

## INTERSPECIFIC VARIATION IN *MOSCHIOLA*, THE INDIAN CHEVROTAIN

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**ABSTRACT.** – We analyzed skins and skulls of chevrotains (*Moschiola* sp., Artiodactyla) from Sri Lanka and India, and found considerable differences within this taxon. Based on the consistency of these differences we concluded that this taxon can be divided into three species: *Moschiola indica* from southern India, *M. meminna* from the Dry Zone in Sri Lanka, and *M. kathygre* n. sp. from Sri Lanka's Wet Zone. A single skull from Sri Lanka's Hill Zone may prove to represent a fourth species.

**KEY WORDS.** – *Moschiola*, Indian chevrotain, mouse-deer, Tragulidae, Sri Lanka, India, new species.

### INTRODUCTION

The chevrotains or mouse-deer (Tragulidae) are an ancient group of ungulates, with a history dating back to the Miocene. They are considered to be the sister-group of the remaining living Ruminantia (Groves & Grubb 1982). Conventionally, 4 species of tragulids have been recognized, the African *Hyemoschus aquaticus* (Water Chevrotain), the Indian and Sri Lankan *Tragulus meminna* (Indian Chevrotain or Meminna), and the South-East Asian *Tragulus javanicus*, and *T. napu* (Lesser and Greater Mouse-deer), but Meijaard & Groves (2004) recently proposed raising several subspecies of *T. javanicus* and *T. napu* to full species level. Because of significant differences between the South-East Asian genus *Tragulus* and the Indian mouse-deer, Groves & Grubb (1982) recommended that the latter should not be included in *Tragulus* as has commonly been done, but assigned to a separate genus, *Moschiola*. Within *Moschiola* (hereinafter called the Meminna) no further division into species or subspecies is currently recognised.

Sri Lanka and India are biogeographically related, but there are also considerable faunistic differences. Many Sri Lankan species are closely related to those in the southwestern part of Peninsular India, with which they form slightly differentiated species pairs, such as *Trachypithecus vetulus/johni*, *Macaca sinica/radiata*, and *Paradoxurus zeylonensis/jerdoni* (Corbet & Hill, 1992). In addition, many species are common to Sri Lanka and the Indian Peninsula but are differentiated at subspecies level.

There is also considerable diversity within Sri Lanka itself. There are several endemic genera in the montane forests of

the central highlands, such as the shrews *Feroculus* and *Solisorex* and the rat *Srilankamys*, as well as endemic species of *Crocidura*, *Suncus*, *Mus*, and *Rattus*. There is striking climatic diversity at lower altitudes, with correlated differentiation between vicariant taxa in the “wet” and “dry” zones (Phillips, 1980). Groves (1998) argued that within Sri Lanka there are two species of *Loris*, one (*Loris tardigradus*) in the island's wet zone and the other (*Loris lydekkerianus*) in the dry country and medium altitudes of Sri Lanka and also in southern India. A similar, but not identical, pattern is also found in *Trachypithecus vetulus*, which has two subspecies in the wet zone, one in the dry zone and at medium altitudes, and one on the high mountains (Groves, 2001). *Prionailurus rubiginosus* has a wet-zone and a dry-zone subspecies, and a third in Peninsular India (Deraniyagala, 1956).

We therefore felt that that *Moschiola meminna* should be investigated to discover whether there might be differences within Sri Lanka and between the Sri Lankan and Indian populations. Material of *Moschiola* appears not to be very abundant in collections, but is sufficient to enable us to at least begin to assess pelage and craniometric variation within the species.

### MATERIALS AND METHODS

One of us (EM) measured 16 skulls of *Moschiola* in the Field Museum (FMNH), Chicago, USA, and the Natural History Museum (BMNH), London, England. CPG measured two further skulls in the Sri Lanka National Museum, Colombo, Sri Lanka (SLNM). The measurements are described in the

Appendix, but for details refer to Meijaard & Groves (2004). Measurements were taken to tenths of a mm with dial calipers. For all skulls, we determined the age-class as follows: Adult = M<sup>3</sup> erupted and basilar suture fused; Young Adult–Adult = M<sup>3</sup> erupted and basilar suture fusing; Young Adult = M<sup>3</sup> erupted and basilar suture open; Juvenile = M<sup>3</sup> not erupted. One skull classified as juvenile was left out of the analysis.

CPG studied 17 skins in the Natural History Museum and 16 in the Sri Lankan National Museum. The overall colours were recorded, and the patterns of spots and stripes. Flesh measurements, as recorded on the labels or in the registration books, were noted. The SLNM register lists numerous specimens which are no longer to be found in the collection; in some cases, flesh measurements were given but the specimen itself was not present. In two cases (SLNM 83C and H), the register specifically stated that skins were juvenile, but in the other cases we had simply to assume that the specimens in question were adult; suffice it to say that their measurements fell within the range of those known to be adult because of associated skulls. The localities of the skulls and skins are listed in the Appendix.

We analysed the skull measurements with SPSS 11.0 software. Firstly, we determined for each species whether there was a significant difference between males and females within each age class. Subsequently, we made classifications between and within the species. We calculated means to tenths of a mm, and standard deviations to hundredths of a mm.

