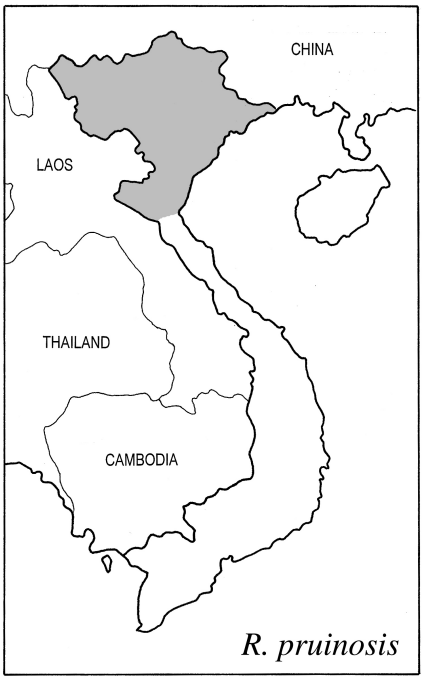
Viet Nam Species:

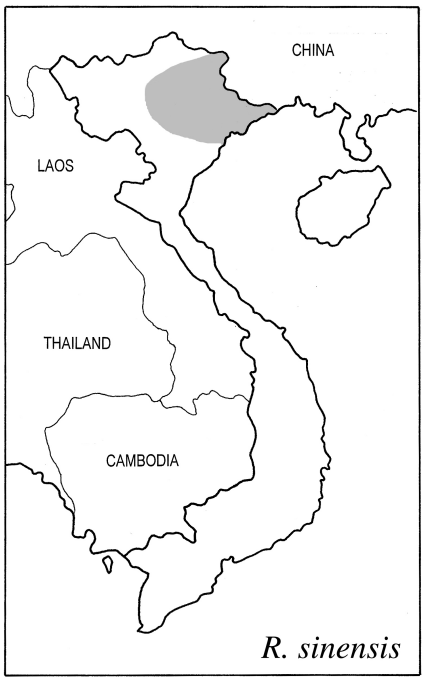
Rhizomys sumatrensis - (HB 280-480, T102-200, HF 71-77.5, E 18-36; values from Lakagul and McNeely (1977)). Dorsum light grey-brown, face reddish brown with darker hairs forming a triangle on the forehead. Hairs on back pale brown at base (grey in *R. pruinosus*) reddish patches on cheeks. Ventrum slightly paler than dorsum; tail tip pink; the two posterior sole pads are joined.

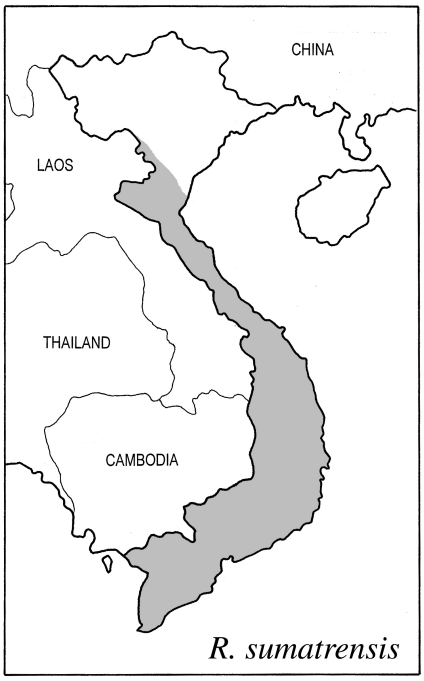
Rhizomys pruinosus - (HB 256-350, T 100-124, HF 45-61, E 18-26; values from Lekagul and McNeely (1977)). Dorsum dark grey-brown, scattered individual hairs tipped white; ventrum somewhat paler than dorsum. The two posterior sole pads are separate.

Rhizomys sinensis - Dorsum pale brownish, darker on forehead and sides of face. Ventrum somewhat paler. The two posterior sole pads are separate. Dao and Cao (1990) described *reductus* as the Viet Nam subspecies of *R. sinensis*

Taxonomic Note: See Cao Van Sung (1984b) for a review of the Bamboo rats (*Cannomys* and *Rhizomys*) of Viet Nam.


CHINA
LAOS
THAILAND
CAMBODIA
R. pruinosis


CHINA
LAOS
THAILAND
CAMBODIA
R. sinensis

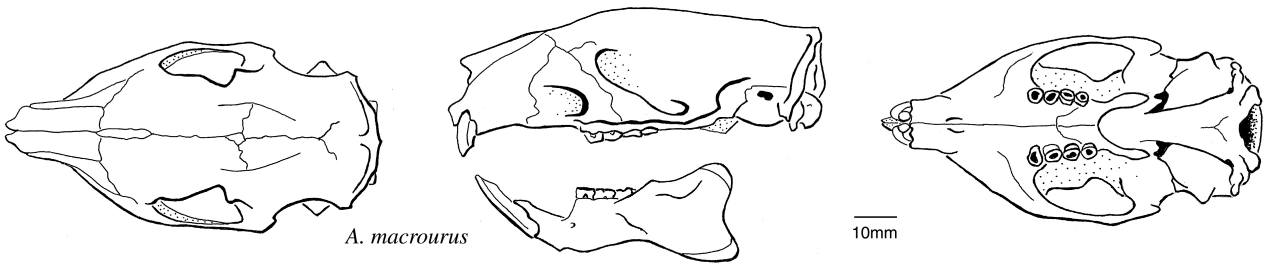

CHINA
LAOS
THAILAND
CAMBODIA
R. sumatrensis

Family Hystricidae

Large rodents characterized by hairs modified into large stiff quills. Both fore- and hind feet with five digits. Skull with very large infraorbital canal, lower jaw with specialized angular process deflected for attachment of masseter muscle. Dental formula: I1/1, C0/0, P1/1, M3/3 x 2 = 20. The crowns of the cheek teeth are flat with transverse folds of enamel surrounding islands of dentine. *Atherurus macrourus* has a long tail and grooved quills while *Hystrix* species have shorter tails and rounded quills.

Atherurus macrourus

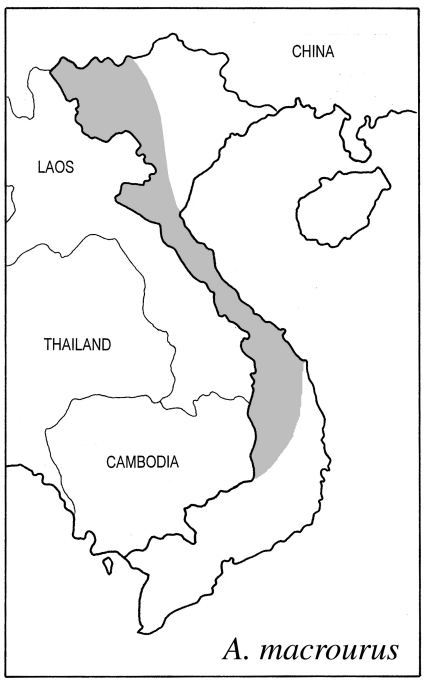
Identification: A small porcupine with a long scaly tail ending in a brush of bristles resembling threaded grains of rice. Dorsum covered with flattened brown spines interspersed with longer, rounder spines toward the rump. All quills on body grooved. Ventrum paler brown. Skull without inflated frontals. Occurs in forests and cultivated areas, where it seems to favor rocky areas. It spends the day in a burrow or cave emerging at night to feed on roots, fruits, crops, and bark. Burrows may be used for many years and are often associated with well-worn, radiating trails and latrines. Terrestrial, but according to Allen (1940) they also climb well.

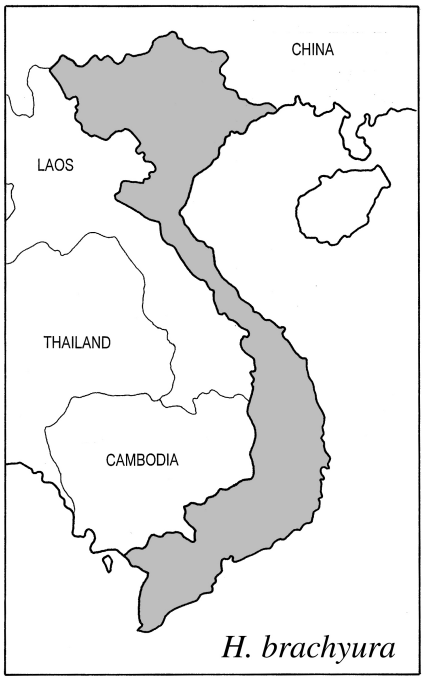


Taxonomic Note: See Van Weers (1977) for a review of the southeast Asian species of *Atherurus*

Hystrix brachyura

Identification: Large porcupines with relatively short tails hidden among the long quills of the hindquarters. Eyes and ears very small. The front half of the body is covered with short, dark brown spines that are not flattened; long, thickened hollow quills protrude from the hind quarters. Skull with inflated pneumatic cavities. Found in all types of forests and plantations. They shelter during the day in caves and rocky areas or burrows and emerge at night to feed on roots, bark, and fallen fruit. When disturbed they will rattle their tail quills.





Taxonomic Note: See Van Weers (1979) for a review of the southeast Asian species of *Hystrix*

The Importance of Zoological Collections

Zoological collections form the basis of our knowledge of species diversity and distribution: 1) specimens are the physical entities upon which species are defined and described for identification and 2) specimens are the physical evidence for the occurrence of that species at a particular time and place. Specimen collections are thus essential for studies of species diversity, distribution, and conservation.

A complete collection of Viet Nam rodents does not exist, and much more fieldwork and collections building will be necessary to understand the full range of Viet Nam's rodent diversity. New species are still being discovered, and the distributions of many species are still poorly known. For these reasons the importance of collections cannot be understated.

The following overview covers the basic field and museum techniques necessary for collecting and preserving rodent specimens. The trapping section covers techniques necessary to get a rodent in the hand, but not the more refined methods necessary for conducting faunal inventories and estimating relative abundance and population density; descriptions of these techniques are provided in Wilson *et al.* (1996). There are several excellent works on preparing mammal specimens (Anderson, 1948; Anthony, 1925; Hall, 1962; Martin, Pine and DeBlase, 2001; Miller, 1932; Nagorsen and Peterson, 1980; Setzer, 1963; Williams and Hanks, 1987) but these are not readily available to students in Viet Nam so a synopsis is provided here. Finally, some basic, collections management techniques are presented in an effort to encourage the continued development of zoological collections in Viet Nam.

