

A new species of ferret-badger, Genus *Melogale*, from Vietnam

Eine neue Sonnendachs-Art, Gattung *Melogale*, von Vietnam

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Abstract

Ferret-badgers, genus *Melogale*, are distributed in the Indochinese region, Java, Bali and NE-Borneo. There are currently four species described each having very similar phenotypes. In March 2005, a living ferret-badger of a different phenotype was confiscated by rangers from Cuc Phuong National Park, Vietnam. This individual died and the carcass was not preserved. In January 2006, a newly deceased individual of the same phenotype was found at the Endangered Primate Rescue Center, Cuc Phuong National Park. Due to several different characteristics these individuals vary greatly from the current species. Thus, we describe an additional species, *M. cucphuongensis* sp. nov. from northern Vietnam, which occurs sympatrically with *M. moschata* and *M. personata*, but differs from both species clearly in skull morphology and other features.

Based on a 423 bp-long fragment of the mitochondrial cytochrome b gene, *M. cucphuongensis* sp. nov. is a member of the genus *Melogale* and represents a sister lineage to a clade consisting of *M. personata* and *M. moschata*.

Keywords: *Mustelidae*; *Helictidinae*; *Melogale*; new species; Vietnam

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Introduction

Ferret-badgers, genus *Melogale*, are distributed in the Indochinese region, Java, Bali and NE-Borneo. All species are very similar in coloration and size. There have been several taxonomic views and changes (Everts, 1967). Currently four species are recognized. *M. personata* occurs from Nepal eastward through Assam, Myanmar, Thailand, Laos, Cambodia, Vietnam and to southernmost parts of China (Schank et al., 2009). *M. moschata* occurs from central China and Taiwan southward to Assam, Bangladesh, northern Myanmar, Laos and north to central Vietnam (Robichaud, 2010). *M. orientalis* occurs on Java and Bali, and *M. everetti* has a small distribution, which was assumed to be restricted to Mount Kinabalu in north Borneo (Corbet & Hill, 1992; Sheng, Ohtaishi, & Lu, 1999; Francis, 2008; Wozencraft, 1993, 2005, 2008).), however recent sightings imply a lowland distribution as well (Boonratana, 2010).

M. personata and *M. moschata* share a large area with a sympatric distribution. Even though these two species are probably the best-known species of ferret-badgers, hardly any information on their biology and ecology is available (Wang & Fuller, 2003). There is even less information available about their habitat requirements or ecological niches, and therefore coexistence and/or competition of these species. The similarity in pelage coloration and the amount of color variation between individuals makes it near impossible to distinguish the species in the field.

Five subspecies are described for *M. personata* (Corbet & Hill, 1992) and six (Wozencraft, 1993; Storz & Wozencraft, 1999) or seven subspecies (Wozencraft, 2008) are recognized for *M. moschata*. The descriptions of subspecies are mostly based on fur coloration and body size. However, the extreme variability of these features makes the validity of several subspecies questionable. The main features to distinguish them are the differences in dental characteristics, the temporal crest and the form of the baculum (Allen, 1938; Gao, 1987; Pocock, 1941). However, the variability in the dentition in both of these species - as main identification feature - makes a specification occasionally difficult (Stefen & Feiler, 2004).

Material

In March 2005 rangers of Cuc Phuong National Park, northern Vietnam confiscated a male ferret-badger with a severe injury on a front leg probably from a snare trap. The veterinarian of the Endangered Primate Rescue Center, U. Streicher, amputated the leg and recognized the phenotypical differences to the known species. The animal recovered but strangulated itself in a cage wire and died in the same month. The carcass of this animal was not under the authority of the authors and was thrown away.

On January 2006, a freshly deceased individual ferret-badger of the same phenotype was found on the premises of the Endangered Primate Rescue Center, Cuc Phuong National Park. Due to several different characteristics these individuals vary greatly from the current species. Thus, we describe an additional species from northern Vietnam, which occurs sympatrically with *M. moschata* and *M. personata*, and which differs from both species clearly in skull morphology and other features.

