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SKIN, SKULL AND SKELETON CHARACTERS OF MOUSE DEER (MAMMALIA, TRAGULIDAE), WITH KEYS TO THE SPECIES

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Abstract

At present, four species are recognized within the family Tragulidae: viz. *Hyemoschus aquaticus* (Ogilby,1841), living in tropical West Africa and Central Africa, north of the Congo River; *Tragulus meminna* (Erxleben,1777), occurring on Sri Lanka (Ceylon) and in the south of peninsular India; and the largely sympatric species *Tragulus javanicus* (Osbeck,1765) and *Tragulus napu* (F.Cuvier,1822), both found in southeast Asia and on the Sunda islands west of the Strait of Makassar.

Keys to these four species are presented. Diagnostic non-meristic characters in the skeleton are found for *H.aquaticus* and *T.meminna*, but not for *T.javanicus* and *T.napu*. The latter two species can be identified on meristic characters in the appendicular skeleton: *T.napu* has stronger and broader feet than *T.javanicus*.

The taxonomy of the family Tragulidae is outlined in table I.

MATERIAL AND METHODS

As part of a study on the taxonomy of Mouse Deer, skin, skull and skeleton material has been studied in the following museum collections:

- American Museum of Natural History, New York (AMNH);
- British Museum (Natural History), London (BMNH);
- Field Museum of Natural History, Chicago (FMNH);
- Museum of Comparative Zoology, Boston (MCZ);
- National Museum of Natural History, Washington (NMNH);
- Rijks Museum van Natuurlijke Historie, Leiden (RMNH);
- Zoölogisch Museum Amsterdam, Amsterdam (ZMA).

This study is based on adult specimens, viz. with the third permanent molars (almost) in place and/or the sutural joints in the appendicular skeleton complete. Several hundred specimens consisting of skin and skull, of *T.javanicus* and *T.napu* were compared and described, about 15 specimens with skin and skull of *T.meminna*, and about 25 specimens with skin and skull of *H.aquaticus*. These specimens were used to compose a key on non-meristic skull characters (key 1). The specimens with skeleton, used for the composition of the second key and for the measurements, were partly identified with the characters mentioned in key 1.

Measurements were taken with an accuracy of 0.1 mm with a pair of vernier callipers (accuracy 0.05

mm). The following measurements were taken: Greatest length and smallest width of femur, tibia, humerus and first and second outer phalange of fore and hind leg. Greatest length of radius, metatarsus and metacarpus. Smallest width was measured over metatarsalia III and IV and metacarpalia III and IV together, respectively.

Salient general skeleton characters of Tragulidae

The skull of Tragulidae is characterized by a rather straight skull axis and the absence of horns or antlers. The dental formula is 0 1 3 3/3 1 3 3. Males have large upper canines, curved laterally backwards and used in defence. Females have small stifts only. The incisors are placed in an interrupted series; the middle ones are broad and spatulate. There is one lacrimal orifice, no lacrimal fossa. The bullae ossea are inflated and filled with cancellate bony tissue.

In the appendicular skeleton, Tragulidae have an unfused ulna and a normal shaped, slender fibula. The distal part of the fibula (os malleolare) is fused with the tibia. In the tarsus, the cubo-naviculare is fused with the two outer cuneiformes (Flower, 1966). The lateral metapodia in fore and hind legs are not functional, but present as complete, slender splints. (See for further characters the comparative anatomical research of Milne-Edwards, 1864 and Carlsson, 1929.)

The most important skin characters and meristic characters in the skull of the four species are summarized in table II.

Non-meristic characters

In the skull, 7 distinct, variable characters could be established, that were used to compose the first key. In the postcranial skeleton, 6 variable characters, 3 in the axial skeleton and 3 in the appendicular skeleton were found. These characters were used to compose the second key.

Key 1. Non-meristic characters in the skull

1a) Premaxillare does not reach nasale. Nasale with partly convex lateral border. Maxillare does not reach frontale. Anteorbital vacuity present between nasale, maxillare, lacrimale and frontale..... .....*Hyemoschus aquaticus* (fig.1a)

b) Premaxillare reaches nasale. Nasale with slightly concave lateral border. Maxillare reaches frontale. Anteorbital vacuity present between maxillare, lacrimale and frontale, or wanting.....*Tragulus*, 2

2a) Anteorbital vacuity present between maxillare, lacrimale and frontale. Supraoccipitale relatively high and narrow (also in *H.aquaticus*, fig.1a). Squamosum with vacuity at the border of supraoccipitale (also in *H.aquaticus*, fig.1a). Bulla ossea rounded.... .....*Tragulus meminna* (fig.1b)

b) Anteorbital vacuity wanting. Supraoccipitale relatively low and broader. Squamosum without vacuity at the border of supraoccipitale. Bulla ossea pointed (also in *H.aquaticus*, fig.1a)..... .....*Tragulus javanicus*, *Tragulus napu* (fig.1c)

Key 2. Non-meristic characters in the postcranial skeleton.