Trapping Rodents

The rat collector's objectives are: 1) to broadly sample species diversity and 2) to collect large enough series of specimens for each species sampled.

A diverse trapline will collect a greater diversity of species; so a variety of traps should be used to sample as many microhabitats as possible. For each species, a number of specimens are necessary to adequately assess variation within and among populations. Understanding this range of variation is essential to determining species limits. A minimum of twenty specimens per species are required from each locality, however, with more specimens, more meaningful scientific results can be expected. The number of animals removed from a population has no significance because most rodents are prolific, and have reproductive potentials sufficient to accommodate increased levels of predation (Reynolds *et al.* 1996).

The art of rat trapping is learning where to expect animals. To maximize trap yield carefully consider the placement of each trap; a smaller well tended trapline is preferable to a longer hastily set line because there will be more time to concentrate on placing traps where you would expect to capture animals.

Traps

Snap Traps: Snap traps kill with a spring-powered metal bar set off when the rat contacts a baited treadle. Victor holdfast snap traps are excellent for rats the size of *Niviventer* and *Maxomys*. Museum special snap traps are too small for most terrestrial rodents but when set on thin branches and lianas are ideal for *Chiropodomys* and other climbing mice.

Box and Cage Traps: Rodents lured into box traps are captured alive when they depress baited pan releasing a spring-loaded door. Sherman live traps and Tomahawk cage traps come as folding or non-folding styles in a variety of sizes. The largest Sherman traps are good for rodents smaller than *Maxomys*. Tomahawk cage traps are ideal for larger-sized rodents such as *Leopoldamys*, *Bandicota* and *Berylmys*. Set box and cage traps on the ground in dense vegetation, on top of and along logs. In Viet Nam locally made traps are available in sizes between those of Shermans and Tomahawks.

Conibear Traps: Conibear traps kill larger rats and squirrels with a pair of spring powered metal squares that snap shut around the body of an animal passing through the trap. Conibear traps are most effective when baited and secured to fallen logs bridging streams. Squirrels tend to use recently felled trees whereas terrestrial rats prefer smooth logs. Conibears can also be set on heavy lianas or at the entrances to burrows, but unless a burrow looks well used, these sets are most often fruitless. Animals must push their way through a Conibear, so it is important that the traps are well secured.

Pitfall Traplines with Driftfences: A pitfall trapline is a line of regularly spaced 10-15 liter buckets sunk flush with the level of the ground. Small mammals are guided into pitfall traps by a 0.5 meter high plastic driftfence stapled to support stakes hammered into the ground every 3-4 m. The driftfence runs uninterrupted through the centers of the pitfall traps. Several centimeters of the driftfence should be folded flat with the ground and covered with dirt to seal the bottom of the driftfence, but this fold must be cut where it passes over the pitfalls.

Pitfall traplines typically include ten to twenty pitfalls spaced evenly over 50-100 meters. Pitfall traps are excellent for small *Mus* sized rodents that scurry close to the ground but species as large as or larger than *Niviventer* sp. are rarely captured.

Running a Trapline

Set a variety of traps in lines running through all suitable habitats. Trap spacing should be a function of habitat complexity, with traps spaced more closely in complex habitats. When working in forest set traps on a branches and lianas as well as on the ground. As you set out a line, flag each trap with a strip of brightly colored, sequentially numbered flags. Traps are easy to miss even when flagged, but if the trap flags are numbered in sequence it will be obvious when a trap has been overlooked.

Bait must be odiferous enough to draw rodents into the traps from some distance,

sticky enough to adhere to the trap, and stable enough to keep from rotting. A mixture of peanut butter, oatmeal, raisins and bacon in a ratio of (6:2:2:1) works well. Other locally available baits include boiled manioc or sticky rice mixed with ground nuts (peanuts) or dried fruit. Slices of coconut or banana can be dropped in Sherman traps or held in small cheesecloth bags tied to Conibear or snap traps.

Re-bait traps daily, preferably in the late afternoon to ensure the freshest possible bait for nocturnal rodents. However, some rodents are diurnal, so do not hesitate to re-bait traps as necessary during the morning trap check. When re-baiting collect the old bait and discard it far from the trapline. It is important to check traps early each morning because ants can devour trapped animals in a short period of time.

Immediately tag captured rats with the next available field number and record any relevant data (see below).

Trapping Notes

The value of a specimen is proportional to the quality of the data associated with it, and the same amount of care should be put into preparing trapping notes as is put into collecting and preparing specimens. Record field notes on the highest quality paper and ink available: paper should be neutral or slightly alkaline, ink should be black, waterproof, and resistant to alcohol and formalin. Store copies of field notes at the institution where the specimens are housed. Notes can be divided into three basic categories: a daily journal, a specimen catalogue, and a log of traplines.

Journal: A journal is a daily account of activities and observations. Begin with a brief description of the trapping location including geographical coordinates and elevation. Once familiar with the collecting locality, write a detailed description of habitat types, including dominant plant species and geological formations. Record wildlife observations, particularly for rare or secretive animals. Much of what we know of the habitats and behavior of mammals has come from such anecdotal observations. Anything that may potentially be of use in the future should be recorded in the field journal, take time each day to write in your journal, even if only a few sentences; it is the only written record of what should be a rewarding experience well worth remembering. Following is a sample journal page.

Journal NTS 1998

Vietnam: Ha Tinh; Huong Son Camp, 980 m

20 May: Yesterday we moved our camp up the trail to 980 meters. Our objectives for the next month will be to sample the rodent fauna at this elevation. The habitat here is "Po Mu forest", and is dominated by the Po Mu tree (*Fokienia hodginsii*). Bamboo and ferns are abundant in the understory. We spent the morning setting up camp, and in the afternoon I went out a set a line of 25 Victor snaptraps, 30 Sherman traps and 10 Conibear traps along a small stream that runs near camp. All of my traps are baited with a mixture of peanut butter, oatmeal, raisins and bacon. Along the trail I saw a troop of 4 *Maccaca*, probably *assamensis* but I could not get a good enough look. I was able to take two pictures before they fled down into a ravine. They were apparently feeding near a fruiting tree, which I can not identify. I took some pictures of the fruiting tree (roll #7).

21 May: I checked the traps as soon as it became light and found a single *Maxomys* in a Sherman trap. It rained heavily last night and many of my traps were apparently set off by rain drops. I saw 3 *Maccaca* along my trapline near the fruiting tree where I saw them yesterday. This time they did not flee so quickly and I managed to get a better look at them. I am certain now that they are *Macacca assamensis* because of the very short length of the tail (only a few centimeters). I watched them for about 20 minutes and confirmed that they were in fact feeding on the fruits of the tree. Two of the animals are smaller and appear to be juveniles. Later in the afternoon I rebaited all my traps with fresh bait and set out 2 more victor traps, 5 more Sherman traps and two more Conibear traps.

22 May: There was no rain last night and I caught three rats: two *Niviventer* and a *Rattus*. I photographed the live *Niviventer* that was caught in the sherman trap (Roll #7).

Field Catalog: A field catalog is a numbered listing of mammals preserved. Each specimen is assigned a field number that is associated with the collector's name. For example the one hundredth specimen collected in the lifetime of Nguyen Truong Son would be recorded NTS 100. Throughout your life never repeat a number once it has been used for an animal. Record the following elements of data in the field catalog:

Species: in pencil, provide a preliminary identification. If species identifications are unknown, distinguish specimens as either species 'A' or 'B' etc. until the specimens can be accurately identified. Field identifications are useful for keeping track of the overall success of trapping efforts.

Locality: all components of the locality where the specimen was collected should be recorded from specific to general. For example: Viet Nam: Ha Tinh; Huong Son Camp, 250m. Simply 'Huong Son Camp' is inadequate. Along with locality names, be sure to include geographical coordinates and elevation above sea level.

Date: the date the specimen was collected. For clarity, always write out the date (ie. 14 September, 2000). Never abbreviate (i.e., 9/14/00).

Measurements and weight: the measurements described in the introduction of Part 1 (head and body, tail, hind foot, ear) and weight should be recorded in the field catalog. If a portion of the mammal is missing, the measurement should be put in brackets [ ] to distinguish it from measurements of intact parts.

Sex and reproductive data: record the sex of the specimen, ♀ for female and ♂ for male. The status of the testes (descended, undescended), or vulva (perforate,

imperforate) should be recorded. During the breeding season, the mammary glands may be enlarged; note their number and position.

Preparation: the nature of the specimen, for example: 'skin,' 'skull,' 'alcoholic carcass,' 'tissues,' 'Whole Alcoholic'.

Notes: a brief description of the circumstance under which the specimen was collected and other noteworthy observations. Following is a sample field catalog.

FIELD CATALOG NTS1998

Vietnam: Ha Tinh; Huong Son Camp, 980m

NTS 125♀ 21 May
Maxomys surifer Skin, Skull, Tissues
TL 310, T 153, HF 41, E 26, 310 grams.
Caught in a sherman traps set in along a fallen log near the banks of a small stream. Lactating, 8 swollen mammae (2 pectoral, 2 postaxillary, 4 inguinal).

NTS 126♂ 22 May
Niviventer langbianis Skin, Skull, Alcoholic Carcass, Tissues
TL 228 T 161 HF 36 E 25 280 grams
Caught in a Victor trap set on a liana that was part of a large tangle over a small stream. Looks like a juvenile animal, testes not descended.

NTS 127♀ 22 May
Rattus nitidus Alcoholic, Tissues
TL 179, T 170, HF 37, E 21,
Caught in a Victor trap set on a flat rock in the middle of the stream, the rat apparently swam out to the trap to eat the bait. Looks like a juvenile animal, vagina imperforate. The hind feet a pearly white, possibly *R. nitidus*, but not sure of species identification.