Melogale cucphuongensis sp. nov.

Holotype

The *Melogale cucphuongensis* sp. nov. holotype is a male. Skull, bones and skin preserved at the Endangered Primate Rescue Center collection at Cuc Phuong National Park, Ninh Binh Province Vietnam.

Type locality

Endangered Primate Rescue Center, Cuc Phuong National Park, Vietnam (20° 45'N / 105° 43'E).

Description of holotype

Body. The general color of the body is brown. The tips of the longer hairs (guard hairs) are lighter in color and give the coat a silvery tone (frosting). The tail is relatively short and bushy and uniform in color (Fig. 1). The upper part of the head is brown and shows several small white markings on the forehead between eyes and ears. The rhinarium extends to the upper side of the nose and forms a small naked wedge (Fig. 2). The elongated nose is characteristic for this species. The snout is long and narrow and bends slightly upward. The mouth is set back in a clear distance from the nose. There are no white markings on the cheeks. The dark brown vibrissae are abundant and very long (Fig. 3). From the neck to shoulder runs a short and small white stripe bordered by black lines (Fig. 4). The first animal shows only a white patch between the shoulders (Fig. 5). The feet are small, digits not webbed, and the soles are naked. The creamy, light brown claws on the forefeet are very long and slightly curved. The under part of the body is cream-colored to light brown (Fig. 6). The holotype has a body weight of 800 g.

Cranium and mandible. The skull (Fig. 7) differs markedly in overall geometry from other skulls of *Melogale*, in particular from *M. personata* (Fig. 8) and *M. moschata* (Fig. 9). Measurements, collected from several sources are combined in Table 1.

The most striking feature of *M. cucphuongensis* is the narrow, slender snout, which also appears elongated. However, the relation of the part from the gnathion to the onset of the zygomatic arch in relation to the total length of the skull is about similar in this skull to *M. personata*. Nevertheless, the snout is more slender as the width of the snout is less in *M. cucphuongensis* than in other species of *Melogale*. In the new species the cranium is about 4 times wider than the snout, whereas it is two times wider than the snout in *M. personata*.

Measurements of the cranium and mandible of *M. cucphuongensis* are illustrated in Figs. 10 and 11 and given in Table 2.

The overall slender appearance of the skull is due to the much smaller zygomatic width (Tab. 1, 2) and the resulting narrow and slender orbitae. Particularly in dorsal view the distance from the zygomatic arch to the skull, frontal and parietal, particularly at the interorbital constriction is much less. The zygomatic arches have a tangential angle to the midline of about 24° in *M. cucphuongensis* compared to about 34° in *M. personata* and *M. moschata*,

The frontoparietal crests are visible from the orbital process to the occipital and are well developed, but still moderate, particularly compared to *M. personata* (Fig. 8, s.a. Everts,



Fig. 1. The body and head of *M. cucphuongensis* sp. nov. is uniform dark brown. The photo doesn't show the holotype but the first found individual. Aufn.: Elke Schwierz.

1967, Abb. 3, 8). They are about parallel with a weak constriction at the interorbital constriction, but the anterior most part at the orbital processes is very weak and thus compared to other species of *Melogale* the orbital processes are less pointed and less pronounced. In dorsal view the occipital is not concave at the midline and like in other species of