1a) Metatarsus with strong lateral metapodia, metatarsalia III and IV only partly fused. Metacarpus with strong lateral metapodia, metacarpalia III and IV not fused. Lumbar vertebrae with the posterior part of the transverse processes grown out slightly backwards (sometimes forming an additional process, that may even articulate with the posteriorly situated transverse process)..... .....*Hyemoschus aquaticus*

b) Metatarsus with slender lateral metapodia, metatarsalia III and IV fused into a cannonbone. Metacarpus with slender lateral metapodia, metacarpalia III and IV fused into a cannonbone. Lumbar vertebrae with the posterior part of the transverse processes not extending backwards, except sometimes in the last lumbar vertebrae.....*Tragulus*, 2

2a) Atlas perforated for the vertebrarterial canal. Humerus without foramen supratrochleare. Fascia lumbala not fused in male or female (neither in *H.aquaticus*).....*Tragulus meminna*

b) Atlas not perforated for the vertebrarterial canal. Humerus with foramen supratrochleare. Male: Fascia lumbala fused into a bony dorsal shield (Milne-Edwards, 1864: pl.4, fig.2, 2a; Gray, 1869: fig.; Lekagul & McNeely, 1977: 665, pl.);fascia lumbala never fused in the female.....*Tragulus javanicus*, *Tragulus napu*

Meristic characters in the appendicular skeleton

Hyemoschus aquaticus is larger than the three *Tragulus* species. The sum of the lengths of the separate hind leg bones, is over 340 mm in *H.aquaticus* (n=3), less than 330 mm in *Tragulus* (n=22); the sum of the lengths of the fore leg bones is over 240 mm in *H.aquaticus* (n=5), less than 230 mm in *Tragulus* (n=22). The interrelationships of the lengths of the dif-