NTS 128♂ 22 May
Niviventer fulvescens Alcoholic, Tissues, ectoparasites
TL 133, T 162, HF 30, E 20, 98 grams
Caught in a sherman trap set inside a hollow log near the banks of a small stream. Adult with testes descended. Animal had some fleas which I collected. I tied a string to the animals hind foot and photographed the animal while alive.

Log of Traplines: Maintain a log for each trapline. Begin with a brief paragraph describing the habitat through which the trapline runs. Record the number of traps; the dates between which the traps were run; and captures. This information will be useful for quantifying trapping effort and success. Following is a sample log of traplines.

TRAPLINE # 1 NTS 1998

Vietnam: Ha Tinh; Huong Son Camp, 980m

This line was started on 20 May and first checked on the morning of 21 May. This trapline runs along a small (3 -5 meter wide) rocky stream in Po Mu forest. Palms are abundant along the banks.

Date	Victor Traps	Sherman Traps	Conibear traps	Captures / Trap	Total trap- nights
21 May	25	30	10	*Maxomys* /Sherman	65
22 May	27	35	12	*Niviventer* / Victor *Rattus* /Victor *Niviventer* / Sherman	139

Preparing Rodent Specimens

In the field, rodents can be prepared as traditional skin and skull specimens, whole alcoholics, or full skeletons. The preparation will depend on the objectives of the field study as well as on the experience and resources available to the collector, but in practice it is usually best to prepare some examples of all three preparation types.

Skin and skull preparations have the advantage of being convenient to handle and are particularly well suited to species-level taxonomic studies where large series of specimens must be examined for comparing nuances of the dried pelage. Traditionally, collectors discarded the animal's carcass after preparing a skin and skull specimen, but in recent years the skinned carcass is routinely saved as an alcoholic specimen. Study skins and skulls are difficult and time-consuming to prepare, and on short field trips to remote areas it is sometimes best to maximize collecting time by preparing more specimens as whole alcoholics.

Whole alcoholic specimens are becoming increasingly popular because the entire animal remains available for study: musculature, fleshy details of the hind feet and tail, reproductive organs, internal organs, stomach contents, internal parasites, etc. However, specimens prepared as alcoholics must be kept moist at all times, and pelage qualities are difficult to discern when the specimen is wet.

A few rodent specimens can be prepared as either whole skeletons or study skins with partial skeletons (foot bones are left in study skins); however, in preparing a full skeleton, much of the specimen is lost, and it is generally best not to skeletonize a specimen unless it is firmly identified. Some collectors prepare study skins with one arm and one leg being left in the study skin and the other being removed for skeletonization (Hafner *et al.* 1984). The methods for preparing full skeletons are the same for preparing skulls from study skins and skulls extracted from alcoholics and are reviewed below.

Regardless of the preparation method employed, a DNA sample should always be taken. As methods in molecular biology become cheaper and more accessible, the demand for DNA samples will increase dramatically.

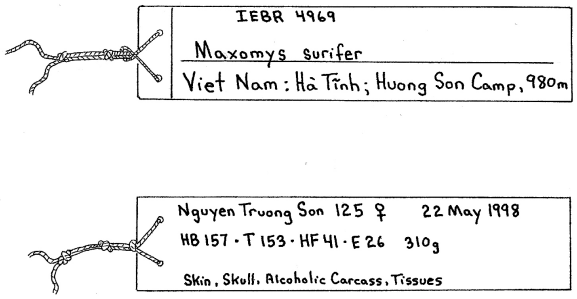
Tools and Supplies

The following are required to prepare rodent specimens: field catalog, specimen tags, pesola scales, ruler, technical pens, pencil, scalpel, scissors, fine scissors, long forceps, fine forceps, absorbent, cotton, wire, wire cutters, thread, needles, pins, pinning board, syringe, patience.

Records and Specimens Tags

Before preparing a rodent specimen, follow the instructions in the section on field notes above for recording data in the field catalog. Transcribe information from the field catalog to a specimen tag to be permanently affixed to the specimen. As with field

notes, use the highest quality of paper and ink available, print as neatly as possible and avoid abbreviations. Tags for fluid preserved specimens must be of heavy stock to resist tearing when wet. If the specimen consists of more than one element (for example, skin, skull, alcoholic carcass), a separate tag must be generated for each element. Following is a sample specimen tag.



Study Skins

A traditional study skin consists of the dried skin of an animal supported with wires and filled with cotton.

To make a study skin, the animal must first be skinned. Lay the specimen on its back and begin with a midventral incision, starting from about the last rib and continuing almost to the anus. Be careful not to cut into the body cavity. While skinning, use an absorbent such as sawdust to keep grease and body fluids from tainting the pelage. At the incision, work the skin free from the body: hold the skin up and use a blunt instrument to gently depress the abdominal muscles away from the skin. Continue to free the skin from the thighs and inguinal region. It is necessary to cut tissue in the vicinity of the genital organs, but otherwise the skin should pull free from the carcass relatively easily.

Hold the foot and push the knee joint upwards out of the skin of the leg and work the skin back to the ankle. Being careful not to cut through any skin, sever each foot from the carcass at the ankle joint. With the hind limbs free from the carcass, work the skin away from the back end of the animal until it is possible to completely encircle the base of the tail with two fingers. Pinch off the skin at the base of the tail and gently pull the tail vertebrae out of the tail sheath; care should be taken to ensure that the skin of the tail does not pull inside out.

With both hind limbs and the tail free from the carcass, unroll the skin over the front of the body until you reach the arms. Never pull the skin until it stretches. Whenever possible, free the skin from the carcass using your fingers. Use the scalpel only for cutting tough strands of fascia that hold the skin to the carcass. As with the hind limbs, hold each hand and push the arm upwards out of the skin of the arm and snip the hands free from the carcass at the wrists. Continue unrolling the skin until you reach the base of the ears, then cut the ear cartilage away from the skull as near to the skull as possible. Continue unrolling toward the posterior margin of the eyes and carefully cut the eye opening of the skin free from the skull. Cut along the inside of the mouth and

finally, unroll the skin to the tip of the nose and pinch or cut the skin completely free from the carcass. Put the carcass aside for eventually preparing as either a skeleton or alcoholic carcass (see below). Carefully snip or peel any adhering bits of flesh from the skin. The skin is now ready to be made into a study skin.

Sew the mouth opening of the skin shut. Using the skinned carcass as a guide, fold a rectangular piece of cotton body into a smooth form that approximates the size of the animal. Hold the tip of the cotton with forceps and starting from the inside of the tip of the nose roll the skin onto the cotton body and tuck the end of the cotton body into the hips. Wrap four lengths of wire, with cotton, to approximate the muscle mass of the limbs and insert into the arms and legs. Plant the sharp tips of the wire into the flesh of the pads. Cut a piece of wire the length of the tail plus several centimeters, wrap with cotton to the appropriate taper of the tail, and carefully insert into the tail sheath.

Before sewing up the skin, adjust the leg wires so that they are parallel along the body. Sew up the initial incision and knot the thread.

In order to dry properly, the skin must be pinned out on a flat piece of cardboard. Arrange the stuffed skin with the legs positioned neatly and symmetrically along the sides of the body. Pin the tail into place with pairs of crossed pins, then arrange the body so that it is in a straight line with the tail. Arrange the hind feet so that they are positioned parallel along the sides of the tail with the soles down and secure in place with a single pin through the metacarpels. Add a second set of pins at the outer side of each foot near the heel to keep it parallel with the body. Position the arms so that they are parallel along the length of the body and pin with the palms down. Securely tie a skin label with the complete data to the right foot just above the ankle. Care must be taken to ensure that insect pests do not damage the specimen as it left to dry. Allow the skin to dry thoroughly before packing in cotton for transport out of the field.

Skeletons

A traditional study skin is always accompanied by the skull of the animal. Disarticulate the skull from the carcass and, using a toothpick or small hooked wire, scoop out the brains, being careful not to damage the base of the skull. Small skulls are likely to be damaged in the field and a certain amount of dried tissue will protect the skull during transport. Label the skull with the same field number used for the skin. Soak the skull in cool water for about an hour to wash out any blood which may stain the skull, and store the labeled skull in alcohol until the specimen can be cleaned.

Carcasses can be either skeletonized along with the skull or preserved whole in alcohol (see below). The first step in preparing a skeleton is roughing out: remove all viscera and cut away any large pieces of flesh. Lightly wrap the roughed out skeleton with thread to make it compact and allow the roughed out skeleton to air dry, or simply store in alcohol. Storage in alcohol is preferable because it prevents decay and mold formation. Roughed out skeletal material is best prepared after the conclusion of a field trip.

Fluid Preserved Specimens

Fluid preserved specimens are first fixed in a formaldehyde solution and then transferred to alcohol for permanent storage. Commercially available formaldehyde is usually 37 %. Dilute a quantity of full strength formaldehyde to 10% of its original concentration (10% "formalin") and buffer to a pH of 7 with a mixture of 4 grams monobasic sodium phosphate and 6 grams dibasic sodium phosphate per liter of 10% formalin (Jones and Owens 1987). If these chemicals are not available, a spoonful of ammonia per liter will suffice. After measuring and weighing the animal, slowly inject several cubic centimeters of formalin into the chest, abdominal cavities, and any large muscle masses. Use just enough to fill the body cavities. Wet the animal in soapy water and slick down the fur to force any air bubbles out from under the fur and submerge in 10% formalin. Care should be taken to keep the specimen in a normal, relaxed position during the fixing process. For larger rats a small incision should be made in the abdominal wall to allow formalin to penetrate the internal organs quickly.

The bones of specimens left in formalin too long will decalcify, and muscles will stiffen excessively; leave the specimen in formalin just long enough for the muscles to become somewhat firm to the touch. Small mice need about 24 hours in formalin, larger specimens can be left in longer.

After fixing in formalin, rinse the specimen under cool water and transfer to a jar of alcohol for storage. Formalin will continue to leech out of the specimen over time, so this first volume of alcohol will eventually be spoiled. Larger quantities of alcoholic specimens can be wrapped in alcohol-soaked cheesecloth and temporarily stored in tightly sealed plastic bags. Such "wet packs" are an efficient way to transport large series of fluid specimens from the field to the lab.