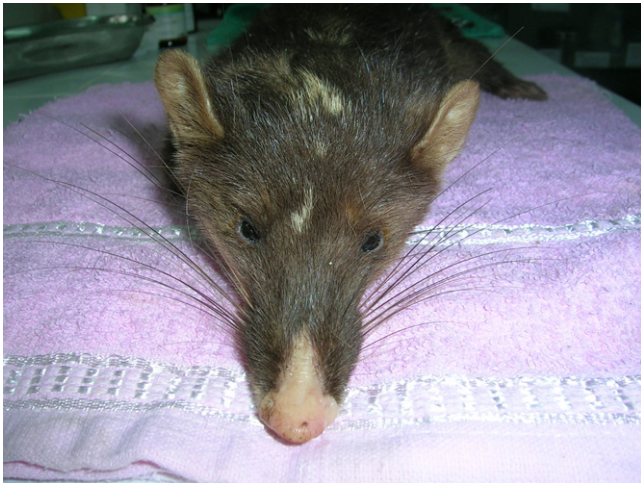


Fig. 2. The upper part of the head of *M. cucphuongensis* sp. nov. is brown and shows only small white spots on the forehead between the eyes and the ears. The rhinarium extends to the upper side of the nose and forms a small naked wedge. The photo doesn't show the holotype but the first found individual. Aufn.: Elke Schwierz.



Fig. 3. There are no white patches or markings on the cheeks of *M. cucphuongensis* sp. nov. The facial vibrissae are abundant and very long. The photo doesn't show the holotype but the first found individual. Aufn.: Elke Schwierz.

Melogale is fairly straight. The occipital plane is at about a right angle to the base of the skull.

In lateral view, the skull of *M. moschata* shows a profile with a smooth, nearly straight and steady incline from the nose towards the cranium and a slightly curved or rounded cranium (Fig. 9). This is similar in *M. orientalis* and *M. everetti* as seen in the illustrations of Everts (1967). In *M. cucphuongensis* the lateral profile also shows a smooth and steady incline from the nose to the cranium, but this shows a slight concave bending and the



Fig. 4. From the neck to shoulder runs a small white stripe bordered with black lines (holotype). There are no white patches or markings on the cheeks. Aufn.: Tilo Nadler.

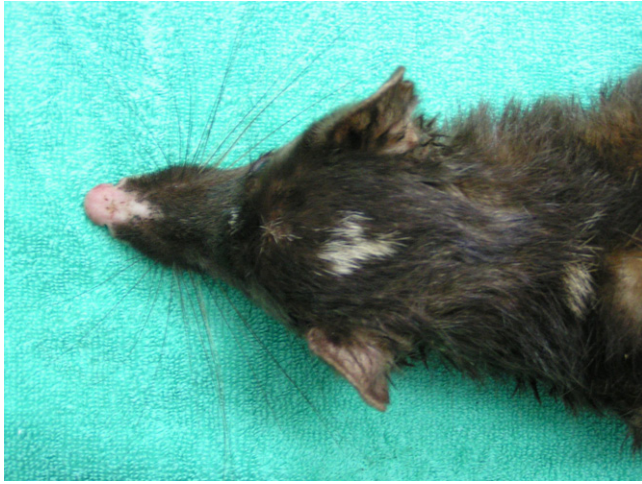


Fig. 5. The first found individual shows only a white patch on the shoulders, no white stripe. Aufn.: Ulrike Streicher.

cranium is slightly less rounded (Fig. 7). Clearly different from both lateral profiles is the one of *M. personata* with a very short nearly flat snout, a relatively short and sharp inline of the frontal to a nearly flat cranium, with a clear decline in the posterior most part to the occipital (Fig. 8). However, the lateral profile of the skull of *M. personata* illustrated by Everts (1967) is different and more similar to the profile described here for *M. moschata*. This discrepancy cannot be resolved here and might be caused by material of very different



Fig. 6. The under part of the body is cream-colored to light brown (holotype). Aufn.: Ulrike Streicher.



Fig. 7. Skull of *M. cucphuongensis* sp. nov. Aufn.: Tilo Nadler.

ages, which would imply fairly great ontogenetic changes in skull morphology or is a result of different taxonomic assignments of specimens.

Sutures are hardly visible indicating an adult specimen, but particularly for a male the frontoparietal crests are moderate and would not indicate a high age for the specimens. The little wear on the teeth supports this.