For the biogeographical analysis and species mapping we plotted the specimens' localities on maps using ArcView GIS 3.2a software. The Sri Lankan localities were classified by forest zone, as Wet Zone (>2,000mm annual rainfall), Dry Zone (<2,000mm), and Hill Zone, as in Phillips (1980) and MacKinnon (1997), but we took a very narrow view of the hill zone, restricting it to the cloud forest region (Nuwara Eliya).

**RESULTS**

**External measurements.** – There were no significant differences for any of the measurements between males and females and these were therefore lumped together. Indian specimens average considerably larger than Sri Lankan, judging by head and body length (Fig.1, Table 1). Within Sri Lanka, Wet Zone animals average smaller than Dry Zone, but there is much overlap. Tail measurements (Table 1) are consistent with this, but there is much variability.

There are striking differences in hindfoot length. Wet Zone specimens are absolutely smaller than Dry Zone, which in turn are smaller than Indian but with a slight overlap. The climatic borderline specimen from Katagamuwa falls within the Wet Zone range, if we have correctly identified this locality (see below) (Fig.2, Table 1). The ear is about equal

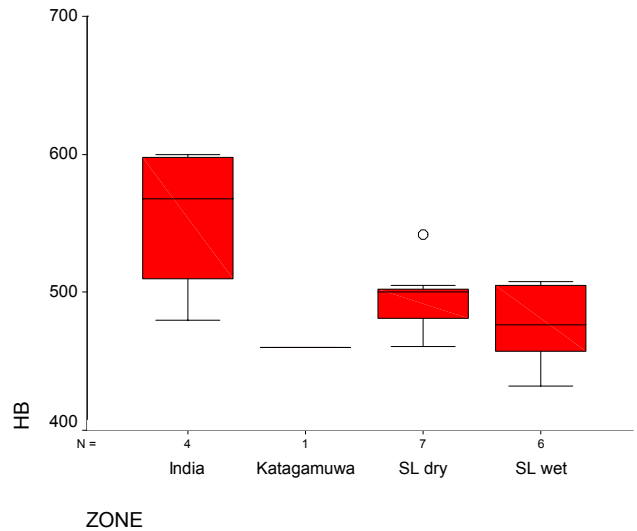


Fig. 1. Size differences between samples, as represented by Head-and-body length (in mm).

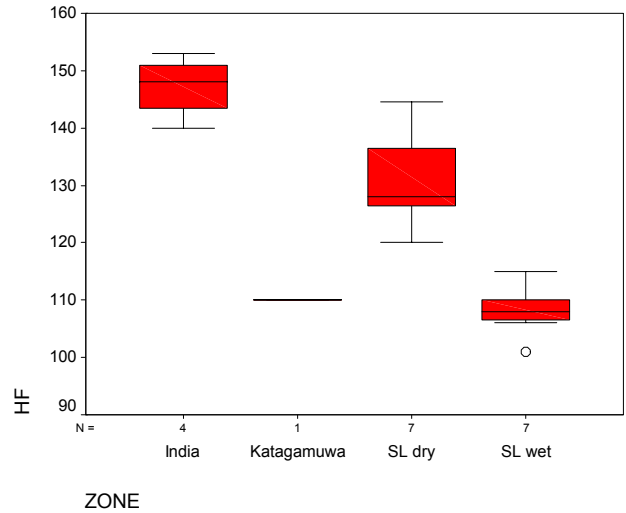


Fig. 2. Hindfoot measurements in the samples (in mm).

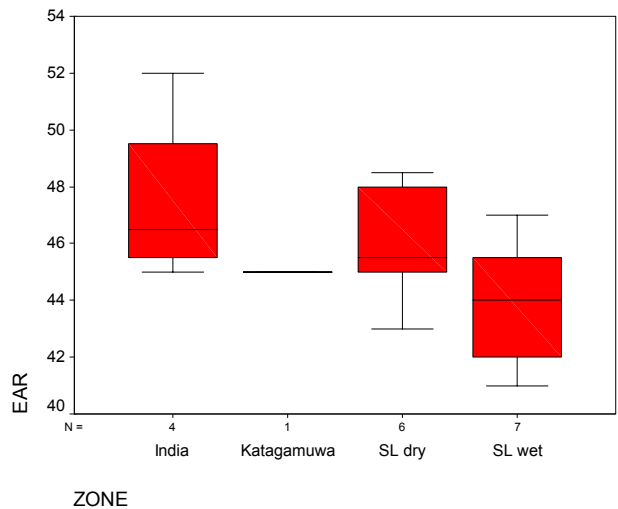


Fig. 3. Ear length measurements (in mm).

Table 1. Means and standard deviations of external (flesh) measurements. Katag = Katagamuwa, on the borders of Wet and Dry Zones.

Zone		HB	T	HF	EAR
India	mean	553.8	46.0	147.3	47.5
	N	4	4	4	4
	s.d.	56.18	12.54	5.44	3.11
	minimum	480	32.0	140.0	45.0
	maximum	600	62.0	153.0	52.0
Katag.	mean	460.0	18.0	110.0	45.0
	N	1	1	1	1
SL dry	mean	495.7	33.2	131.2	45.9
	N	7	7	7	6
	s.d.	25.57	22.05	8.44	2.04
	minimum	461	18.5	120.0	43.0
	maximum	542	82.0	144.5	48.5
SL wet	Mean	475.8	20.9	108.1	43.9
	N	6	7	7	7
	s.d.	29.14	4.30	4.30	2.27
	minimum	432	16.0	101.0	41.0
	maximum	508	26.0	115.0	47.0

in length in India and Dry Zone, but distinctly smaller, although slightly overlapping in Wet Zone (Fig.3, Table 1). When hindfoot length is plotted against head plus body length, the difference between Wet Zone (plus Katagamuwa) is even more striking (Fig.4).