DNA Samples

Sterilize a pair of forceps and fine scissors with ethanol, snip a small piece of liver tissue (about the size of this 12 point capital O) and place in an individually labeled cryogenic tube with full strength ethanol (97%).

Processing New Specimens from the Field

Skeletons: There are at least three methods for cleaning roughed out skeletal material from the field: 1) boiling, 2) bacterial maceration, and 3) with the use of insects. Boiling is suitable for larger skeletons but not for smaller, more delicate specimens. Simply boil the bones and after cooling, pick away any adhering bits of flesh by hand. A small amount of washing soda or detergent will help de-grease the specimens. This method has the disadvantage of causing the skeleton to completely disarticulate, and teeth may fall out or crack.

A second method is bacterial maceration. The roughed out carcass is soaked in a jar of warm water and the flesh allowed to slowly rot away from the skeleton. Change discolored water periodically to prevent it from staining the bones. This method has the disadvantages of sometimes causing the skeleton to completely disarticulate and is also slow, and very offensive to the olfactory sense.

The preferred method for cleaning rodent skeletons is with the aid of a colony of flesh-eating insects, which are allowed to pick the skeletons clean. Carnivorous beetles (dermestid) and ants work well but the beetles are preferred because they do not secrete formic acid that can damage bones. Maintain colonies in a tank far from the collections storage areas. Insect-cleaned skeletons should be soaked in a weak ammonia solution to clean and degrease the bones, and also to kill any insect eggs on the skeleton. Allow the bones to dry and write the museum number on the skull, mandible, and long bones. Detailed techniques for maintaining beetle colonies were described by Hall (1933) and Sommer and Anderson (1974).

Skins: New study skins should be fumigated or frozen for several weeks to ensure that the skins and cleaned skeletal materials are not infested with insect pests that may wreak havoc on a collection. After treatment the specimens can be identified, sorted by species and arranged neatly in a drawer with their cleaned skeletal material.

Fluid specimens: Newly acquired fluid preserved specimens must be soaked free of all formalin. Rinse specimens under cool water, preferably for several hours, before transferring to alcohol. Test for the presence of formalin in alcohol by mixing small amounts of water and alcohol, if the mixture turn milky white the alcohol is tainted with formalin and must be discarded.

Depositing Specimens in a Permanent Collection

New specimens should eventually be deposited in a permanent collection where they will be available for study. Specimens deposited in a collection are assigned a unique identifying number from the museum catalog (a museum catalog is a permanent, sequentially numbered listing of specimens held in a collection and may be a paper ledger, an electronic database, or typically both). The data associated with the specimen (from the field notes) is entered in the museum catalog and the specimen number is then written on all field tags, labels, and on the skull, mandibles and long bones of the

skeleton. The unique museum number assigned to a specimen from the catalog serves to identify individual specimens in the collection. Once a museum number is assigned to a specimen from the catalog, it is never to be assigned to any other specimen.

Storage and Organization of Collections

Collections must be protected from the damaging effects of light, dust and insect pests, but at the same time must be accessible to legitimate researchers. Specimens of skins and skulls should be stored on metal drawers in metal specimen cabinets with tightly sealing doors. Alcoholic specimens can be stored on open shelving provided there is some protection from the damaging effects of light. Air conditioning is essential as insect pests thrive in a warm, moist environment.

Organize specimens taxonomically. Within a family organize genera alphabetically and likewise for species within a genus. Within a species specimens can be sorted alphabetically by locality. Skins and skulls should always be kept together so that researchers will have ready access to all available material for each specimen. Label the outside of each case to facilitate specimen location. All available specimens of a particular species should be stored together; specimens should never be stored by expedition. Alcoholic specimens are generally stored separately from skin and skull collections. Sort alcoholic specimens by species and store in tightly sealing jars filled with 70% ethanol. Label the jar with the species name, locality and the museum numbers of the specimens inside.

Type Collections

A holotype is the single specimen upon which a new nominal species-group taxon is based in the original publication (Article 73, International Code of Zoological Nomenclature, 1999). Type specimens should always be marked with red specimen labels so that they can be readily distinguished from ordinary scientific specimens, which are used differently. Type specimens are examined when a researcher needs to determine the morphological paradigm associated with a particular name. The names associated with type specimens do not necessarily represent valid species; oftentimes the name is included in synonomy under a previous name (i.e., the specimen is considered the same species as a previously described species). Most major museums have published annotated catalogs of the type specimens in their care.

Specimen Curation and Access

Curation involves re-identifying and re-organizing specimens according to some accepted taxonomy and is typically undertaken at the family or genus level by an expert on that group. During curation, the general storage conditions of a collection are also improved: specimens are dusted off and specimen drawers are lined with clean acid-free paper. Never discard original specimen labels no matter how worn out.

Systematic collections can be considered the general property of science, not of a specific institution or curator. Every reasonable effort must be made to accommodate valid requests to study scientific specimens.

Allen, G.M., 1940 - The mammals of China and Mongolia, central Asiatic expeditions of the American Museum of Natural History, New York, 2:621-1350

Anderson, R.M., 1965 - Methods of collecting and preserving vertebrate animals. National Museum of Canada, Bulletin 69, Biological series 18, Ottawa, Ontario Canada.

Ando, M. and S. Shiraishi, 1993 - Gliding flight in the Japanese giant flying squirrel *Petaurista leucogenys*. J. Mamm. Soc. Japan 18(1): 19-32.

Anthony, H.E., 1925 - The capture and preservation of small mammals for study. American Museum of Natural History Guide leaflet No. 61. New York, New York.

Aoki, Bunichiro, and Ryo Tanaka, 1938 - Biostatistical research on *Rattus losea* (Swinhoe, 1870), a Formosan wild rat, with special reference to its diagnostic characters for taxonomy. Mem. Fac. Sci. and Agricul. Taihoku Imperial Univ., vol. 23, no.1. pp 1-74.

Askins, R.A., 1977 - Family Sciuridae. Pp. 337-387, *In* Mammals of Thailand (B. Lekagul and J.A. McNeely eds.). Association for the Conservation of Wildlife. Bangkok, Thailand, 758 pp.

Baskevich, M.I. and G.V. Kuznetsov, 1998 - Cytogenetic differentiation of species from the genus Rattus (Rodentia, Muridae) from the Dalat Plateau in southern Vietnam. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Moscow 117071, Russia. [in Russian]

Cao Van Sung, 1984a - Inventaire des rongeurs du Vietnam. Mammalia 48: 391-395.

Cao Van Sung, 1984b - Sur les rats du bamboo (Rhizomyidae) au Vietnam. Mammalia 48:606-607.

Cao Van Sung, 1985 - Sur les rats du bambou (Rhizomyidae) au Vietnam. Mammalia 48: 606-607.

Cao Van Sung, Dang Huy Huynh, Bui Kinh, 1980 - Nhung loai gam nham Viet Nan Nha Xuat Ban Khoa Hoc Va Ky Thuat. Ha Noi p 1-201.

Cao Van Sung and G.V. Kuznetsov, 1992 - About the taxonomic position of the rats of the genus *Rattus* (Muridae, Mammalia) in Vietnam. - Pp. 74-81 In Zoological studies in Vietnam (ed. Sokolov, V.E.) - Nauka, Moscow.

Cao Van Sung and Tran, V. M., 1985 - Karyotypes et systematique des rats (genre *Rattus*) du Vietnam. Mammalia 48 (1984): 557-564.

Carleton, M.D., and G.G. Musser, 1984 - Muroid rodents. Pp 289-379, *In* Orders and families of Recent mammals of the world (S. Anderson and J.K. Jones, Jr., eds.). John Wiley and Sons , New York, 686 pp.

Corbet, G.B., 1978 - The Mammals of the Palaearctic region: a taxonomic review.

British Museum of Natural History (London) 1-314.

Corbet, G.B., and J.E. Hill, 1992 - The mammals of the Indomalayan region: a systematic review. Natural History Museum Publications, Oxford University Press, Oxford, United Kingdom, 481 pp.

Dang, H.H., Dao, V. T., Cao, V. S., Pham, T.A., Hoang, M.K., 1994 - Danh luc cacloaithu (Mammalia) Viet Nam. Ha Noi.

Dao Van Tien, 1961 - Recherches zoologiques dans la region de Thai Nguy n. Zool. Anz., 165, 718:298-308.

Dao Van Tien, 1967 - Sur les formes de l'ecureuil bicolore, *Ratufa bicolor* (Rodentia, Sciuridae) au Vietnam et dans les regions voisines. Mitt. Zool. Mus Berlin Band 43.

Dao Van Tien, 1969 - Sur l'existence des deux formes de l'ecureuil de Perny, *Dremomys pernyi pernyi* Milne-Edwards et *D.p. flavior* G. Allen au Nord-Vietnam Zoalogische Abhand lugen, Staatliches Mus. fur tierkunde, Dresden. Band 30. Nr. 3.

Dao Van Tien, 1970 - Sur les formes de l' cureuil de McClelland, *Callosciurus* (*Tamiops*) *mcclellandi* Horsfield (Sciuridae, Rodentia) au Vietnam. Mitteilungen zool. Mus. Berl. 46: 53-60.

Dao Van Tien and Cao Van Sung, 1990 - Six new Vietnamese rodents. Mammalia, 54:233-238.

Day, Y.-T., 1988 - Subspecies and geographic variation of *Petaurista alborufus* and *P. peturista* (Rodentia: Sciuridae). Journal of the Taiwan Museum, 41(1): 75-83.

Martin, R.E., Pine, R.H., and A.F. DeBlase, 2001 - A manual of Mammalogy: with keys to families of the world, Third Edition. McGraw-Hill, New York.

Duckworth, J.W., R.J. Timmins, R.C.M. Thewlis, T.D. Evans and G.Q.A. Anderson, 1994 - Field observations of mammals in Laos, 1992-1993. Natural History Bulletin of the Siam Society, 42: 177-205.

Ellerman, J.R. and T.C.S. Morrison-Scott, 1951 - Checklist of Palaearctic and Indian Mammals 1758-1946. Trustees of the British Museum (Natural History), London, 1-810.