Great variability in course and development of the frontoparietal crests is indicated for *M. personata* by Everts, 1967 and clear correlation of age and development of crest in different species of *Melogale* is not known.

Dentition. The dental formula is like other *Melogale* species: I3/3, C1/1, P4/4, M1/2 = 38.

Size and relation of P¹ and P², and also of P⁴ and M¹ is an important feature for the taxonomy of *Melogale* and particularly in the differentiation between *M. moschata* and *M. personata* (Storz & Wozencraft, 1999). In *M. cucphuongensis* P¹ is only slightly smaller than P², more resembling the condition supposed to be typical for *M. moschata*. P² and P³ are about equal in size, also like in *M. moschata*. P⁴ is about 1/4 of the length of the upper tooth row (P¹-M¹), again similar to *M. moschata*. P⁴ is elongated with well developed paracone, mesostyle and parastyle lingually and protocone. Laterally, the protocone is slightly convex, otherwise the side of the tooth is straight. The higher labial and the lower lingual part of the tooth are separated by a fairly deep notch, again supposed to be similar to *M. moschata* (Everts, 1967).

M¹ outline is large and almost oval shaped extending nearly as far lingual as P⁴ and with a marked notch or concavity between paracone and metacone at the outside.



Fig. 8. Skull of *M. personata* (ZM HNU – M 776, s. also Table 1). Aufn.: Tilo Nadler.

Molecular genetics. In a 423 bp-long fragment of the mitochondrial cytochrome b gene, both known individuals are identical. Based on phylogenetic tree reconstructions, *M. cucphuongensis* is a member of the genus *Melogale* and represents a sister lineage to a clade consisting of *M. personata* and *M. moschata* (Fig. 12). *M. cucphuongensis* diverged from *M. personata* and *M. moschata* ~3.54 million years ago (range: 2.01-5.32), while latter two separated ~1.45 million years ago (range: 0.70-2.31) from each other. The partial sequence of the mitochondrial cytochrome b gene was submitted to GenBank and is available under accession number JN032659.

Etymology. The taxon name refers to the type locality which is the only known place of occurrence, the Cuc Phuong National Park in northern Vietnam. English name: Cuc Phuong



Fig. 9. Skull of *M. moschata* (ZM HNU – M 1043, s.also Table 1). Aufn.: Tilo Nadler.

ferret-badger, German name: Cuc Phuong Sonnendachs, French name: Blaireau-furet de Cuc Phuong.

Distribution and habitat. The species is currently only known from the type locality. Cuc Phuong National Park lies in a limestone formation with primary forest and the Endangered Primate Rescue Center is located close to the entrance of the park in an area with secondary forest. Some of the smaller limestone hills in the surroundings are covered with slightly degraded primary forest.

Table 1. Measurements of *M. moschata*, *personata* and *cucphuongensis* sp. nov. (in mm) (ZM HNU – Zoological Museum at Hanoi National University).