**Pelage features.** – Meminna skins are a medium to dark olive-toned brown, marked with four or five light longitudinal stripes or spot-rows, whose continuity may be hard to trace if they break up too fully into spots; there are generally two broken transverse stripes or spot-rows across the shoulders, and two or three better-marked ones across the haunch and rump.

Dry Zone skins are dull brown, paler and less richly toned than those from the Wet Zone. The stripes and spots are very clear and white (in the Wet Zone they are yellowed). The longitudinal stripes are broken completely into rows of spots: only the upper one is anything like complete (and that not very). The lowermost spot-row is especially poorly distinguished, and in effect consists of two rows interwoven, and the lower spots almost disappear into the pale underside zone. The three spot-rows across croup and rump are partly fused to stripes. The crown is dark brown, this colour extending onto the forehead. No part of the underside is white: the paler, creamier central strip grades into the (usually) paler beige lateral area.

Wet Zone skins are much warmer, more ochery brown. The pattern is essentially of two complete longitudinal stripes (the upper one more complete, the lower one being still only partly fused), with an elongated spot-row between them, and two spot-rows above them; the upper stripe disappears further back on the haunch, and begins further back on the shoulders

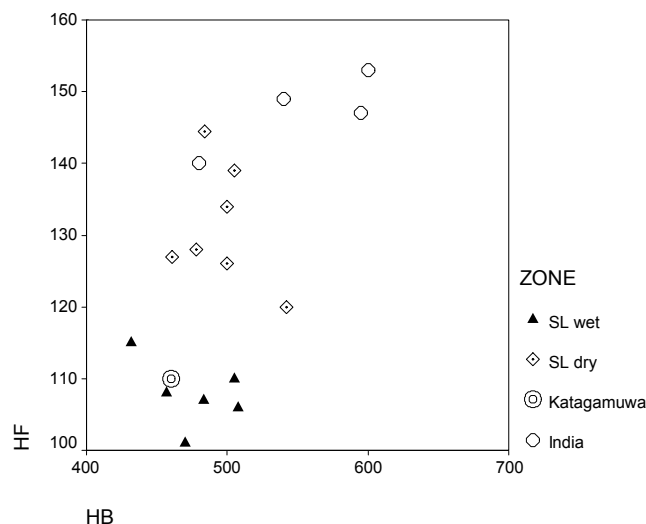


Fig. 4. Relative hindfoot to head plus body length (in mm).

where it curves round to be continuous with the anterior transverse stripes. There are two bold stripes over the haunch and a third one further back under the tail; the Kumbalgamuwa skin is intermediate in having a third, vague, broken transverse stripe anterior to the 2 haunch stripes. As noted, the spots and stripes are yellowed, not white. The haunch itself is more spotted, with 6-8 spots as opposed to 4-6 in the Dry Zone. The crown and nose darkening are less distinct. On the underparts there is a sharp difference between a white median strip and the rest of underside which is pale ochery. The lower halves of the hindlimbs are darker.

The Sinharaja skin differs from the others in having no complete longitudinal or transverse stripes: all are spot-rows; and in its extremely ochery underside.

Indian skins are like the dry zones ones. The upper spot-row is a complete stripe on the shoulder, but disintegrates into spots halfway back. One of the skins has as many as four transverse haunch bands. In three of the nine skins, the transverse haunch stripes meet in midline, which they do not in any Sri Lankan skins. The underside is again more as in the dry zone.

**Craniometrics.** – Only adults were used: skulls with the third molars in wear and the basilar suture closed. A one-way ANOVA showed that there were significant differences between Indian and Sri Lankan specimens ( $p < 0.05$ ) for all measurements, except occipital height from basion ( $p = 0.068$ ), mandible height ( $p = 0.073$ ), and inter-bullar distance ( $p = 0.087$ ); mean measurements for width of bullae and nasal length were similar for Sri Lankan and Indian specimens. Table 2 shows that, in most cranial variables, Indian specimens are larger than Sri Lankan, but within Sri Lanka Wet Zone are bigger than Dry Zone (the single Hill Zone skull being like the Wet Zone). Fig. 5 illustrates this for Condylbasal length. Exceptions to this are Canine width and Least breadth of maxilla, in which Dry Zone are larger than Wet Zone; in these measurements, Indian specimens are especially large, but the Hill Zone skull is large like the

Table 2. Means and standard deviations of cranial measurements.