Francis, C.M., 1999 - Order Rodentia, Family Muridae. *In* Wildlife in Lao PDR. 1999 Status Report. Compiled by J.W. Duckworth, R.E. Salter and K. Khounboline. IUCN, Vientiane, Lao PDR.

Hafner, D.J., J.C. Hafner, and M.S. Hafner, 1984 - Skin-plus-skeleton preparation as the standard mammalian museum specimen. Curator 27: 141-145.

Hall, E.R., 1962 - Collecting and preparing study skins of vertebrates. University of Kansas, Museum of Natural History, Miscellaneous publications 30. Lawrence, Kansas.

Hill, J.E., 1962 - Notes on flying squirrels of the genera *Pteromyscus*, *Hylopetes*, and *Petinomys*. Annals and Magazine of Natural History, series 13, 4:721-737.

International Commission on Zoological Nomenclature, 1999 - International Code of Zoological Nomenclature, 4th Edition. The International Trust for Zoological Nomenclature. London.

Kuznetsov, G., 2000 - Mammals of coastal islands of Vietnam: zoogeographical and ecological aspects. *In* Isolated Vertebrate Communities in the tropics, Proc. 4th Int. Symp., Bonn. Bonn. Zool. Monographs, 46, 2000.

Lekagul, B. and J.A. McNeely, 1977 - Mammals of Thailand. Association for the Conservation of Wildlife. Bangkok, Thailand. 758 pp.

Marshall, J.T., 1977a - Family Muridae Pp. 397-487, *In* Mammals of Thailand (B. Lekagul and J.A. McNeely eds.). Kurusapha Press, Bangkok, Thailand, 758 pp.

Marshall, J.T., 1977b - A synopsis of Asian species of *Mus* (Rodentia, Muridae). Bulletin of the American Museum of Natural History 158:3.

Medway, L., 1964 - The marmoset rat, *Hapalomys longicaudatus* Blyth. Malayan Nat. Jour., vol. 18 no. 2 and 3.

Medway, L., 1969 - The wild mammals of Malaya and offshore islands including Singapore. Oxford University Press, London, 118 pages.

Medway, L., 1977 - Mammals of Borneo: Field keys and an annotated checklist. Second Edition. Monograph, Malay Branch of the Royal Asiatic Society, 7:1-172.

Medway, L., 1978 - The wild mammals of Malaya (Peninsular Malaysia) and Singapore. Oxford University Press, Kuala Lumpur, 128 pages.

Miller, G.S., 1932 - Directions for preparing specimens of mammals. Bulletin of the U.S. National Museum 39, Part N. Washington D.C.

Missonne, X., 1969 - African and Indo-Australian Muridae: evolutionary trends. Annales Muse'e Royal de l'Afrique Centrale, Tervuren, Belgique, Serie IN-8, Sciences Zoologiques, 172:1-219.

Moore, J.C. and G.H.H. Tate, 1965 - A study of the diurnal squirrels, Sciurinae, of the Indian and Indo-Chinese subregions. Feldiana Zool. 48: 1-351.

Musser, G.G., 1972 - The species of *Hapalomys* (Rodentia, Muridae). American Museum Novitates 2503.

Musser, G.G., 1973 - Zoogeographical significance of the ricefield rat, *Rattus arginiventer*, on Celebes and New Guinea and the identity of *Rattus pesticulus*. American Museum Novitates 2511.

Musser, G.G., 1973 - Species-limits of *Rattus cremoriventer* and *Rattus langbianis*, Murid rodents of southeast Asia and the greater Sunda Islands. American Museum Novitates. No. 2525.

Musser, G.G., 1979 - Results of the Archbold expeditions. No. 102. The species of

Chiropodomys, arboreal mice of Indochina and the Malay Archipelago. Bull. Am. Mus Nat Hist. 162:6.

Musser, G.G., 1981 - Results of the Archbold expeditions. No. 105. Notes on the systematics of the Indo-Malayan Murid rodents, and a descriptions of new genera and species from Ceylon, Sulawesi, and the Philippines. Bulletin of the American Museum of Natural History 168:3.

Musser, G.G. and E.M. Brothers, 1994 - Identification of Bandicoot rats from Thailand (*Bandicota*, Muridae, Rodentia). American Museum Novitates 3110.

Musser, G.G., and M.D. Carleton, 1993 - Family Muridae. *In* D.E. Wilson and D.M. Reeder (eds.), Mammal species of the world. A taxonomic and geographic reference, 2nd ed., pp.501-755. Washington D.C. : Smithsonian Inst. Press.

Musser, G.G. and L.R. Heaney, 1992 - Philippine rodents: Definitions of *Tarsomys* and *Limnomys* plus a preliminary assessment of phylogenetic patterns among native Philippine murines (Murinae, Muridae). Bulletin of the American Museum of Natural History, 211:1-138.

Musser, G.G. and M.E. Holden, 1991 - Sulawesi Rodents (Muridae: Murinae): Morphological and geographic boundaries of species in the *Rattus hoffmanni* group and a new species from Pulau Peleng. *In* Contributions to mammalogy in honor of Karl F. Koopman. Griffiths, T.A. and D. Klingener, Eds. Bulletin of the American Museum of Natural History: 206

Musser, G.G., J.T. Marshall Jr. and Boeadi, 1979 - Definition and contents of the sundaic genus *Maxomys* (Rodentia, Muridae). J. Mammalogy, 60(3):592-606.

Musser, G.G. and C. Newcomb, 1983 - Malaysian Murids and the giant rat of Sumatra. Bulletin of the American Museum of Natural History 174:4.

Musser, G.G. and C. Newcomb, 1985 - Definitions of Indochinese *Rattus losea* and a new species from Vietnam. American Museum Novitates 2814.

Muul, I., 1989 - Rodents of conservation concern in the southeast Asian region. *In*: Rodents. A world survey of species of conservation concern. Ed. Lidicker, W.Z.Jr., Pp. 51-52.

Muul, I., and L.B. Liat, 1978 - Comparative Morphology, Food Habits, and Ecology of some Malaysian Arboreal rodents. *In*: The ecology of arboreal folivores. Ed. G.G. Montgomery, Smithsonian Institution Press, Washington, D.C. Pp. 361-368.

Nagorsen and Peterson, 1980 - Mammal Collectors' Manual. Life Sciences Misc. publications Royal Ontario Museum.

Nguyen Minh Tam, 1998 - Rodent diversity: description of a species in Pumat natural reserve. Unpublished report of the Social forestry and nature conservation in Nghe An province, biodiversity survey programme. Ha Noi.

Osgood, W.H., 1932 - The mammals of the Kelly-Roosevelts and Delacour Asiatic

expeditions. Field Museum of Natural History, Zoological Series 18: 193-339.

Reynolds, R.P., R.I. Crombie, R. W. McDiarmid, and T.Y. Yates, 1996 - Voucher Specimens. *In*: Measuring and Monitoring Biological Diversity Standard Methods for Mammals (Eds. D.E. Wilson *et al.*)

Setzer, H.W., 1968 - Directions for preserving mammals for museum study. United States national museum, Smithsonian Institution, Information leaflet 380:1-19.

Sokolov, V.E., S.A. Shilova, V.S. Gromov, O.N. Shekarova, and N.A. Shchipanov, 1993 - Some features of the ecology and behavior of red spiny rats *Maxomys surifer* Miller, 1900. Russian Journal of Ecology, Vol. 24, No. 4.

Tate, G.H.H., 1947 - Mammals of eastern Asia. Macmillan. New York. Pp 1-365.

Thorington, R.W., Jr., A.L. Musante, C.G. Anderson, and K. Darrow, 1996 - Validity of three genera of flying squirrels: *Eoglaucomys*, *Glaucomys*, and *Hylopetes*. J. Mammalogy 77: 69-83.

Tien, D.V., 1972 - Ve cac dang chuot dui lon (*Bandicota indica*) (Rodentia, Muridae) o Viet Nam va vung lan can. Thong bao khoa hoc. SVH, DHTH Ha Noi, 4: 49-54.

Tien, D.V., and C.V. Sung, 1971 - Donnees ecologiques sur les rats de bambou (*Rhizomys pruinosus* Blyth et *Rhizomys sumatrensis cinereus* McClelland) au Vietnam. Zool. Garten 40:227-31.

Van Peenen, P.F.D., Ryan, P.F., and R.H. Light, 1969 - Preliminary identification manual for mammals of South Vietnam. Smithsonian Institution, Washington D.C.

Van Weers, D.J., 1977 - Notes on southeast asian porcupines (Hystricidae, Rodentia) II. On the taxonomy of the Genus Atherurus F. Cuvier. Beaufortia (University of Amsterdam), 26(336):205-230.

Van Weers, D.J., 1979 - Notes on southeast Asian porcupines (Hystricidae, Rodentia) IV. On the taxonomy of the subgenus Acanthion F. Cuvier. Beaufortia, 29(356):215-272.

Williams, S.L. and C.A. Hanks, 1987 - History of the preparation materials used for recent mammal specimens. Pp. 21-49. In H.H. Genoways, C. Jones, and O.L. Rossolimo (eds.), Mammal collection management. Texas Tech University press, Lubbock, Texas.

Wilson D.E., F.R. Cole, J.D. Nichols, R. Rudran, and M.S. Foster (Eds.), 1996 - Measuring and monitoring biological diversity. 1996. Standard methods for mammals. Smithsonian Institution, Washington D.C.

Woods, C.A., 1993 - Suborder Hystricogathi. *In* D.E. Wilson and D.M. Reeder (eds.), Mammal species of the world. A taxonomic and geographic reference, 2nd ed., pp.771-806. Washington D.C. : Smithsonian Inst. Press.

Yong, H.S., 1970 - A Malayan view of *Rattus edwardsi* and *R. sabanus* (Rodentia:

Muridae). Zool. J. Linn. Soc. 49, pp 359-370

Yong, H.S., 1972 - The systematic status of Malayan *Rattus rajah* and *Rattus surifer*. Bull. British Mus. (Nat. Hist.) Zool., 23:157-165.