| Greatest length of the skull | males | females | males+females |
|--|------------------------------|-----------------------------|---------------|
| <i>M. moschata</i> | | | |
| Hainan (Allen, 1938) | 76.7 (n = 4) | 74.8 (n = 10) | |
| SE-China (Stefen & Feiler, 2004) | sex? 72.6 (n = 1) | | |
| North Vietnam ZM HNU (this paper) | 80.1 (78.1-81.5) (n = 3) | 77.3 (75.0-79.3) (n = 3) | |
| <i>M. moschata moschata</i> | | | |
| Southern China (Gao, 1987) | 79.3 (78.2-81.3) (n = 15) | 78.1 (76.3-79.4) (n = 7) | |
| <i>M. moschata ferreogrisea</i> | | | |
| South and West China (Gao, 1987) | 80.7 (78.6-82.0) (n = 9) | 79.8 (78.0-81.0) (n = 5) | |
| <i>M. moschata taxilla</i> | | | |
| Mainland China & Hainan (Gao, 1987) | 79.0 (75.2-82.9) (n = 3) | 74.9 (71.5-77.4) (n = 5) | |
| <i>M. personata</i> | | | |
| North Vietnam ZM HNU (this paper) | 82.5 (80.5-84.2) (n = 3) | | |
| <i>M. cucphuongensis</i> | | | |
| | 81.5 (n = 1) | | |
| Condylbasal length | | | |
| <i>M. moschata</i> | | | |
| Hainan (Allen, 1938) | 68.0 (n = 4) | 65.6 (n = 10) | |
| SE-China (Stefen & Feiler, 2004) | sex? 68.6 (n = 1) | | |
| <i>M. moschata moschata</i> | | | |
| Southern China (Gao, 1987) | 70.3 (65.3-71.7) (n = 15) | 68.1 (66.5-70.0) (n = 7) | |
| <i>M. moschata ferreogrisea</i> | | | |
| South and West China (Gao, 1987) | 70.8 (68.0-73.8) (n = 9) | 70.4 (67.9-75.5) (n = 5) | |
| <i>M. moschata taxilla</i> | | | |
| Mainland China & Hainan (Gao, 1987) | 70.6 (67.2-74.5) (n = 3) | 64.7 (60.4-69.0) (n = 5) | |
| <i>M. cucphuongensis</i> | | | |
| | 73.5 (n = 1) | | |

Table 1 (Continued).

| Greatest length of the skull | males | females | males+females |
|--|------------------------------|-----------------------------|---------------|
| Palatal length | | | |
| <i>M. moschata</i> | | | |
| Hainan (Allen, 1938) | 33.8 (n = 4) | 32.9 (n = 10) | |
| North Vietnam ZM HNU (this paper) | 35.8 (33.6-37.2) (n = 3) | 35.2 (35.0-35.6) (n = 3) | |
| <i>M. moschata moschata</i> | | | |
| Southern China (Gao, 1987) | 34.2 (33.0-35.9) (n = 15) | 32.8 (32.3-33.8) (n = 7) | |
| <i>M. moschata ferreogrisea</i> | | | |
| South and West China (Gao, 1987) | 35.4 (34.8-36.1) (n = 9) | 35.8 (35.4-36.2) (n = 5) | |
| <i>M. moschata taxilla</i> | | | |
| Mainland China & Hainan (Gao, 1987) | 34.1 (32.4-35.1) (n = 3) | 31.9 (29.2-37.0) (n = 5) | |
| <i>M. personata</i> | | | |
| North Vietnam ZM HNU (this paper) | 38.5 (36.6-39.9) (n = 3) | | |
| <i>M. cucphuongensis</i> | 37.6 (n = 1) | | |
| Zygomatic width | | | |
| <i>M. moschata</i> | | | |
| Hainan (Allen, 1938) | 43.4 (n = 4) | 43.1 (n = 10) | |
| SE-China (Stefen & Feiler, 2004) | sex? 38.7 (n = 1) | | |
| North Vietnam ZM HNU (this paper) | 49.5 (48.1-50.8) (n = 3) | 43.4 (41.2-45.5) (n = 3) | |
| <i>M. moschata moschata</i> | | | |
| Southern China (Gao, 1987) | 46.1 (44.4-48.5) (n = 15) | 43.3 (40.9-45.9) (n = 7) | |
| <i>M. moschata ferreogrisea</i> | | | |
| South and West China (Gao, 1987) | 43.5 (41.0-45.2) (n = 9) | 44.5 (41.9-45.6) (n = 5) | |
| <i>M. moschata taxilla</i> | | | |
| Mainland China & Hainan (Gao, 1987) | 46.2 (46.0-46.3) (n = 3) | 39.0 (36.6-42.2) (n = 5) | |
| <i>M. personata</i> | | | |
| North Vietnam ZM HNU (this paper) | 50.5 (47.5-51.0) (n = 3) | | |
| <i>M. cucphuongensis</i> | 37.8 (n = 1) | | |