Zone		CBL	zyg. br.	occip. ht. basion	canine width	least br. maxilla	br. braincase	br. bulla	interbullar distance
India	mean	101.1	52.2	28.3	16.3	16.1	34.7	9.6	8.8
	N	5	5	5	5	5	5	5	4
	s.d.	4.89	1.61	0.59	1.64	1.31	0.50	0.80	0.78
	minimum	95.0	50.0	27.8	15.2	14.5	34.2	8.8	7.8
	maximum	108.1	54.5	29.1	19.2	17.7	35.5	10.8	9.7
SL dry	mean	91.9	46.0	26.4	14.1	14.1	31.5	9.2	7.6
	N	5	6	6	4	6	6	4	4
	s.d.	3.21	2.01	0.82	0.67	0.83	1.13	1.11	0.52
	minimum	88.2	43.8	25.2	13.3	13.2	30.1	7.9	6.8
	maximum	95.7	49.4	27.4	14.9	15.4	32.7	10.6	7.9
SL hill	mean	97.3	49.3	26.1	16.3	14.6	32.1	9.6	8.1
	N	1	1	1	1	1	1	1	1
SL wet	mean	96.4	48.0	27.5	13.8	13.2	32.5	8.4	8.2
	N	3	3	3	3	3	3	3	3
	s.d.	5.08	3.00	2.16	0.95	0.87	0.90	0.87	0.50
	minimum	90.6	44.9	25.1	12.9	12.6	31.4	7.7	7.7
	maximum	99.9	50.9	29.2	14.8	14.2	33.0	9.4	8.7

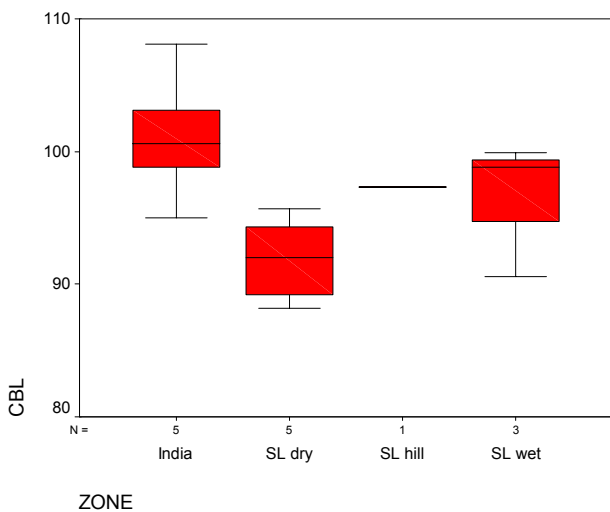


Fig. 5. Size differences between samples, as represented by Condylbasal length (in mm).

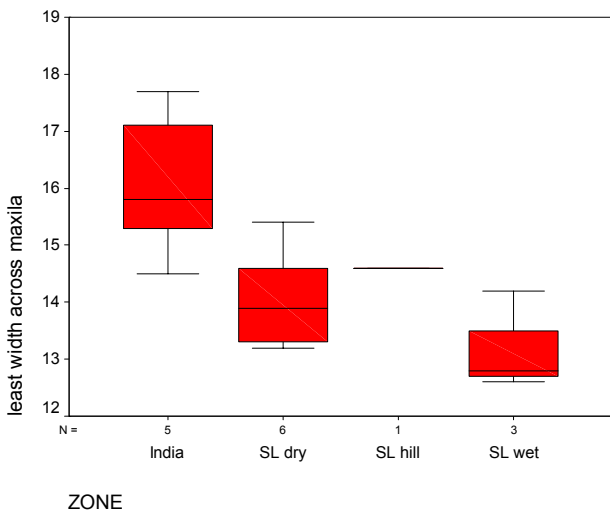


Fig. 6. Rostrum breadth (least width across maxilla) (in mm).

Indian ones in Canine width but not in Least maxillary breadth (for which see also Fig.6). Bulla measurements seem very significant: in bullar width, in particular, India and Hill are larger than Dry which is much larger than Wet and, as would be expected, Wet have a greater distance between the bullae than do dry, but India, presumably because of their overall large (especially broad) skulls, also have a wide interbullar distance.

There is a curious discrepancy between external and cranial measurements: in external, Wet Zone are slightly smaller than Dry Zone, in cranial the reverse is true. Unfortunately, there are too few specimens with associated skin and skull to examine this oddity more closely.

The relationship between Least Maxilla breadth and Condylbasal length (Fig.7) shows that Wet Zone skulls are narrower for their length than others; the Hill Zone skull falls into the Dry Zone/India range, but on the Wet Zone margin of it.

The plot of bulla width against interbullar distance (Fig.8) emphasizes the wide bullae and narrower distance between them of Dry Zone, and here Hill is in the range of Dry; Indian specimen scatter across both of them.

Finally, a Discriminant Analysis was performed. Ideally, a variable set should not be larger than the sample size of the smallest sample. In this case, one of the samples (Wet Zone) is only 3, so three variables were used for the analysis: CBL (Condylbasal length), Zygbr (Zygomatic breadth) and Least maxillary breadth. All three samples separate absolutely (Fig.9). The Hill Zone (Nuwara Eliya) skull falls in the middle of the others.

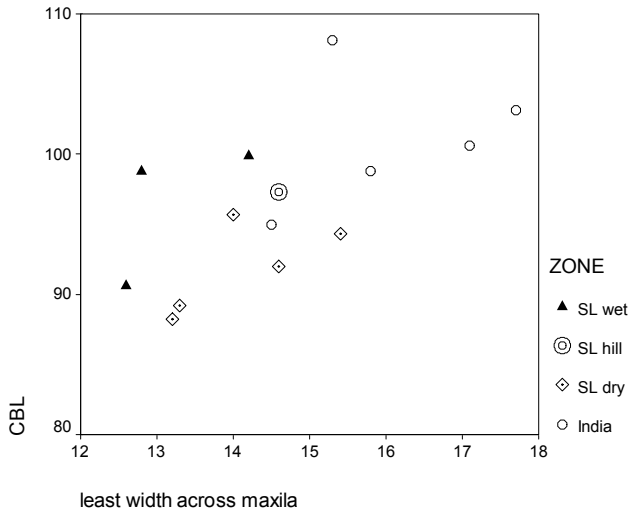


Fig. 7. Relative rostrum breadth compared to condylobasal length (in mm).