APPENDIX I

A Systematic List of the Rodents of Viet Nam

Family Sciuridae
Subfamily Sciurinae
Callosciurus erythraeus
Callosciurus finlaysonii
Callosciurus inornatus
Dremomys gularis
Dremomys pernyi
Dremomys rufigenis
Menetes berdmorei
Ratufa bicolor
Tamiops macclellandi
Tamiops maritimus
Tamiops rodolphei
Tamiops swinhoei
Sundasciurus hippurus

Subfamily Pteromyinae
Belomys pearsonii
Hylopetes alboniger
Hylopetes phayrei
Hylopetes spadiceus
Petaurista elegans
Petaurista philippensis

Family Muridae
Subfamily Murinae
Bandicota indica
Bandicota savilei
Berylmys berdmorei
Berylmys bowersi
Berylmys mackenziei
Chiromyscus chiropus
Chiropodomys gliroides
Dacnomys millardi
Hapalomys delacouri
Leopoldamys edwardsi
Leopoldamys sabanus
Maxomys moi
Maxomys surifer
Micromys minutus
Mus caroli
Mus cervicolor
Mus cookii
Mus musculus
Mus pahari
Niviventer confucianus
Niviventer fulvescens
Niviventer langbianis
Niviventer tenaster
Rattus argentiventer
Rattus exulans
Rattus losea
Rattus nitidus
Rattus norvegicus
Rattus osgoodi
Rattus rattus
Rattus remotus
Rattus tanezumi
Vandeleuria oleracea

Subfamily Platacanthomyinae
Typhlomys chapensis

Subfamily Arvicolinae
Eothenomys melanogaster

Subfamily Rhizomyinae
Cannomys badius
Rhizomys pruinosus
Rhizomys sinensis
Rhizomys sumatrensis

Family Hystricidae
Atherurus macrourus
Hystrix brachyura

APPENDIX II

Cranial Measurements of Selected Murid Genera

Definitions of Cranial Measurements (after Musser, 1979).

Occipitonasal Length (ONL) - The distance from the tip of the nasals to the posterior margin of the occiput.
Zygomatic Breadth (ZB) - The greatest breadth across the zygomatic arches.
Interorbital Breadth (IB) - The least distance, as viewed dorsally, across the frontal bones between the orbital fossae.
Length of Rostrum (LR) - The distance from the tip of the nasal bones to the posterior margin of the zygomatic notch (the anterior edge of the dorsal maxillary root of the zygomatic plate).
Breadth of Rostrum (BR) - The greatest breadth across the rostrum, including the bony capsules enclosing the nasolacrimal canals.
Breadth of Braincase (BB) - The breadth of the braincase measured just above the squamosal roots of each zygomatic arch.
Height of Braincase (HB) - The distance from the top of the braincase to the ventral surface of the basisphenoid bone.
Length of Diastema (LD) - The distance from the posterior alveolar margins of the upper incisors to the anterior alveolar margins of the first upper molars.
Post Palatal Length (PPL) - The distance from the posterior margin of the palatal bridge to the posterior edge of the basioccipital bone (the ventral lip of the foramen magnum).
Length of Bony Palate (LBP) - The distance from the posterior edge of the incisive foramina to the posterior margin of the bony palate.
Breadth Across First Molars (BAM) - The least distance between the lingual edge of the alveolus of the first molar and the lingual edge of the opposite molar.
Breadth of Mesopterygoid Fossa (BMF) - The distance from one edge of the mesopterygoid fossa to the other.
Length Incisive Foramina (LIF) - The distance from the anterior edge of one of the foramina to its posterior edge.
Breadth Incisive Foramina (BIF) - The greatest distance across both foramina.
Length of Bullae (LB) - The length of the bullae, excluding the bony eustachian tube.
Length of Molar Toothrow (LM) - The distance from the anterior crown of the first molar to the posterior crown of the third molar.
Breadth of First Molar (BFM) - The greatest distance from the labial crown, to the lingual crown of the first molar.

Bandicota indica - Specimens from Viet Nam and Thailand (values from Musser and Brothers, 1994).

	MEAN	RANGE	SD	N
ONL	55.6	49.0-64.2	3.30	30
ZB	30.2	26.1-33.6	2.09	32
IB	7.6	6.7-8.7	0.48	34
LR	-	-	-	-
BR	11.7	9.7-13.5	0.61	35
BB	20.2	18.7-21.4	0.64	35
HB	15.6	13.9-17.6	0.81	33
LD	17.1	14.6-20.1	1.46	35
PPL	-	-	-	-
LBP	12.3	10.7-14.5	0.96	35
BAM	4.1	2.8-5.0	0.48	35
BMF	3.5	2.7-4.2	0.34	35
LIF	10.3	8.8-11.5	0.70	35
BIF	2.9	2.6-3.5	0.29	35
LB	10.4	9.3-12.2	0.61	34
LM	11.5	10.7-12.4	0.43	35
BFM	-	-	-	-

Bandicota savilei - Specimens from Thailand (values from Musser and Brothers, 1994).

	MEAN	RANGE	SD	N
ONL	44.9	42.0-47.8	1.88	31
ZB	24.6	22.4-26.5	1.04	31
IB	6.4	5.8-6.9	0.28	33
LR	-	-	-	-
BR	9.0	8.1-10.2	0.58	32
BB	17.5	16.6-18.3	0.46	33
HB	13.4	12.3-14.4	0.51	33
LD	13.1	11.5-15.5	1.04	33
PPL	-	-	-	-
LBP	9.5	8.6-10.5	0.49	33
BAM	3.3	3.1-4.1	0.22	33
BMF	2.9	2.6-3.4	0.20	35
LIF	8.1	7.3-9.5	0.53	33
BIF	2.5	2.1-3.0	0.20	33
LB	8.9	8.1-9.5	0.34	33
LM	9.2	8.6-9.7	0.29	33
BFM	-	-	-	-

Berylmys berdmorei- Specimens from Viet Nam (values from Musser and Newcomb, 1983).

	MEAN	RANGE	SD	N
ONL	44.8	44.3-45.3	0.7	2
ZB	22.7	21.7-23.6	0.9	3
IB	6.9	6.6-7.3	0.4	3
LR	15.2	15.1-15.2	0.1	2
BR	8.8	8.1-9.3	0.6	3
BB	17.3	16.9-18.0	0.6	3
HB	13.2	12.6-14.3	0.9	3
LD	14.1	13.9-14.2	0.2	3
PPL	16.4	16.1-16.8	0.4	3
LBP	7.8	7.3-8.1	0.4	3
BAM	3.7	3.5-3.8	0.2	3
BMF	2.8	2.5-3.1	0.3	3
LIF	8.1	8.1-8.2	0.1	3
BIF	2.9	2.6-3.1	0.3	3
LB	8.1	8.0-8.2	0.1	3
LM	7.6	7.2-8.0	0.4	3
BFM	2.3	2.2-2.4	0.1	3

Berylmys bowersi - Specimens from Viet Nam (values from Musser and Newcomb, 1983).

	MEAN	RANGE	SD	N
ONL	55.8	54.7-56.7	0.8	6
ZB	26.7	24.6-28.2	1.3	7
IB	8.3	7.8-8.9	0.1	7
LR	18.4	17.8-19.2	0.6	7
BR	10.4	9.7-11.7	0.6	7
BB	20.9	20.4-21.2	0.3	7
HB	15.8	15.4-16.4	0.4	6
LD	16.8	16.0-17.8	0.7	7
PPL	22.0	-	0.0	1
LBP	10.2	9.5-11.2	0.6	7
BAM	4.8	4.5-5.1	0.2	7
BMF	3.8	3.5-4.2	0.2	7
LIF	10.6	9.7-11.2	0.5	7
BIF	3.7	3.4-4.2	0.3	7
LB	7.5	7.3-8.0	0.3	7
LM	9.8	9.2-10.6	0.4	7
BFM	2.8	2.7-2.9	0.1	7

Berylmys mackenziei - Specimens from Viet Nam (values from Musser and Newcomb, 1983).

	MEAN	RANGE	SD	N
ONL	53.2	52.3-53.2	0.8	3
ZB	26.1	25.3-27.4	1.1	3
IB	7.8	7.6-8.3	0.4	3
LR	17.9	17.5-18.3	0.4	3
BR	9.4	8.9-9.9	0.5	3
BB	20.0	19.6-20.4	0.4	3
HB	14.4	13.8-15.0	0.6	3
LD	16.2	15.7-16.6	0.5	3
PPL	19.3	19.0-19.6	0.3	3
LBP	10.6	10.1-10.9	0.4	3
BAM	4.6	4.5-4.7	0.1	3
BMF	3.6	3.5-3.7	0.1	3
LIF	9.6	9.5-9.8	0.2	3
BIF	3.2	3.1-3.5	0.2	3
LB	7.1	6.6-7.6	0.5	3
LM	9.3	9.0-9.8	0.4	3
BFM	2.7	2.6-2.7	0.1	2

Chiromyscus chiropus - Specimens from Viet Nam.

	MEAN	RANGE	SD	N
ONL	41.7	41.3-42.2	0.65	2
ZB	20.1	20.0-20.2	0.13	2
IB	6.8	6.72-6.84	0.08	2
LR	13.7	13.6-13.7	0.07	2
BR	7.4	7.4	0	2
BB	16.3	16.1-16.5	0.28	2
HB	13.4	13.2-13.5	0.19	2
LD	11.5	11.3-11.7	0.28	2
PPL	15.0	14.5-15.5	0.76	2
LBP	7.10	6.6-7.6	0.64	2
BAM	4.5	4.3-4.7	0.28	2
BMF	3.1	2.9-3.3	0.28	2
LIF	7.93	7.7-8.2	0.37	2
BIF	3.4	3.1-3.7	0.42	2
LB	5.0	4.9-5.1	0.13	2
LM	7.5	7.5	0	2
BFM	8.8	8.6-9.0	0.28	2

Chiropodomys gliroides - Specimens from Viet Nam, Laos, Thailand (values from Musser, 1979).

