

AN ACCOUNT OF THE HIMALAYAN MOUNTAIN SORICID COMMUNITY,  
WITH THE DESCRIPTION OF A NEW SPECIES OF *CROCIDURA*  
(MAMMALIA: SORICOMORPHA: SORICIDAE)

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**ABSTRACT.** — Information on distribution, altitudinal range and taxonomy is provided on the shrews belonging to the family Soricidae that have been recorded from the Himalayan region. The geographical and historical knowledge of the study of mammals in the Himalayan region is briefly outlined and a formerly unrecognised species of *Crocidura* is described. Biogeographical patterns and species associations of the soricids of the Himalayan region are examined.

**KEY WORDS.** — Soricidae, Himalayas, biogeography, species patterns, new species

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INTRODUCTION

The biogeographically complex Himalayan region supports a diverse shrew fauna belonging to two subfamilies within the family Soricidae. The subfamily Soricinae includes representatives of three tribes: the Anourosoricini (two species belonging to the genus *Anourosorex*), the Nectogalini (monospecific *Chimarrogale*, *Nectogale* and *Soriculus*, and five species belonging to the genus *Episoriculus*) and the Soricini (three species of *Sorex*). The subfamily Crocidurinae is represented by three species of *Suncus* and three species of *Crocidura*, including one that was formerly unrecognised and is described below.

The Himalayan mountains are bounded in the west by the Indus river and in the east by the Brahmaputra River. The Himalayas comprise three east-west directed roughly parallel ranges: the southernmost Siwaliks forming the Outer Himalayas, the Middle Himalayas rising to approximately 5000 m and the northernmost Inner Himalayas with high altitude peaks exceeding 7000 m (Wikramanayake et al., 2002). The Himalayan region spans the northeastern part of Pakistan, Nepal, Bhutan, the southern region of Xizang, China and the Indian states of Jammu and Kashmir, Himachal Pradesh, Punjab, Uttarakhand, Sikkim, the northern hill region of West Bengal, Arunachal Pradesh and hill regions of Assam. Because of ecological similarities, observations are also included on shrews that occur both in the Himalayas and also in the hill country of Meghalaya and Nagaland.

At various times the Himalayas have been separated into three more or less artificial divisions of western, central and

eastern Himalayas. The classification adopted by MacKinnon (1997) divided the Himalayas into four subunits as follows: 12a, the Northwest Himalayas from Jammu and Kashmir and Himachal Pradesh to Uttarakhand; 12b, West Nepal; 12c, Central Himalayas from central and eastern Nepal to Bhutan; 12d, Eastern Himalayas including eastern Bhutan and Arunachal Pradesh. MacKinnon considered that the Eastern Himalayas subunit showed a close relationship with Assam, which he regarded as a distinct unit.

The eastern Himalayas, rising from the Gangetic Plains, receive the greatest proportion of monsoonal precipitation, because of their proximity to the Bay of Bengal. Precipitation is progressively less to the west and the western Himalayas are consequently drier and floristically less species-rich than the eastern Himalayas. There is a general south-north trend in ecosystems ascending the south-facing slopes of the Himalayas, from savannah and grasslands, through broadleaf and mixed forests, then sub-alpine conifer forests, to the alpine shrub and meadows. Wikramanayake et al. (2002) defined 10 ecoregions within the Himalayas, and these are shown by van Dijk & Das (2013, this volume). The Kali Gandaki Gorge in Nepal [c. 28.7068°N, 83.6453°E] serves as a principal east-west floristic division between three of the western (Ecoregion 27 Western Himalayan broadleaf forests; Ecoregion 29 Western Himalayan sub-alpine conifer forests; Ecoregion 38 Western Himalayan alpine shrub and meadows) and three of the eastern ecoregions (Ecoregion 26 Eastern Himalayan broadleaved forests; Ecoregion 28 Eastern Himalayan sub-alpine conifer forests; Ecoregion 39 Eastern Himalayan alpine shrub and meadows). Ecoregion 25 Himalayan subtropical broadleaved forests lies along the

Siwaliks or Outer Himalayan Range and occupies central Nepal and extends eastwards through the Darjeeling area of West Bengal into Bhutan but also westwards into Uttar Pradesh. This ecoregion is also bisected by the Kali Gandaki Gorge.