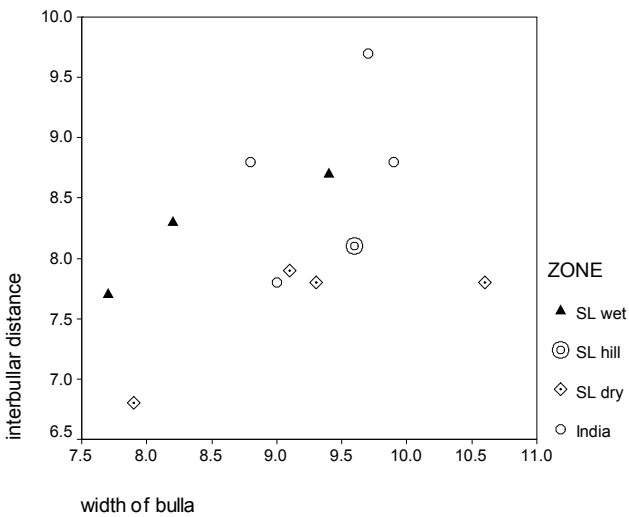


Fig. 8. Distance between bullae compared to bulla width (in mm).

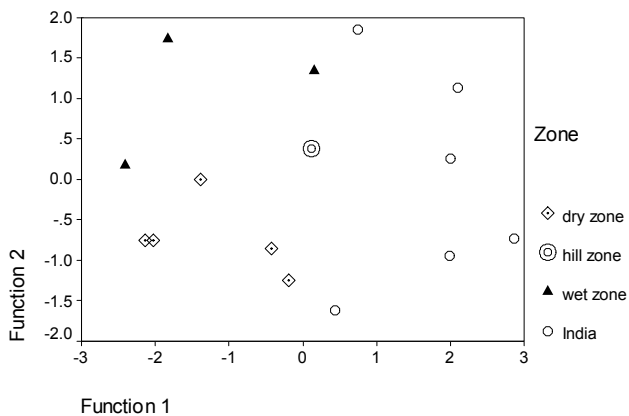


Fig. 9. Discriminant analysis, based on three cranial variables. DF1 – 82.8% of variance, DF2 – 17.2 % of variance.

Table 3. Weightings for Discriminant Functions plotted in Fig.9.

Functions	1	2
Condylobasal length	-0.427	0.658
Zygomatic width	0.831	0.440
Least width across maxilla	0.797	-0.796

DISCUSSION

Our analysis suggests that there are considerable differences between *Moschiola* specimens from India and from the two main (lowland) zones of Sri Lanka. Indian examples are large in size. Sri Lankan Dry Zone specimens are smaller but otherwise mostly resemble Indian. Sri Lankan Wet Zone are the most distinctive, both in pelage, in body proportions, and in skull proportions.

The differences between the samples are consistent, as far as our admittedly small sample sizes go. Under the Phylogenetic Species Concept (see, for example, Groves, 2001: 30–32, 34–35), diagnosability is the essential criterion for species recognition. This implies that, unless there is an unsuspected amount of phenotypic plasticity, there are fixed heritable differences between the species we are recognizing here: reproductive isolation is a largely unverifiable concept, whereas genetic discreteness relies on the evidence available.

The meminna was first described as a distinct species by Erxleben (1777), who placed all mouse deer in the Linnaean genus *Moschus* along with musk deer. He described it as follows:

Meminna: *M. supra cinero-olivaceus, subtus albus, lateribus albo maculatis. Meminna Knox Ceylon, p.21; Le Chevrotain à peau marquetée de taches blanches Buff.hist.nat.XII p.315; The Indian Musk Penn.syn.quadr.p.59 n.48 tab.10 fig.2.*

Pennant’s “Indian musk” is listed, but as the first reference is to Knox’s book on Ceylon, and the second reference (Buffon) depends primarily on Knox’s description, subsequent authors, such as Ellerman & Morrison-Scott (1951), are surely correct when they give “Ceylon” (=Sri Lanka) as the type locality. The precise locality of the specimens that formed the basis for Erxleben’s name is discussed below. At the same time, Erxleben also listed three other species in *Moschus*: *moschiferus*, *pygmaeus* and *americanus*. Of these the first is the musk deer, and the third is a species of brocket (now referred to family Cervidae, genus *Mazama*). The species *pygmaeus* is based primarily on the African Royal Antelope (*Capra pygmaea* Linnaeus, now *Neotragus pygmaeus*, family Bovidae), but incorporates both the African Water Chevrotain and Southeast Asian mouse-deer.