	MEAN	RANGE	SD	N
ONL	24.73	23.6-25.9	0.64	18
ZB	14.37	13.8-15.1	0.33	17
IB	4.52	4.1-4.8	0.18	21
LR	5.76	5.2-6.3	0.31	21
BR	4.87	4.3-5.2	0.22	21
BB	12.22	11.9-12.7	0.23	18
HB	7.94	7.4-8.5	0.29	17
LD	6.46	5.9-7.0	0.31	22
PPL	8.69	7.8-9.6	0.42	19
LBP	4.58	4.1-5.0	0.24	21
BAM	3.00	2.8-3.4	0.15	21
BMF	1.79	1.5-2.3	0.20	21
LIF	4.33	3.8-4.9	0.28	22
BIF	2.07	1.8-2.2	0.10	21
LB	3.63	3.5-3.8	0.14	19
LM	3.92	3.6-4.1	0.16	22
BFM	-	-	-	-

Hapalomys delacouri - Specimens Viet Nam, (values from Musser, 1972).

	MEAN	RANGE	SD	N
ONL	34.0	33.6-34.2	-	3
ZB	17.57	17.4-17.8	-	3
IB	4.75	4.3-5.1	-	4
LR	9.47	9.3-9.7	-	3
BR	6.38	6.0-6.7	-	4
BB	15.20	15.1-15.3	-	4
HB	9.33	9.1-9.5	-	4
LD	8.45	8.1-8.8	-	4
PPL	-	-	-	-
LBP	6.85	6.4-7.1	-	4
BAM	2.35	2.1-2.6	-	4
BMF	1.93	1.8-2.1	-	4
LIF	6.28	6.1-6.6	-	4
BIF	1.95	1.9-2.0	-	4
LB	6.25	-	-	4
LM	6.35	-	-	4
BFM	-	-	-	-

Leopoldamys sabanus - Specimens from Viet Nam.

	MEAN	RANGE	SD	N
ONL	55.5	51.8-58.9	2.01	21
ZB	23.7	20.7-25.4	1.15	21
IB	8.3	7.6-9.0	0.35	21
LR	18.6	17.0-19.8	0.73	21
BR	9.5	8.9-10.4	0.47	21
BB	20.3	19.0-21.3	0.65	21
HB	14.1	13.1-15.0	0.56	21
LD	14.4	13.0-15.9	0.83	21
PPL	20.1	18.1-22.3	1.25	21
LBP	10.4	9.3-11.4	0.52	21
BAM	4.5	3.8-5.1	0.30	21
BMF	4.6	4.0-5.5	0.39	21
LIF	8.8	7.4-9.6	0.65	21
BIF	3.9	3.6-4.4	0.22	21
LB	5.8	5.5-6.3	0.23	21
LM	9.3	8.8-10.1	0.28	21
BFM	2.8	2.5-3.1	0.14	21

Maxomys moi - Values from Musser, Marshall and Boeadi, (1979).

	MEAN	RANGE	SD	N
ONL	43.4	40.3-45.9	1.5	26
ZB	19.4	18.3-20.4	0.6	24
IB	6.7	6.3-7.4	0.4	26
LR	14.4	13.1-16.4	0.8	26
BR	7.6	6.8-8.3	0.4	26
BB	16.6	16.1-17.2	0.3	25
HB	11.5	10.9-11.9	0.3	25
LD	11.8	10.9-13.1	0.5	26
PPL	15.9	14.5-17.0	0.7	25
LBP	17.6	16.6-19.1	0.6	26
BAM	-	-	-	-
BMF	-	-	-	-
LIF	4.7	4.0-5.4	0.4	21
BIF	2.5	2.0-2.9	0.2	21
LB	4.2	3.9-4.7	0.2	21
LM	5.5	5.1-6.2	0.3	21
BFM	1.6	1.5-1.8	0.1	21

Maxomys surifer - Specimens from Viet Nam

	MEAN	RANGE	SD	N
ONL	43.6	40.1-46.9	2.09	14
ZB	19.1	18.0-20.2	0.72	14
IB	7.0	6.1-7.5	0.36	14
LR	14.1	13.0-15.1	0.74	14
BR	7.7	7.0-8.5	0.45	14
BB	17.0	16.2-17.5	0.42	14
HB	11.8	10.9-12.4	0.44	14
LD	11.8	10.8-13.2	0.76	14
PPL	15.5	13.7-17.7	0.98	14
LBP	8.1	7.5-8.7	0.44	14
BAM	4.3	3.8-4.9	0.3	14
BMF	3.2	2.8-3.5	0.21	14
LIF	6.8	6.1-7.3	0.42	14
BIF	3.3	2.9-3.7	0.24	14
LB	5.3	5.0-5.7	0.18	14
LM	6.5	6.1-6.9	0.20	14
BFM	2.1	2.0-2.2	0.09	14

Micromys minutus - Specimens from northern Myanmar and southern China.

	MEAN	RANGE	SD	N
ONL	18.2	17.6-18.6	0.50	4
ZB	9.4	8.8-9.8	0.35	9
IB	3.1	2.9-3.3	0.10	14
LR	4.3	4.0-5.0	0.30	9
BR	3.2	2.9-3.5	0.19	12
BB	9.2	8.7-9.5	0.27	8
HB	6.1	5.5-6.9	0.52	6
LD	4.2	3.9-4.6	0.24	13
PPL	5.8	5.4-6.3	0.37	5
LBP	4.0	3.7-4.6	0.28	10
BAM	1.8	1.7-1.9	0.08	11
BMF	0.8	0.6-1.0	0.14	6
LIF	3.6	3.5-4.1	0.31	12
BIF	1.3	1.1-1.4	0.09	11
LB	4.1	3.8-4.3	0.15	8
LM	3.0	2.8-3.1	0.09	12
BFM	0.9	0.9-1.0	0.03	13

Mus caroli - Specimens from Laos.

	MEAN	RANGE	SD	N
ONL	20.1	18.9-20.5	0.95	6
ZB	10.5	10.1-11.2	0.43	5
IB	3.7	3.5-3.8	0.09	9
LR	5.8	5.3-6.7	0.50	9
BR	3.8	3.5-3.8	0.26	8
BB	9.3	8.8-9.8	0.38	9
HB	7.9	7.5-8.7	0.37	8
LD	5.5	5.1-6.2	0.36	8
PPL	7.5	7.0-8.7	0.58	8
LBP	3.5	3.1-4.1	0.34	8
BAM	2.0	1.7-2.3	0.17	9
BMF	0.8	0.8-0.9	0.06	9
LIF	4.2	3.5-4.5	0.29	8
BIF	1.4	1.3-1.6	0.12	8
LB	3.5	3.2-3.8	0.20	9
LM	3.4	3.2-3.8	0.17	9
BFM	-	-	-	-

Mus cervicolor - Specimens from Viet Nam.

	MEAN	RANGE	SD	N
ONL	21.8	20.4-24.5	1.91	4
ZB	10.7	9.9-11.1	0.53	4
IB	3.6	3.5-3.8	0.13	4
LR	7.0	5.9-8.2	0.94	5
BR	3.9	3.6-4.4	0.32	5
BB	9.3	8.9-9.7	0.44	3
HB	7.2	6.4-8.4	0.92	4
LD	6.1	5.5-7.3	0.69	5
PPL	7.8	7.3-9.0	0.78	4
LBP	3.6	3.3-3.9	0.26	5
BAM	2.0	1.9-2.4	0.21	5
BMF	0.8	0.7-0.9	0.07	4
LIF	4.7	4.4-4.9	0.23	5
BIF	1.6	1.4-1.7	0.14	5
LB	3.8	3.7-4.0	0.13	4
LM	3.7	3.4-4.0	0.32	4
BFM	1.2	1.2-1.3	0.06	2

Mus cookii - Specimens from Thailand and Yunnan, China.

	MEAN	RANGE	SD	N
ONL	24.4	24.0-25.0	0.42	4
ZB	11.4	9.9-12.3	1.00	5
IB	3.9	3.7-4.0	0.14	6
LR	7.3	6.7-7.7	0.36	6
BR	4.2	4.0-4.5	0.21	7
BB	10.3	10.0-10.7	0.34	4
HB	7.2	6.9-7.6	0.33	5
LD	6.5	6.1-7.0	0.38	7
PPL	8.7	7.8-9.2	0.51	5
LBP	4.0	3.7-4.2	0.18	6
BAM	2.4	2.2-2.7	0.20	6
BMF	1.0	0.9-1.0	0.10	5
LIF	5.13	4.6-5.6	0.39	7
BIF	1.6	1.4-1.9	0.20	6
LB	4.0	3.8-4.2	0.22	5
LM	4.0	3.8-4.3	0.17	7
BFM	1.4	1.3-1.5	0.06	7

Mus pahari - Specimens from Viet Nam.

	MEAN	RANGE	SD	N
ONL	24.0	24.0-24.0	0	2
ZB	10.9	10.8-11.0	0.15	2
IB	4.5	4.5-4.5	0	2
LR	7.9	7.7-8.0	0.21	2
BR	4.5	4.3-4.6	0.21	2
BB	10.2	10.0-10.3	0.21	2
HB	6.7	6.6-6.8	0.14	2
LD	7.1	6.9-7.2	0.21	2
PPL	8.8	8.5-9.0	0.35	2
LBP	4.2	4.1-4.2	0.07	2
BAM	2.7	2.5-2.8	0.21	2
BMF	1.4	1.2-1.5	0.21	2
LIF	4.4	4.4-4.4	0	2
BIF	2.1	2.0-2.1	0.07	2
LB	4.1	4.1-4.1	0	2
LM	3.3	3.3-3.3	0	2
BFM	1.2	1.1-1.2	0.07	2

Niviventer langbianis - Specimens from Viet Nam.