Table 1 (*Continued*).

| Greatest length of the skull | males | females | males+females |
|--|------------------------------|-----------------------------|-----------------------------|
| Mastoid width | | | |
| <i>M. moschata</i> | | | |
| Hainan (Allen, 1938) | 34.5 (n = 4) | 34.8 (n = 10) | |
| <i>M. moschata moschata</i> | | | |
| Southern China (Gao, 1987) | 36.5 (34.0-37.5) (n = 15) | 35.7 (34.8-36.9) (n = 7) | |
| <i>M. moschata ferreogrisea</i> | | | |
| South and West China (Gao, 1987) | 36.4 (34.2-37.8) (n = 9) | 35.8 (34.1-38.2) (n = 5) | |
| <i>M. moschata taxilla</i> | | | |
| Mainland China & Hainan (Gao, 1987) | 37.0 (36.5-38.0) (n = 3) | 34.7 (32.6-38.0) (n = 5) | |
| <i>M. cucphuongensis</i> | 32.3 (n = 1) | | |
| Interorbital width | | | |
| <i>M. moschata</i> | | | |
| North Vietnam ZM HNU (this paper) | 18.8 (17.8-20.4) (n = 3) | 17.8 (17.0-17.9) (n = 3) | |
| <i>M. moschata moschata</i> | | | |
| Southern China (Gao, 1987) | 20.6 (19.7-21.2) (n = 15) | 20.2 (19.5-21.2) (n = 7) | |
| <i>M. moschata ferreogrisea</i> | | | |
| South and West China (Gao, 1987) | 18.8 (18.2-19.3) (n = 9) | 18.8 (18.1-19.2) (n = 5) | |
| <i>M. moschata taxilla</i> | | | |
| Mainland China & Hainan (Gao, 1987) | 20.2 (19.1-20.9) (n = 3) | 18.8 (17.9-19.3) (n = 5) | |
| <i>M. personata</i> | | | |
| North Vietnam ZM HNU (this paper) | 18.0 (16.6-19.9) (n = 3) | | |
| <i>M. cucphuongensis</i> | 17.7 (n = 1) | | |
| Total length | | | |
| <i>M. moschata</i> | | | |
| Mainland China (Zheng & Yu, 1983) | | | 385.6 (341-418) (n = 28) |
| <i>M. moschata moschata</i> | | | |
| Southern China (Gao, 1987) | 380.1 (n = 15) | 354.0 (315-400) (n = 10) | |

Table 1 (Continued).

| Greatest length of the skull | males | females | males+females |
|--|-----------------------------|-----------------------------|-----------------------------|
| <i>M. moschata ferreogrisea</i> South and West China (Gao, 1987) | 379.4 (350-417) (n = 5) | 372.1 (340-403) (n = 7) | |
| <i>M. moschata taxilla</i> Mainland China & Hainan (Gao, 1987) | 401.7 (385-430) (n = 9) | 334.3 (305-362) (n = 5) | |
| <i>M. cucphuongensis</i> tail base to top of head | 280 | | |
| tail base to nose tip | 360 (n = 1) | | |
| Tail length | | | |
| <i>M. moschata</i> Mainland China (Zheng & Yu, 1983) | | | 163.4 (140-192) (n = 28) |
| <i>M. moschata moschata</i> Southern China (Gao, 1987) | 150.3 (136-168) (n = 15) | 155.0 (131-170) (n = 10) | |
| <i>M. moschata ferreogrisea</i> South and West China (Gao, 1987) | 166.0 (160-175) (n = 5) | 175.1 (150-211) (n = 7) | |
| <i>M. moschata taxilla</i> Mainland China & Hainan (Gao, 1987) | 154.0 (115-192) (n = 9) | 158.8 (145-176) (n = 5) | |
| <i>M. cucphuongensis</i> | 170 (n = 1) | | |