Gray (1821) named a new genus *Memina* (sic), which he placed alongside *Moschus* in his family Moschidae. Unfortunately the genotype was *Moschus pygmaeus*; hence the name is a synonym of *Neotragus* and not available for a mouse-deer of any kind; and as pointed out by Thomas



(1916) the name is in any case preoccupied by Fischer (1814), for a Neotropical marsupial (now *Chironectes*). Fifteen years later Gray (1836) put mouse deer back into the genus *Moschus*, but recognised *Meminna* (this time spelt correctly, as *per* Erxleben) as one of three subgenera, including in it the species *meminna*. Later (1843) he again raised *Meminna* to generic rank, and recognised two species. The first was the “Pissay” *Meminna indica* (the type specimen is BM(NH) 679a = 45.8.12.9/10, a skin and skull from the Eastern Ghats, which we could not find in the collection during our visits). Gray’s second species, “the Malacca Pissay”, *Meminna malaccensis* (type specimen 42.5.26.19, is a skin of unknown locality), but there is no description, so this name is a *nomen nudum*. The name *indica* however is available. In his 1843 work it is a *nomen nudum*, but it is available from 1852, where it is the only species listed under the genus *Meminna*, which is well described (see Gray, 1852). In both 1843 and 1852 Erxleben’s *Moschus meminna* is given as the primary source, but in both cases he says it comes from India and lists only Indian specimens, commencing with the type specimen given above.

Hodgson (1844) mentioned *Tragulus mimenoides*, from Vulgo Bijay, Nepal, as a new species without giving a description, *pace* Ellerman & Morrison-Scott (1951), who characterized it as “published in proper form”. The name has never been formally applied and remains a *nomen nudum*. Champion (1929) doubted the occurrence of *Moschiola* in Nepal, and suggested that the approximate northern limit of the species was 24° N latitude, in the Mandla and Hoshangabad districts (M.P.) and Palamau (Bihar); Tehsin (1980) recently reported it at 24°04'N in Rajasthan.

Hodgson (1844) based a new generic name, *Moschiola*, on Indian mouse deer; the name is not available, being undescribed and so a *nomen nudum*. Thomas (1916) proposed that the name is available from Gray (1852), where it is in the synonymy of his genus *Meminna*. This meets the requirements of the *Code* (Art.11.6.1: “if... a name published as a junior synonym had been treated before 1961 as an available name and... adopted as the name of a taxon... it is made available thereby but dates from its first publication as a synonym”). The generic name for the Indian Chevrotain is, consequently, *Moschiola* Gray, 1853, and the type species is *Meminna indica* Gray, 1843 by monotypy (Art.68.3).

There are thus two available names for species of the genus *Moschiola*: *M. meminna* Erxleben, 1777 and *M. indica* Gray, 1852. The type locality of Erxleben’s name is given as “Ceylon”. It is based on Knox (1681). Knox says only:

Deer are of great abundance in the woods, from the largeness of a cow to the smallness of a hare, for here is a creature in this land no bigger than the latter, though every part rightly resembleth a deer: it is called *meminna*, of a grey colour, with white spots and good meat. (Knox, 1681: 21).

The Robert Knoxes, father and son, were held captive by the king of Kandy at “Bonder-Coos-Watte” (Knox, 1681), i.e. Bandara Coswatta, near Wariyapola, although after the father’s death the son was allowed to live in the Kandy district. Wariyapola may be fixed as the type locality, and indeed we might maintain the “grey colour” is more compatible with the dull brown of the Dry Zone species. The Wet Zone species, therefore, is the one so far without a name.

## CONCLUSIONS

The genus *Moschiola* can be divided into three species, as follows:

### 1. *Moschiola indica* Gray, 1852

*Type*. – BM 45.8.12.9/10 (specimen apparently now lost).

*Type locality*. – “Eastern Ghats”.

*Distribution*. – India, from the southern tip to about 24° N, in both the east (Mandla, Hoshangabad, Palamau) and west (Rajasthan).

*Diagnosis*. – Colour dull brown; stripes and spots are very clear, white; upper row of spots forms a continuous stripe on the shoulder, but disintegrates into spots halfway back along the body, and other longitudinal stripes are broken completely into rows of elongated spots; the three spot-rows across croup and rump partly fused to stripes; crown and forehead dark brown; underside pale beige, becoming creamy medially. Size very large, with long hindlegs; skull broad, especially across rostrum. Diagnostic measurements (in mm): hindfoot >140, zygomatic breadth >50, occipital height (measured from basion) >27.8, width across canine alveoli >15.2, least maxillary breadth >14.5, braincase >34.2.

### 2. *Moschiola meminna* Erxleben, 1777

*Type*. – none in existence.

*Type locality*. – (here selected), Wariyapola, 7°37'N, 80°13'E, 416m, North Central Province, Sri Lanka.

*Distribution*. – Dry Zone of Sri Lanka.

*Diagnosis*. – Colour and pattern much as in *M. indica*, but upper row of spots does not extensively fuse into a continuous stripe on the shoulder. Size small, hindlegs relatively long (this is not an artifact of differing measurement styles; it can be verified by laying the hindlegs). Measurements mostly intermediate between the other two species; in that the observed ranges are completely separate (and the means are at least 1 s.d. apart, usually 2 s.d.), the following are diagnostic cf. *M. indica* (in mm): zygomatic breadth <50, occipital height (from basion) <27.5, width across canine alveoli <15, braincase breadth <33; and the following is diagnostic cf. *M. kathygre* new species: hindfoot >120.