For the purposes of this report, in general the western Himalayas is taken to include 12a and 12b of MacKinnon (1997) and the Western Himalayan ecoregions of Wikramanayake et al. (2002); the central Himalayas is equivalent to 12c of MacKinnon (1997) and part of the eastern Himalayan ecoregions of Wikramanayake et al. (2002); the eastern Himalayas to 12d of MacKinnon (1997) and part of the eastern Himalayan ecoregions of Wikramanayake et al. (2002).

This study is based on the collection of the Natural History Museum, London (formerly the British Museum and then the British Museum [Natural History]) the holdings of which include material from Hodgson, Horsfield, Blanford and others. One of the earliest, and very significant, collections for the study of Himalayan mammals was that of Brian H. Hodgson, who became assistant to the British Resident and subsequently the Resident at Katmandu, Nepal from 1820 to 1843, and then settled at Darjeeling from about 1845 to 1858 before returning to Britain. His collections from Nepal, Sikkim, the Darjeeling district of West Bengal and Xizang, China [Tibet] contained several type specimens of shrews, some described by himself and others by Thomas Horsfield. Hodgson's collections were donated directly to the British Museum in the early 1840s and a catalogue of the collection was published (Gray, 1847).

Thomas Horsfield was Curator of the Museum of the East India Company in London and duplicate specimens were donated to the British Museum from 1841 onwards. A catalogue, which included the description of a number of new species was published (Horsfield, 1851), and the India Museum, as it was known, continued to grow and flourish until its collections were incorporated into those of the British Museum in 1879 (Thomas, 1906).

William Thomas Blanford was a professional geologist but also a naturalist employed by the Geological Survey of India, who served in India from 1855–1867 and again from 1874–1882, at which time he retired to England. During his retirement he wrote the volume on mammals and two on birds for the Fauna of British India and edited many of the volumes in the series. In addition to his important writing and research on the collections, he donated specimens and stimulated donations by other naturalists (Thomas, 1906; Anonymous [T.G.B], 1907).

One of the most important contributions to knowledge of the mammalian fauna of the Indian subcontinent was that of the Bombay Natural History Society's Mammal Survey [BNHSMS] of India, Burma [Myanmar] and Ceylon [Sri Lanka]. This survey was initiated by Robert Charles Wroughton and interested friends and fellow members of the Society in 1911 and continued for 18 years. The object,

as suggested by the title, was to survey specific locations throughout the Indian subcontinent and make extensive well-documented collections of the mammalian fauna. Wroughton worked for the Indian Forest Service from 1871 to 1904, subsequently retiring to London, where he became a regular worker at the British Museum. He acted as the main proponent for the surveys and was responsible for sorting and cataloguing specimens, writing some, and editing many, of the reports and scientific results. He was assisted in this work by T. B. Fry, who continued with the work after Wroughton's death in 1921 (Wroughton, 1912, 1918; Kinnear, 1952). Wroughton himself wrote many of the earlier reports on the Himalayan region from 1914 to 1917, while Martin A. C. Hinton co-authored several of the subsequent reports on the region. Reports were produced for each of the surveyed locations, providing the dates of the survey; the principal collector; information about the geography of the main localities; and the number, sex and localities of specimens of the recorded species.

Twelve surveys were carried out in the Himalayan and adjacent regions under the aegis of the BNHSMS. The western Himalayan region consisting of Pakistan and the Indian states of Jammu and Kashmir, Uttarakhand and Himachal Pradesh was covered in reports by Wroughton (1914), Hinton & Thomas (1926), and Lindsay (1926a, 1926b). The central Himalayan region, of Nepal and the Indian states of Sikkim and the northern hill country of West Bengal, roughly equivalent to subunit 12c of MacKinnon (1997), received a disproportionate concentration of effort and was covered in reports by Wroughton (1916a, 1916b, 1917a, 1917b), Hinton & Fry (1923), and Fry (1925). The eastern Himalayan region, of Arunachal Pradesh and hill regions of Assam, and also the hill country in Meghalaya and Nagaland, was covered in reports by Mills (1923) and Hinton & Lindsay (1926). During the course of the survey, taxonomic results were published on specific mammalian groups, including two groups of shrews: *Soriculus* in a paper by Hinton (1922) and *Suncus* by Lindsay (1929).