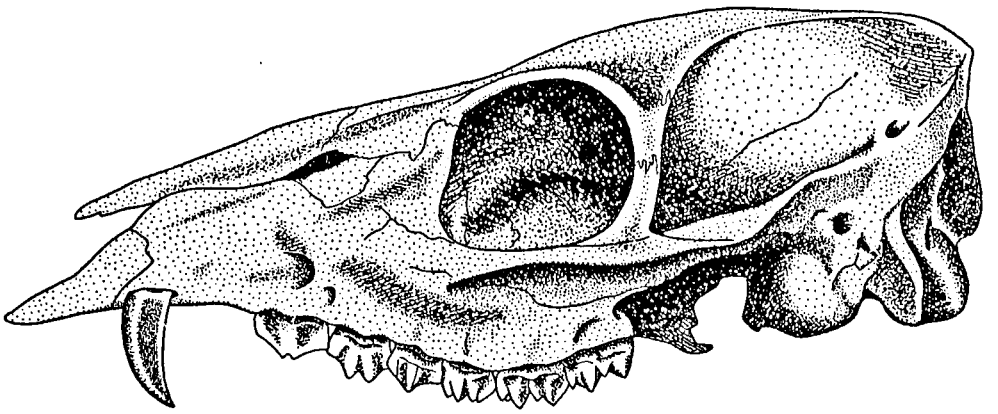

Figure 1a

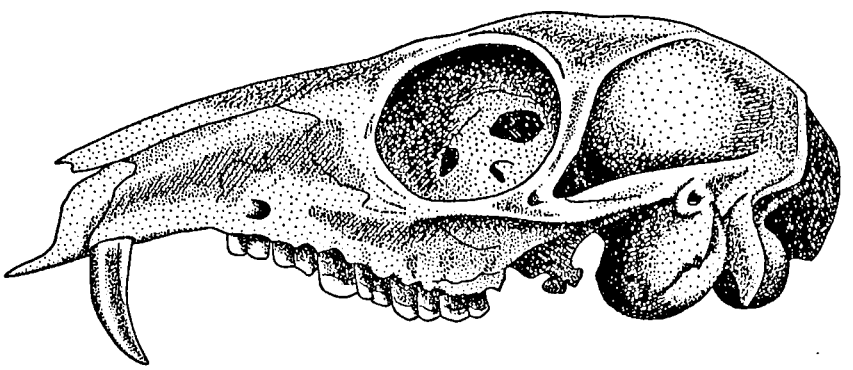

Figure 1c

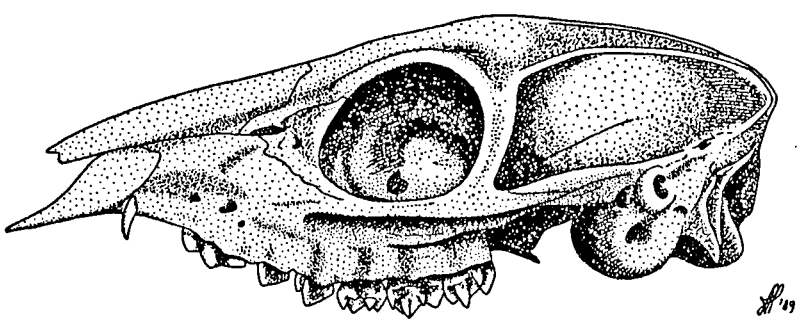

Figure 1b

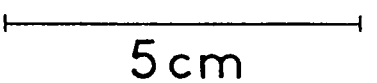

Figure 1a. *Hyemoschus aquaticus* (Ogilby); skull lateral view, RMNH cat.ost.d; adult male
Figure 1b. *Tragulus meminna* (Erxleben); skull lateral view, RMNH cat.ost.d; adult female
Figure 1c. *Tragulus napu* (F.Cuvier); skull lateral view, ZMA 22.919; adult male.

Figure 2

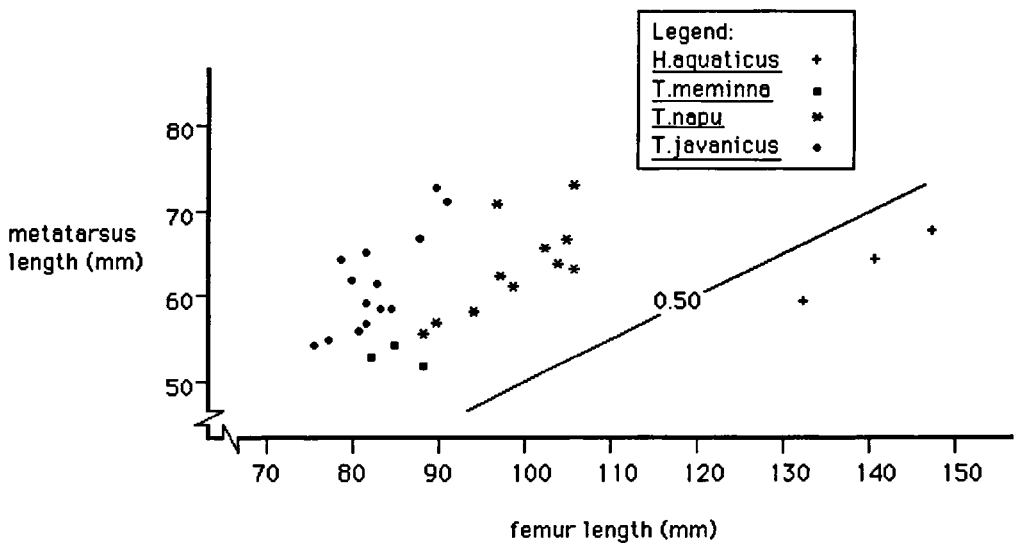

Figure 3

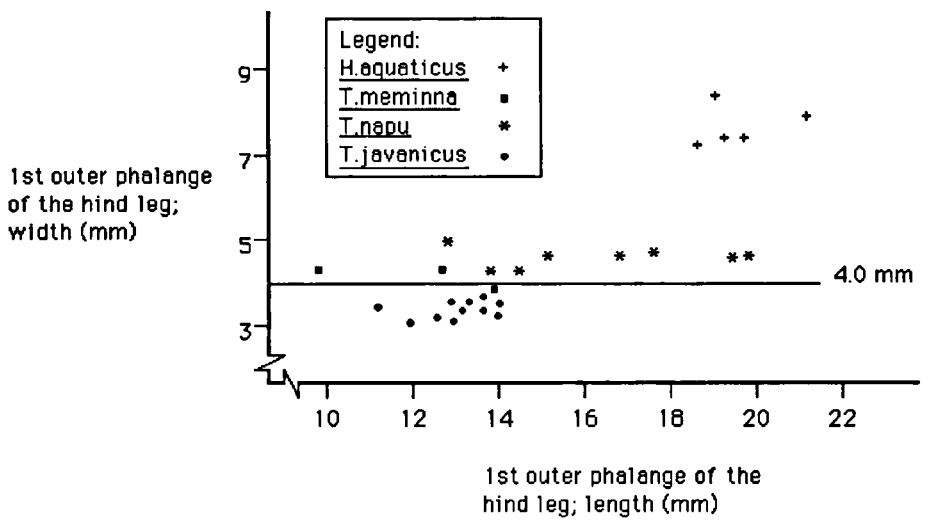

Figure 2. Relationship between femur lengths (mm) and metatarsus lengths (mm).
Figure 3. Relationship between lengths and widths of the first outer phalanges of the hind legs.