Fig. 10. Skins of *Moschiola*, dorsal view. Left to right: *Moschiola kathygre*, new species (BM 77.4.14.1), *M. meminna* (BM 15.3.1.251), *M. indica* (BM 19.6.3.86).



Fig. 11. Skins of *Moschiola*, ventral view. Left to right: *Moschiola kathygre*, new species (BM 77.4.14.1), *M. meminna* (BM 15.3.1.251), *M. indica* (BM 19.6.3.86).



Fig. 12. Skins of *Moschiola*, ventral view, to illustrate differences in length of limbs. Two skins of approximately similar size have been laid with the base of the hindlimbs in equivalent positions; the hooves of the Dry Zone skin reach much further forward. Left to right: *Moschiola kathygre*, new species (SLNM 83A), *M. meminna* (SLNM 83G).

### 3. *Moschiola kathygre* new species

**Type.** – B.M. 46.209, skin and skull.

**Type locality.** – Kumbalgamuwa, 7°06'N, 80°51'E, 747m (=2454 feet), Kandy District, Central Province, Sri Lanka.

**Distribution.** – Wet Zone of Sri Lanka, from Sinharaja Forest through the lowlands around Colombo north to Katagamuwa on the border of the Dry Zone at 6°24'N, 81°25'E, and into the highlands at least to the Kandy district.

**Diagnosis.** – Colour a much warmer, more ochery brown than other species; spots and stripes are yellowed, not white; at least two tolerably complete longitudinal stripes along flanks, with an elongated spot-row between them, and two spot-rows above them; the upper stripe curves round on shoulder to be continuous with the anterior transverse stripes; two bold stripes over the haunch, and a third one further back under the tail; haunch is more densely spotted; crown and nose less darkened; on underside is a sharp differentiation between a white median strip and the pale ochery of the rest of underside; lower halves of the hindlimbs are darker. Size small, hindlegs relatively short. The following measurements are diagnostic cf. *M. indica* (in mm): tail length max. 26, width across canine alveoli <50, least breadth across maxilla max. 14.2, braincase breadth max. 33; and the following is diagnostic cf. both *M. indica* and *M. meminna*: hindfoot length max. 115. Compared to both other species, rostrum breadth is less relative to skull length; compared to *M. meminna*, bullae are narrower, especially relative to interbullar distance.

**Etymology.** – Greek *kathygre*, feminine of *kathygros* (*kata* [down from, on account of] + *hygros* [wetness], hence = growing in wet places, with reference to its Wet Zone habitat).

#### ?4. *Moschiola* undescribed species

**Remarks.** – A single skull from Nuwara Eliya, 6°58'N, 80°46'E, 2013m (=6607 feet), differs from all other members of the genus; it is intermediate in some features and idiosyncratic in others. It may prove to represent a fourth species. Its external characters are unknown.

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#### LITERATURE CITED

- Champion, S. W., 1929. The distribution of the mouse-deer (*Moschiola meminna*). *Journal of the Bombay Natural History Society*, **33**: 984–986.
- Corbet, G. B. & J. E. Hill, 1992. *The mammals of the Indomalayan region: a systematic review*. Oxford University Press, Oxford. 488 pp.
- Deraniyagala, P. E. P., 1956. A new subspecies of rusty spotted cat from Ceylon. *Spolia Zeylanica*, **28**: 113–114.
- Ellerman, J. R. & T. C. S. Morrison-Scott, 1951. *Checklist of Palaearctic and Indian Mammals, 1758 to 1946*. British Museum Trustees, London. 810 pp.
- Erxleben, C. P., 1777. *Systema Regni Animalis per Classes, Ordines, Genera, Species, Varietates, cum Synonymia et Historia Animalium. Classis I, Mammalia*. Weygand, Leipzig. xlviii + 636 pp.
- Fischer von Waldheim, G., 1814. *Zoognosia tabulis synopticis illustrate*. Nicolai Sergeidis Vsevolozsky, Moscow. xxiii + 605 pp.
- Gmelin, J. F., 1788. *Caroli a Linné, Systema Naturae per Regna Tria Naturae, secundum Classes, Ordines, Genera, Species. Tomus I*. 13th edition. Georg Emanuel Beer, Leipzig. 3 vols.
- Gray, J. E., 1821. On the natural arrangement of Vertebrate animals. *London Medical Repository*, **15**: 296–310.
- Gray, J. E., 1836. On the genus *Moschus* of Linnaeus, with descriptions of two new species. *Proceedings of the Zoological Society of London*, **4**: 63–66.
- Gray, J. E., 1843. *List of the Specimens of Mammalia in the Collection of the British Museum*. Trustees of the British Museum, London. 216 pp.
- Gray, J. E., 1852. *Catalogue of the specimens of Mammalia in the collection of the British Museum*. Part 3: Ungulata Furcapeda. xvi+286 pp, 37 pls.
- Groves, C. P., 1998. Systematics of tarsiers and lorises. *Primates*, **39**: 13–27.
- Groves, C. P., 2001. *Primate Taxonomy*. Smithsonian Institution Press, Washington, DC. 350 pp.
- Groves, C. P. & P. Grubb, 1982. Relationships of living deer. In: Wemmer, C. M. (ed.), *Biology and management of the Cervidae*. Research symposia of the National Zoological Park. Smithsonian