There was little organised collection after this time, although sporadic collections continued to be made well into the 1970s, including two notable expeditions to Nepal by NHM staff, the latest by Gordon Corbet, who concentrated on the collection of small mammals.

## MATERIAL AND METHODS

This study is based on more than 450 specimens of Soricidae from the Himalayas and associated regions from the collections mentioned above. Information on localities was derived from specimen labels, field notes held in the NHM archives and published accounts, such as the Bombay Natural History Society surveys (Wroughton, 1914, 1916a, 1916b, 1917a, 1917b; Hinton & Fry, 1923; Mills, 1923; Fry, 1925; Hinton & Lindsay, 1926; Hinton & Thomas, 1926; Lindsay, 1926a, 1926b). With the exception of collections made in the second half of the 20<sup>th</sup> century, coordinates for localities were rarely recorded. Therefore coordinates of

collecting localities were determined by a variety of methods, principally by reference to the Official Standard Names gazetteer of the United States Board on Geographic Names (USBGN, 1952, 1978) or by using Google Earth (<http://earth.google.com>) to locate collection localities from original descriptions of geographic landmarks, or from sources such as India Mapia (<http://www.indiamapia.com>). Distribution maps were prepared using DMAP (<http://www.dmap.co.uk>).

Measurements in millimetres were taken with digital callipers. Cranial and dental nomenclature follows that of Meester (1963), Mills (1966), Butler & Greenwood (1979), Dannelid (1998), and Jenkins et al. (2009). External measurements were those recorded by collectors on skin labels.

## SYSTEMATICS

Subfamily Soricinae  
Tribe Anourosoricinae

### *Anourosorex assamensis* Anderson, 1875

Eastern Himalayas in the Mishmi Hills of Arunachal Pradesh, and also from Meghalaya, Nagaland and Manipur (Hinton & Lindsay, 1926; Motokawa & Lin, 2002). See Fig. 1 for distribution map of specimen localities in this study.

Altitude: 686–1567 m.

Originally described as a separate species, *A. assamensis* was regarded as a subspecies of *A. squamipes* by Ellerman & Morrison-Scott (1951). Motokawa & Lin (2002) demonstrated geographical variation between samples of *assamensis* from Assam and of *squamipes* from China and Vietnam, which they considered to represent two subspecies of *A. squamipes*. Hutterer (2005) extended their study and concluded that the two taxa represented distinct species, *A. assamensis* occurring in north east India and the more wide-ranging *A. squamipes* occurring in E. India, Myanmar, China and Vietnam. He noted that the exact ranges of the two species are unknown and may overlap. Little is known

about this species, but from its morphological similarity to *A. squamipes*, it is believed to be fossorial.

### *Anourosorex schmidi* Petter, 1963

There is little information on this species which, according to Hutterer (2005) and Molur (2008a), occurs in subtropical and tropical montane forests in the Himalayan slopes of Bhutan, and the Indian states of Sikkim and Arunachal Pradesh (Hutterer, 2005; Molur, 2008a).

Tribe Nectogalinae

### *Chimarrogale himalayica* (Gray, 1842)

This species has a wide but sporadic distribution across the Himalayas. In this study it was recorded from Jammu and Kashmir (Hinton & Thomas, 1926) and Uttarakhand (Wroughton, 1914) in the west, to Sikkim (Wroughton, 1916a), West Bengal (Wroughton, 1916b) and Arunachal Pradesh (Hinton & Lindsay, 1926) (see Fig. 2). It also occurs in Nagaland (Mills, 1923) in the east. It was recorded from the temperate zone in central Nepal by Abe (1982).

Altitude: 610–3048 m.

This semi-aquatic shrew is generally associated with clear streams in temperate evergreen forests (see Hoffman & Lunde, 2008; Molur, 2008b) and transcends several eastern and western ecogeographic regions.