Table 2. Cranial measurements of the holotype *Melogale cucphuongensis* (in mm) (see also Fig. 10 and 11).

| Cranium | | |
|---------|----------------------------------|------|
| gsl | greatest skull length | 81.5 |
| cbl | condylobasal length | 73.5 |
| ch | cranial height | 30.1 |
| chP4 | cranial height behind premolar 4 | 13.5 |
| chC | cranial height behind canine | 9.8 |
| zw | zygomatic width | 37.8 |
| pob | post orbital breadth | 17.7 |
| cb | cranial breadth | 31.6 |
| pall | palatal length | 37.6 |
| bP4 | breadth premolar 4 | 4.5 |
| l P4 | length premolar 4 | 6.0 |
| bM1 | breadth molar 1 | 6.4 |
| lM1 | length molar 1 | 3.8 |
| lbull | length bulla | 16.5 |

Table 2 (Continued).

| Cranium | | |
|-------------------|---|------|
| b _{bull} | breadth bulla | 14.1 |
| P1M1 | length premolar 1 to molar 1 | 22.4 |
| CM1 | length canine to molar 1 | 26.5 |
| CC | upper outer canine width | 9.3 |
| α | tangential angle of zygomatic arch to the midline | 24° |
| Mandible | | |
| d _l | dentary condyle to tip dentary | 51.0 |
| p _{cr} | ramus coronoid process | 20.1 |
| p _{cp} | ramus condylar process | 9.0 |
| r _h | ramus height | 6.5 |
| cm | canine to Molar 1 | 25.2 |

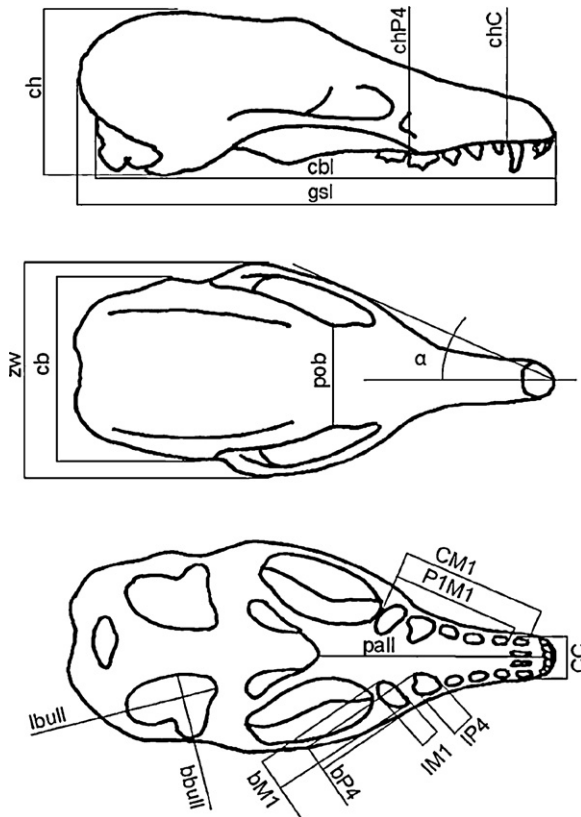


Fig. 10. Measurements of the cranium.

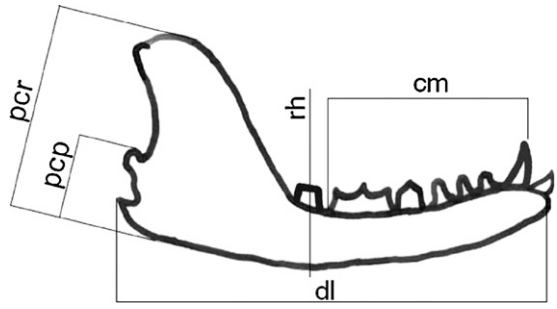


Fig. 11. Measurements of the mandible.