ferent leg parts are not identical in *Hyemoschus* and *Tragulus*; in *Tragulus* the metacarpus is longer, compared to the humerus, than it is in *Hyemoschus* (table III). The same holds for the length of metatarsus, compared to femur length (table III; fig.2). It appears (table III), that the tibia is the longest hind leg bone in *Tragulus*, whereas this is the femur in *Hyemoschus*. According to Carlsson (1926: 77,91, after Winge, 1906 and Kowalewsky, 1876), there is an evolutionary trend in the recent Ruminantia, to lengthen certain parts of the leg, especially metacarpus and metatarsus; furthermore, the tibia becomes longer than the

Figure 4

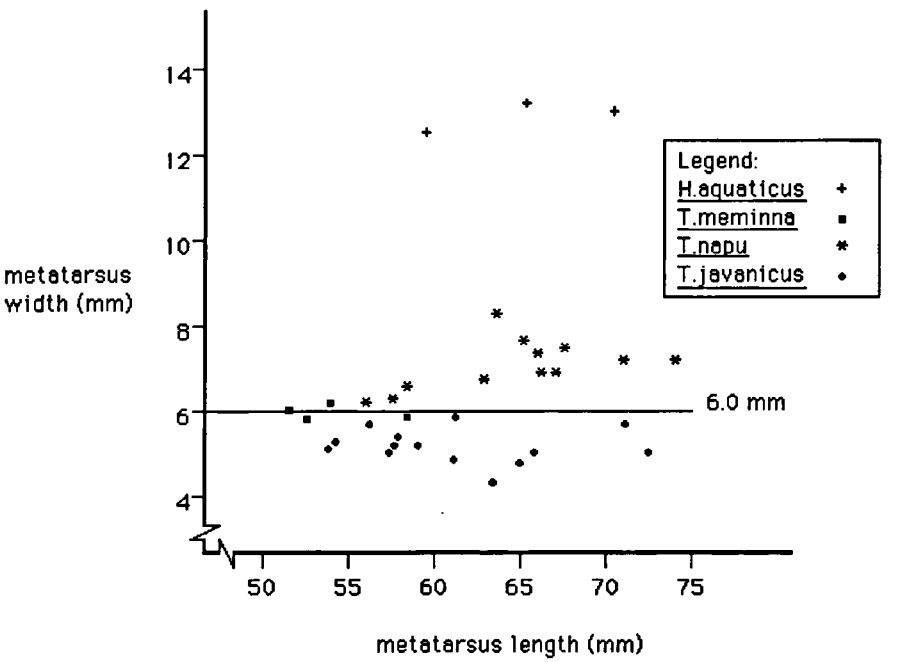

Figure 4 . Relationship of the lengths and widths of the metatarsalia.

femur. In this, *Tragulus* is apparantly more advanced than *Hyemoschus*.

Within the genus *Tragulus*, the differences between the species are not so conspicuous. The extremities of *T.meminna*, namely the fore legs, are somewhat shorter than those of *T.napu* . The index of metatarsus length and femur length is larger in absolute sense in *T.javanicus* than in *T.meminna* (table III; fig.2).

The two very closely related species *T.javanicus* and *T.napu*, which cannot be distinguished from each other on non-meristic skull and postcranial skeleton characters, also show a considerable amount of size overlap (fig.2; Van Dort, 1988:124). Chasen (1940: 194) wrote on these two species: "I now find that the two species, however altered, can always be recognized by the larger 'feet' (lengthened toes and shortened metatarsus) of *javanicus* [=*T.napu*, see Van Bemmel,1949], which is more addicted to swamp country than *kanchil* [=*T.javanicus*, see Van Bemmel,1949]." From table IV, it is obvious, that the difference between *T.javanicus* and *T.napu* in the index of first outer phalange of the hind leg and metatarsus is not so distinct. Some specimens of *T.javanicus* (all from Sabah, East Malaysia) have a more lengthened metatarsus, indicating that most probably a subspecific or ecological adaptation is concerned. Furthermore, some specimens of *T.napu* have strongly lengthened first phalanges (fig.3). This too is not a character of the species, but much more an ecological or subspecific adaptation, perhaps to more swampy ground.