### *Nectogale elegans* Milne Edwards, 1870

In this study, this species was recorded from Sikkim (Wroughton, 1916a), Bhutan, Arunachal Pradesh and Xizang, and also from Assam (see Fig. 1). It has been reported from Xizang, China (Zhang et al., 1997; Hoffman & Lunde, 2008).

Altitude: 1524–3962 m.

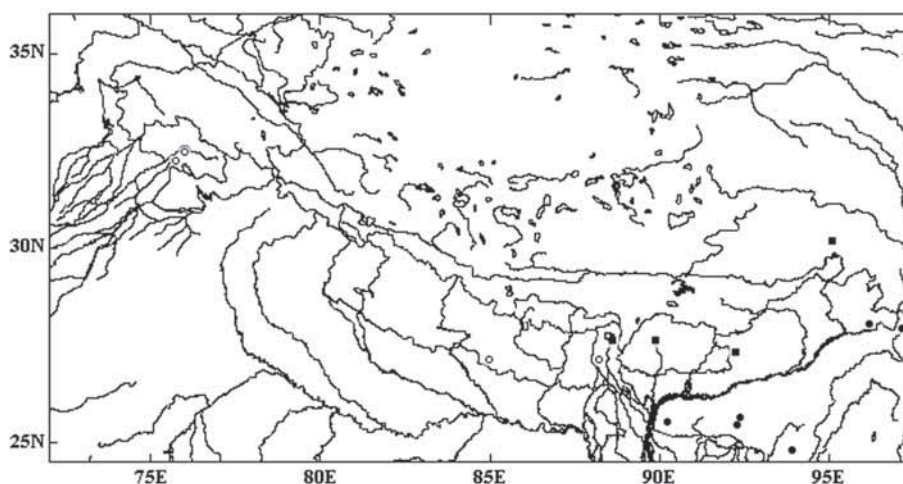


Fig. 1. Distribution map of specimen localities of *Nectogale elegans* ■; *Anourosorex assamensis* ●; *Suncus stoliczkanus* ○. Locality with *N. elegans* and *S. stoliczkanus* ■.

This aquatic shrew shows the greatest adaptation to its habitat in swiftly flowing mountain streams (Hoffman & Lunde, 2008).

***Episoriculus* Ellerman & Morrison-Scott, 1951**

The genus *Episoriculus* Ellerman & Morrison-Scott, 1951 was originally described as a subgenus of *Soriculus* and employed as such in the important review by Hoffman (1985). *Soriculus* and *Episoriculus* are currently regarded as separate genera (Hutterer, 2005). The taxonomy of *Episoriculus* is very confused and there have been many changes in the understanding of species and the application of species names.

***Episoriculus baileyi* (Thomas, 1914)**

The species is recorded by specimens from Sikkim (Wroughton, 1916a, as *Soriculus caudatus*, in part) in the central Himalayas and from the Mishmi Hills, Arunachal

Pradesh (Thomas, 1914, the type of *S. baileyi*; Hinton & Lindsay, 1926 as *S. caudatus*) in the eastern Himalayas (see Fig. 3).

Altitude: 1567–2682 m.

This name was regarded as a synonym of *Episoriculus leucops* by Hoffman (1985), Motokawa (2003) and Hutterer (2005). The species was however shown to be distinct by Motokawa & Lin (2005), who separated it from *E. caudatus* and *E. macrurus* on the basis of its greater size, and from *E. leucops* by greater size of the tympanic ring.

***Episoriculus caudatus* (Horsfield, 1851)**

This species was recorded from Uttarakhand (Wroughton, 1914), Nepal (Horsfield, 1851; Fry, 1925; Abe, 1977, 1982), Sikkim and hill regions of West Bengal (Wroughton, 1916a) (see Fig. 3). Reported to occur in Xizang, China (Zhang et al., 1997; Hoffman & Lunde, 2008).