- Institution Press, Washington, D.C. xiii + 577 pp.
- Hodgson, B. H., 1844. Classified catalogue of mammals of Nepal (corrected to end of 1841, first printed in 1832). *Calcutta Journal of Natural History*, **4**: 284–294.
- Knox, R., 1681. *An historical relation of the island Ceylon, in the East Indies: with an account of the detaining in captivity the author and divers other Englishmen now living there, and of the author's miraculous escape*. Richard Chiswell, London. xx + 189 pp.
- MacKinnon, J., 1997. *Protected areas system review of the Indo-Malayan realm*. The Asian Bureau for Conservation Limited, Canterbury. 284 pp.
- Meijaard, E. & C. P. Groves, 2004. A taxonomic revision of the *Tragulus* mouse deer (Artiodactyla). *Zoological Journal of the Linnaean Society of London*, **140**: 63–102.
- Phillips, W. W. A., 1980. *Manual of the mammals of Sri Lanka*. 2nd edition. Wildlife and Nature Protection Society of Sri Lanka, Colombo. xxix + 389 pp.
- Tehsin, R. H., 1980. Occurrence of the large brown flying squirrel and mouse deer near Udaipur, Rajasthan. *Journal of the Bombay Natural History Society*, **77**: 498.
- Thomas, O. 1916. On the generic names applicable to the Chevrotains. *Annals and Magazine of Natural History* (8), **18**: 72–73.

#### APPENDIX 1

##### 1. List of skull measurements

All measurements were made with an accuracy of 0.1 mm with Vernier calipers (precision 0.05 mm).

Condylobasal length  
 Basion-palate length (between basion and staphylion)  
 Mandible length  
 Zygomatic width  
 Width across orbits  
 Condylar width (width across occipital condyles)  
 Nasal length (median)  
 Occipital height from basion  
 Occipital height from opisthion  
 Canine width (width of rostrum across canine alveoli)  
 Least width across maxilla  
 Width of braincase  
 Mandible height  
 Width of tympanic bulla  
 Length of tympanic bulla  
 Interbullar distance

##### 2. List of specimens

Sri Lanka, Wet Zone: BM 36.11.26.16 (Ketala-Patela, Sinharadja [Sinharaha] Forest), skin only; 46.209 (Kumbalgamuwa, Kandy District), skin and skull; 76.5.30.5 (Perandeniya), skin only; 77.3.14.1 (Kandy), skin only; 77.11.1.8 (Kandy), skin only, infant; FMNH 95017, -8 (Kottowa, WP), skulls only; SLNM 83, 83A (Bandaragama), skins only; 83C, D (Rigam Korale), skins only; 83R (Valallawita, Kalutara), skin only; 1970-10-3, -4 (Karambaketiya), skins only. The following specimens are listed, and their flesh measurements recorded, in the SLNM register, but appear to be no longer in the collection: 83B (Kesbewa), 83E (Panadura), 83F (Katagamuwa).



Four places called Katagamuwa are listed in the gazetteer— a village and reservoir in Yala, a village in the dry zone at 7°43'N, 80°10' E (actually spelt Katagomuwa), and a village at 07°36'N, 80°11'E, between Kurunegala and Chilaw on the west coast, and actually on the border of the Dry Zone). We think it most likely to be this last, as being a more centralised location, closer to Colombo. We thank Rohan Pethiyagoda, of the Wildlife Heritage Trust of Sri Lanka, for help, and a discussion of these locations.

Sri Lanka, Dry Zone: BM 15.3.1.251 (Tammanewa, NCP), skin and skull; 15.3.1.252 (Chaddikulam, NP), skin and skull; 15.3.1.253 (Kumbukkan, Uva), skin and skull; FMNH 98275, -6 (Wariyapola, NWP); 99373 (Galge, "Sabaragamuwa" [actually Uva]); SLNM 83G (Passava), 83H (Kitulgala; juvenile); 83M (Maeliwela); 83Q (Yala), skin and skull; 83S (Marichchikadae); 83T, U (Pooneryn), skins only; 83V (Vihara Halmillewa, Kebutgallewa), skin and skull. The following specimens are listed,

and their flesh measurements recorded, in the SLNM register, but appear to be no longer in the collection: 83J (Thantiromala), 83K (Tunakai), 83L (Verugala).

Sri Lanka, Hill Zone: FMNH 99411 (Nuwara Eliya, CP, 7000'), skull only.

India: BM 50a (Madras), skin only, juvenile; 57 ("India"), skull only; 12.11.28.125 (Hulekal, near Sirsi, Kanara), skin and skull; 13.8.22.88 (Chamrajnagar, S. Mysore), skin and skull; 13.8.22.89 (Wottekuli, S. Coorg), skin and skull; 19.6.3.79, -80 (Khandula, former Bombay Province), skins and skulls; 19.6.3.81 (Lonaula, Western Ghats), skull only; 38.3.13.47 ("northern Circass"), skin only; 79.11.2.5 (Dakhun), skull only; 79.11.21.588 (Dakhun), skin only, juvenile; 79.11.21.657 (Dakhun), skin and skull; FMNH 83106 (Virajpet: S. India), skull only.

Unknown origin: BM 42.5.26.19 (type of *Meminna malaccensis* Gray), skin only; FMNH 82021; 81517.