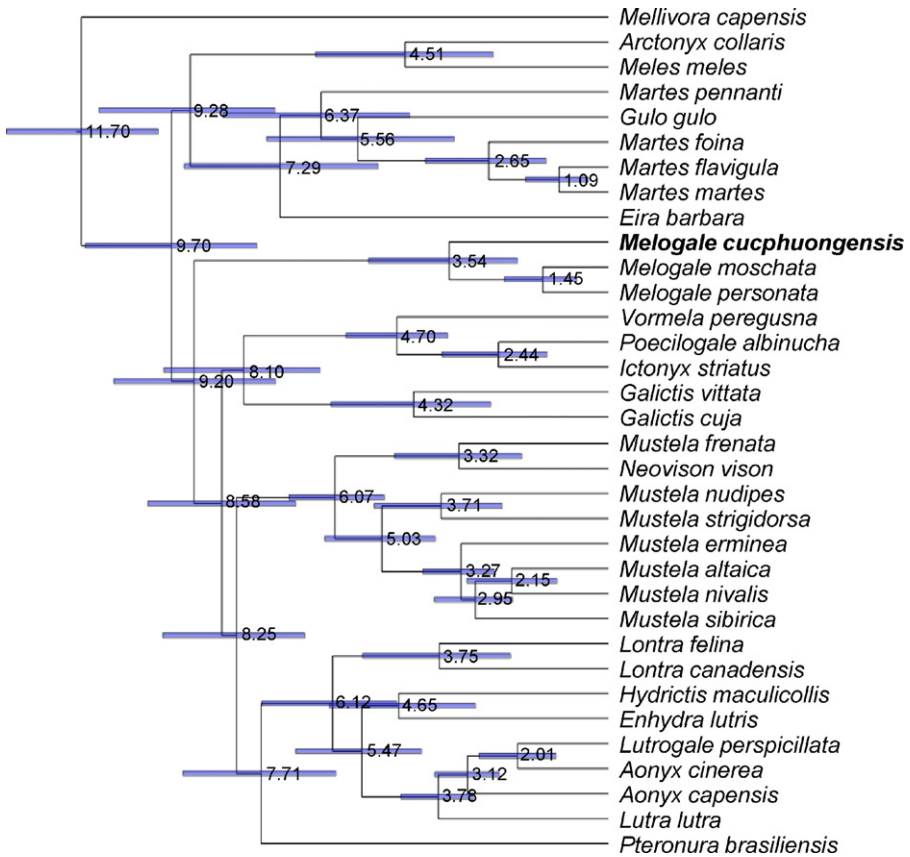


Fig. 12. Ultrametric tree showing phylogenetic relationships and divergence ages among various Mustelidae representatives based on partial mitochondrial cytochrome b gene sequences (sequences taken from Koepfli et al., 2008). The grouping of *M. cucphuongensis* with *M. personata* and *M. moschata*, and the basal position of *M. cucphuongensis* among analyzed *Melogale* species is significantly supported by maximum-likelihood (bootstrap values: 95%, 95%) and Bayesian analysis (posterior probabilities: 1.0, 0.99). Numbers on branches indicate divergence ages in million years ago and bars the 95% highest credibility intervals.

Zusammenfassung

Sonnendachse, Gattung *Melogale*, sind in der indochinesischen Region, auf Java, Bali und in Nordost-Borneo heimisch. Vier Arten – in Färbung und Grösse sehr ähnlich - werden gegenwärtig unterschieden. Zwei Exemplare vom Cuc Phuong Nationalpark, Nordvietnam unterscheiden sich in der Färbung, der Form des Schädels und der Molekulargenetik deutlich von den bekannten und im Gebiet sympatrisch vorkommenden Arten *M. personata* und *M. moschata*. Darauf basierend beschreiben wir eine neue Sonnendachsart als *Melogale cucphuongensis* sp. nov.

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