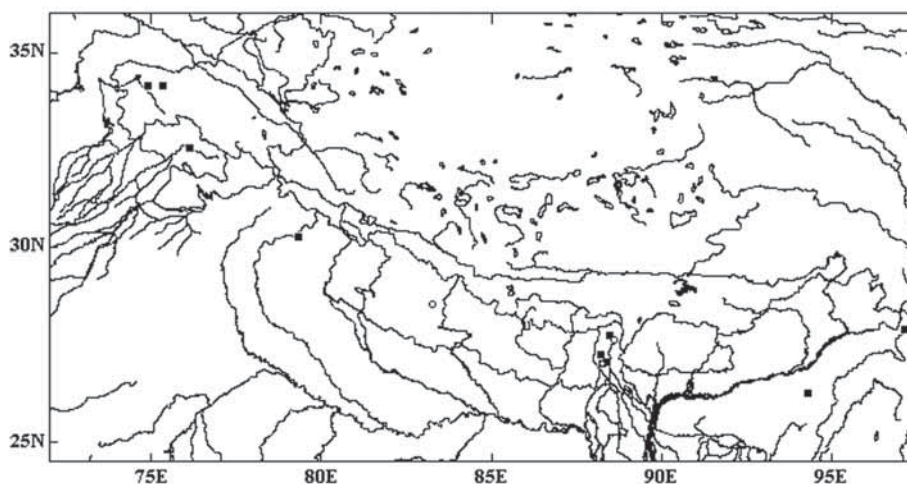


Fig. 2. Distribution map of specimen localities of *Chimarrogale himalayica* ■ and *Episoriculus macrurus* ○. Localities where both species have been collected are indicated by ■.

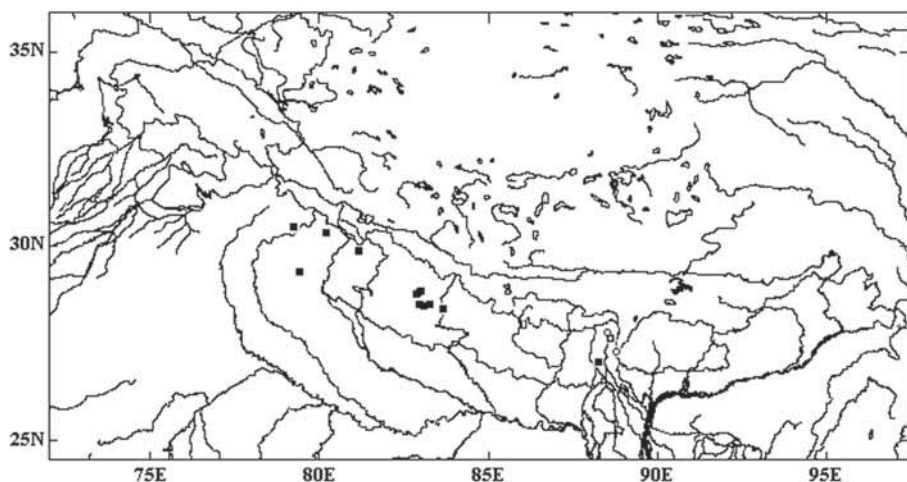


Fig. 3. Distribution map of specimen localities of *Episoriculus caudatus* ■ and *Episoriculus baileyi* ○. Locality where both species occur sympatrically is indicated by ■.

Altitude: 1631–3658 m.

According to Hoffman (1985) this species is less morphologically specialised than either of the other two species of *Episoriculus* that he recognised at that time, and is also more widespread and common. In central Nepal this species was observed to range from evergreen broadleaved, rhododendron and conifer forests in the temperate zone to the alpine zone of shrubs and herbs (Abe, 1982).

#### *Episoriculus leucops* (Horsfield, 1855)

This species is known only from the holotype from an unspecified locality in Nepal and from two specimens from Nepal identified as *S. baileyi* (Abe, 1977, 1982) and reidentified as *E. leucops* by Motokawa & Lin (2005).

There is much confusion in the literature between this and other species of *Episoriculus*. It was distinguished from *E. caudatus* and *E. macrurus* on the basis of its greater size (Hoffman, 1985) and the distinction between *E. leucops* and *E. caudatus* was confirmed by Motokawa (2003). Further morphological study by Motokawa & Lin (2005) served to separate *E. baileyi* from *E. leucops*.