Although the lengths of the different leg bones show a great amount of size overlap, the metatarsus, metacarpus and the first outer phalanges of the fore and hind legs are definitely stronger and broader in absolute sense in *T.napu*, than they are in *T.javanicus* (table IV; figs.3,4). *T.meminna* is somewhat in between. All *Tragulus* species have much more slender feet than *H.aquaticus* (figs.3,4).

Summarizing, *H.aquaticus* has relatively short, broad feet, *T.meminna*, *T.napu* and *T.javanicus* have lengthened, slender feet. *T.napu* has a broader hind and fore foot than *T.javanicus*.

Meristic and non-meristic diagnostic (unique) characters of the four species.

Hyemoschus aquaticus can be distinguished from the *Tragulus* species by several characters in the skull and postcranial skeleton.

Skull (fig.1a): condylobasal length over 125 mm; premaxillare does not reach nasale; lateral border of nasale partly convex; anteorbital vacuity between maxillare, nasale, frontale and lacrimale.

Postcranial skeleton: lumbar vertebrae with additional process at the posterior part of the transverse process. femur longer than tibia; metatarsus and metacarpus with strong lateral metapodia, middle metacarpalia not, middle metatarsalia partly fused into a cannon bone; width of metatarsus and metacarpus >10 mm; index metatarsus length/femur length < 0.50.

Tragulus meminna differs from the other three species only in skull characters. Skull (fig.1b): anteorbital vacuity between maxillare, frontale and lacrimale; bulla ossea rounded.

Tragulus napu or *T.javanicus* can only be distinguished from the other three species by skin characters: *T.napu* skin: mottled fur; light superciliairy lines on the head. *Tragulus javanicus* skin: three white lines in the throat pattern.

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Table I. Taxonomy of the family Tragulidae.

Family Tragulidae		Mouse Deer, Chevrotains
Genus *Hyemoschus*	*H.aquaticus*	African Water Chevrotain
Genus *Tragulus*		
Subgenus *Moschiola*	*T.meminna*	Indian Chevrotain
Subgenus *Tragulus*	*T.javanicus*	Lesser Indo-Malayan Chevrotain
	T.napu	Larger Indo-Malayan Chevrotain

Table II. Main skin characters and meristic skull characters.

	H.aquaticus	*T.meminna*	*T.napu*	*T.javanicus*
	Africa	India	Indo-Malaya	Indo-Malaya Indo-China
Mottled fur (*)	no	no	yes	no
White spotted skin	yes	yes	no	no
Dark lines from the eye to the nose	yes	no	yes	no
Light superciliairy lines on the head	no	no	yes	no
Coloured crossband between throat and chest	variable	no	yes	yes
Nr. of white lines in the throat- pattern	4 ,5 or 7	5 or 7	5	3
C.B.L.(mm) (**)	131-147	85-108	90-118	81-99
Zygomatic width (mm)	59- 68	39- 53	42- 59	37-51

(*) Mottled = Irregular pattern of dark and light coloured markings on a differently coloured background.

(**) C.B.L. = Condylobasal length

Table III. Indices (***).

	L.Mc./L.H.	L.Mt./L.F.	L.T./L.F.
T.javanicus (n=14)	0.57 (0.48-0.64)	0.74 (0.69-0.80)	0.86 (0.79-0.90)
T.napu (n=11)	0.54 (0.48-0.60)	0.66 (0.61-0.74)	0.91 (0.86-0.95)
T.meminna (n=4)	0.50 (0.45-0.53)	0.63 (0.58-0.65)	0.94 (0.88-0.97)
H.aquaticus (n=4)	0.41 (0.35-0.44)	0.46 (0.45-0.48)	1.03 (1.00-1.06)

Table IV. Meristic differences between *T.javanicus* and *T.napu* (abbreviations as in table III).

	T.javanicus (n=12)	*T.napu* (n=10)
W.Ph.1 h.l./W.Mt.	0.66 (0.58-0.70)	0.67 (0.60-0.72)
W.Mt.	< 6.0 mm	> 6.0 mm
W.Ph.1 h.l.	< 4.0 mm	> 4.0 mm
W.Mc.	< 6.0 mm	> 6.5 mm
W.Ph.1 f.l.	< 3.5 mm	> 3.5 mm

(***) F= femur; f.l.= fore leg; H= humerus; h.l.= hind leg; L= length; Mc= metacarpus; Mt= metatarsus; Ph.1= first outer phalange; T= tibia; W= width.

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