	MEAN	RANGE	SD	N
ONL	36.00	33.3-40.5	1.37	48
ZB	16.9	15.7-18.9	0.62	48
IB	5.8	5.1-6.5	0.29	48
LR	11.0	9.7-12.7	0.65	48
BR	5.9	5.3-6.7	0.31	48
BB	15.0	14.3-16.2	0.36	48
HB	9.9	9.0-10.9	0.36	48
LD	9.1	7.9-10.4	0.54	48
PPL	12.3	10.9-14.5	0.68	48
LBP	6.1	5.3-6.9	0.36	48
BAM	3.3	3.0-3.9	0.19	48
BMF	2.7	2.3-3.4	0.24	48
LIF	6.6	5.6-7.5	0.45	48
BIF	2.6	2.2-3.1	0.19	48
LB	5.4	5.0-5.8	0.18	48
LM	6.2	5.8-6.5	0.17	48
BFM	1.8	1.7-2.0	0.08	48

Niviventer tenaster - Specimens from Viet Nam

	MEAN	RANGE	SD	N
ONL	39.9	37.0-41.9	1.38	11
ZB	17.2	16.5-18.0	0.48	11
IB	6.1	5.8-6.7	0.26	11
LR	13.1	11.8-14.5	0.75	11
BR	6.6	6.4-7.3	0.25	11
BB	15.5	15.2-16.1	0.23	11
HB	10.6	10.2-11.1	0.27	11
LD	10.2	9.2-10.9	0.50	11
PPL	13.9	12.5-14.6	0.58	11
LBP	7.0	6.5-7.3	0.22	11
BAM	3.9	3.6-4.3	0.21	11
BMF	3.3	2.4-3.7	0.35	11
LIF	6.7	6.3-7.3	0.34	11
BIF	2.9	2.8-3.1	0.08	11
LB	5.4	5.2-5.7	0.16	11
LM	6.1	5.9-6.4	0.15	11
BFM	1.8	1.7-1.9	0.07	11

Niviventer confucianus - Specimens from western Sichuan Prov., China, near the type locality of *confucianus.*

	MEAN	RANGE	SD	N
ONL	34.5	32.0-39.2	1.58	59
ZB	15.6	14.5-17.6	0.66	59
IB	5.2	4.8-5.8	0.20	59
LR	10.9	9.7-12.8	0.75	59
BR	5.7	5.1-7.1	0.43	59
BB	14.3	13.5-15.2	0.35	59
HB	9.6	8.8-10.5	0.40	59
LD	8.5	7.5-9.9	0.57	59
PPL	11.9	10.7-13.9	0.70	59
LBP	6.0	5.3-8.0	0.42	59
BAM	3.4	3.1-3.9	0.21	59
BMF	2.7	2.4-3.7	0.23	59
LIF	6.1	5.4-7.4	0.39	59
BIF	2.6	2.2-3.1	0.21	59
LB	5.1	4.7-5.5	0.18	59
LM	5.8	5.3-6.3	0.19	59
BFM	1.7	1.5-1.8	0.07	59

Niviventer fulvescens - Specimens from Viet Nam.

	MEAN	RANGE	SD	N
ONL	36.9	33.6-40.0	1.56	28
ZB	16.3	15.0-17.7	0.68	28
IB	5.7	5.0-6.3	0.29	28
LR	11.8	10.5-13.5	0.71	28
BR	6.1	5.3-6.7	0.35	28
BB	14.9	13.7-15.7	0.53	28
HB	10.0	9.4-10.5	0.30	28
LD	9.3	7.6-10.2	0.56	28
PPL	12.5	10.7-14.5	0.85	28
LBP	6.6	5.9-7.1	0.30	28
BAM	3.6	3.1-3.9	0.20	28
BMF	2.8	2.4-3.5	0.24	28
LIF	6.3	5.5-6.8	0.35	28
BIF	2.5	2.2-3.0	0.21	28
LB	4.6	4.4-4.8	0.10	28
LM	6.1	5.8-6.3	0.15	28
BFM	1.8	1.6-1.9	0.06	28

Rattus argentiventer - Specimens from Viet Nam.

	MEAN	RANGE	SD	N
ONL	34.5	32.9-38.3	1.54	10
ZB	17.2	16.5-18.8	0.75	10
IB	5.2	5.0-5.8	0.23	10
LR	10.4	9.6-11.7	0.58	10
BR	6.0	5.7-6.6	0.26	10
BB	14.9	14.2-16.1	0.52	10
HB	11.6	10.7-12.2	0.43	10
LD	8.7	8.0-9.5	0.42	10
PPL	11.3	10.6-13.2	0.77	10
LBP	6.8	6.0-7.9	0.50	10
BAM	3.0	2.6-3.6	0.28	10
BMF	2.0	1.7-2.1	0.11	10
LIF	6.4	6.1-6.8	0.27	10
BIF	2.0	1.7-2.1	0.15	10
LB	6.7	6.3-7.2	0.24	10
LM	6.6	6.3-7.1	0.21	10
BFM	7.1	6.8-7.8	0.29	10

Rattus exulans - Specimens from Viet Nam.

	MEAN	RANGE	SD	N
ONL	29.0	26.3-32.5	1.79	11
ZB	13.5	12.7-14.3	0.54	9
IB	4.6	4.4-4.9	0.15	12
LR	9.2	8.4-10.6	0.78	12
BR	4.7	4.2-5.1	0.26	12
BB	12.6	12.2-13.3	0.37	11
HB	10.1	9.5-11.0	0.46	11
LD	7.4	6.6-8.6	0.63	12
PPL	9.7	8.5-11.3	0.85	11
LBP	5.3	4.6-5.9	0.45	12
BAM	2.7	2.3-3.2	0.28	11
BMF	1.8	1.5-1.9	0.14	11
LIF	5.3	4.9-6.4	0.41	12
BIF	1.9	1.7-2.1	0.12	12
LB	5.3	5.0-5.9	0.25	11
LM	4.7	4.5-4.9	0.15	11
BFM	-	-	-	-

Rattus losea - Specimens from Viet Nam (values from Musser and Newcomb 1985).

	MEAN	RANGE	SD	N
ONL	36.6	34.6-37.8	1.0	10
ZB	17.3	16.0-18.2	0.8	7
IB	5.1	4.8-5.3	0.1	10
LR	10.9	10.3-11.6	0.5	10
BR	6.8	6.4-7.2	0.3	10
BB	14.1	13.6-14.6	0.3	10
HB	10.6	10.1-11.1	0.3	10
LD	10.2	9.3-10.9	0.5	10
PPL	12.4	11.6-12.8	0.4	10
LBP	7.5	7.0-8.0	0.4	10
BAM	3.5	3.1-3.9	0.3	10
BMF	2.3	2.2-2.4	0.1	10
LIF	7.0	6.4-7.6	0.4	10
BIF	2.4	2.2-2.8	0.2	10
LB	6.6	6.2-7.0	0.2	10
LM	6.6	6.2-6.7	0.3	10
BFM	-	-	-	-

Rattus nitidus - Specimens from Viet Nam and Laos.

	MEAN	RANGE	SD	N
ONL	38.1	33.8-43.8	3.99	6
ZB	18.9	15.8-20.4	2.16	4
IB	5.7	5.2-6.4	0.41	8
LR	12.7	10.9-14.6	1.43	8
BR	6.7	5.6-7.9	1.07	8
BB	15.8	14.7-16.5	0.67	7
HB	12.6	11.6-13.8	0.91	6
LD	10.3	8.8-12.5	1.50	7
PPL	12.5	10.7-14.5	1.63	6
LBP	7.2	6.4-8.4	0.81	8
BAM	3.9	3.2-4.6	0.63	7
BMF	2.6	2.3-2.9	0.26	8
LIF	7.3	6.5-8.5	0.84	8
BIF	2.4	2.0-2.8	0.33	8
LB	6.2	5.7-6.8	0.39	8
LM	6.6	6.1-7.2	0.40	8
BFM	1.9	1.9-2.0	0.06	2

Rattus osgoodi - Specimens from Viet Nam (values from Musser and Newcomb 1985).

	MEAN	RANGE	SD	N
ONL	32.8	31.0-36.2	1.4	15
ZB	16.6	15.2-17.9	0.9	12
IB	5.1	4.8-5.5	0.2	16
LR	9.5	8.1-11.1	0.8	16
BR	6.0	5.6-6.7	0.4	16
BB	13.9	13.4-14.5	0.3	16
HB	9.9	9.6-10.4	0.2	15
LD	8.8	8.0-10.0	0.6	16
PPL	10.8	10.0-12.0	0.6	15
LBP	6.5	6.0-7.1	0.3	16
BAM	3.2	2.7-3.7	0.3	16
BMF	2.0	1.7-2.3	0.2	16
LIF	6.5	5.9-7.2	0.4	16
BIF	2.0	1.7-2.5	0.2	16
LB	6.1	5.8-6.7	0.3	16
LM	5.8	5.3-6.0	0.2	16
BFM	-	-	-	-

Rattus remotus - Specimens from southern Viet Nam

	MEAN	RANGE	SD	N
ONL	41.9	40.1-43.4	0.88	16
ZB	20.3	19.3-21.4	0.53	16
IB	6.02	5.6-6.4	0.25	16
LR	13.1	12.2-13.7	0.45	16
BR	7.4	6.9-7.9	0.30	16
BB	16.4	15.5-17.2	0.46	16
HB	11.5	10.7-12.2	0.51	16
LD	10.9	10.1-11.5	0.41	16
PPL	14.0	13.2-15.1	0.55	16
LBP	8.8	8.2-9.2	0.30	16
BAM	4.1	3.6-4.5	0.30	16
BMF	3.0	2.6-3.3	0.20	16
LIF	7.7	6.8-8.7	0.49	16
BIF	2.87	2.6-3.2	0.20	16
LB	6.6	6.2-7.1	0.24	16
LM	7.0	6.7-7.3	0.17	16
BFM	2.2	2.0-2.3	0.07	16

Rattus tanezumi - Specimens from southern Viet Nam.

	MEAN	RANGE	SD	N
ONL	40.9	37.7-44.4	1.65	22
ZB	19.2	15.7-21.2	1.10	22
IB	6.1	5.7-7.2	0.42	22
LR	12.5	11.2-14.2	0.72	22
BR	7.2	6.6-9.2	0.56	22
BB	16.1	15.0-19.1	0.81	22
HB	11.5	10.8-12.4	0.41	22
LD	10.2	7.3-12.5	1.00	22
PPL	14.0	12.7-15.3	0.60	22
LBP	7.8	6.9-9.0	0.54	22
BAM	3.7	3.2-4.7	0.36	22
BMF	2.7	2.1-3.5	0.30	22
LIF	7.6	6.5-8.8	0.6	22
BIF	2.8	2.3-3.3	0.29	22
LB	7.1	6.3-7.5	0.33	22
LM	6.7	6.0-7.2	0.30	22
BFM	2.1	2.0-2.3	0.11	22