#### *Episoriculus macrurus* (Blanford, 1888)

This species occurs in central Nepal (Abe, 1982, as *S. leucops*), Sikkim (Wroughton, 1916a) and West Bengal (Blanford, 1888, the type from Darjeeling). See Fig. 2 for distribution of specimen localities.

Altitude: 1631–2438 m.

The species was separated from *E. leucops* by Hoffman (1985).

#### *Episoriculus soluensis* Gruber, 1969

This name was considered to be a synonym of *E. caudatus* (see Hutterer, 2005; Hoffman & Lunde, 2008). Abe (1977) recorded specimens of two subspecies of *E. caudatus* from central Nepal, namely *E. c. caudatus* and *E. c. soluensis*, which he distinguished on the basis of size. In a subsequent molecular analysis including samples from this material a large genetic difference between these supposed subspecies was demonstrated (Ohdachi et al., 2006). Motokawa et al. (2008) provided additional cytological evidence to support their view that *soluensis* should be regarded as a subspecies of *E. sacratu*s (Thomas, 1911), a species described from Sichuan, China. In a further study, Motokawa et al. (2009) proposed the elevation of *E. soluensis* to specific rank on the basis of karyotypic differences between the three species, *E. sacratu*s from Sichuan, and *E. caudatus* and *E. soluensis* from Nepal. These authors emphasised that further studies are required to establish the morphological and distributional boundaries of these species.

#### *Soriculus nigrescens* (Gray, 1842)

Occurs in Uttarakhand (Wroughton, 1914; Hinton, 1922, the type of *S. n. caurinus*), Nepal (Hinton, 1922, the type of *S. n. centralis*; Hinton & Fry, 1923; Fry, 1925; Abe, 1977, 1982), Sikkim (Wroughton, 1916a; Hinton, 1922, the type of *S. n. pahari*) and West Bengal (Gray, 1842; Hodgson, 1849; Wroughton, 1916a, 1916b). Reported from Xizang, China (Zhang et al., 1997; Hoffman & Lunde, 2008). The smaller subspecies, *S. n. minor* Dobson, 1890 from Manipur, was recorded from Bhutan and Arunachal Pradesh (Thomas, 1922, the type of *S. radulus*; Hinton & Lindsay, 1926 as *S. radulus*). See Fig. 4 for distribution of specimen localities.

Altitude of *S. n. nigrescens*: 1067–4267 m and of *S. n. minor*: 1567 m.

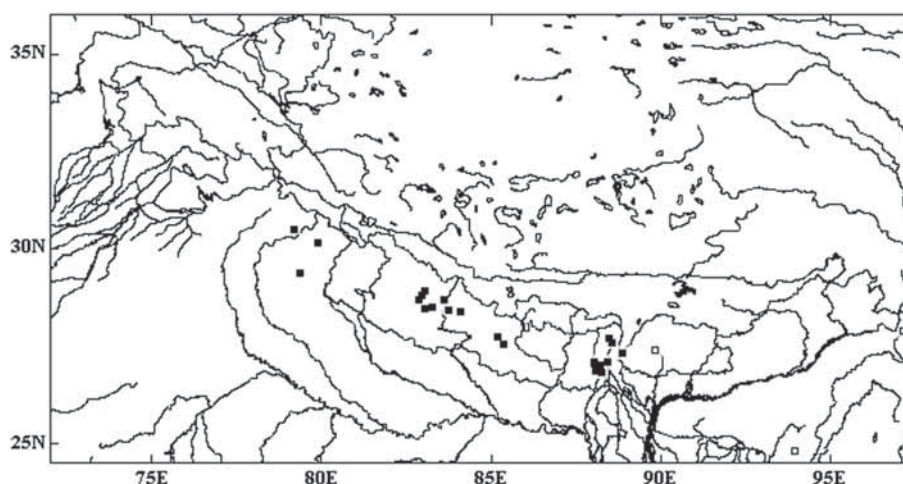


Fig. 4. Distribution map of specimen localities of *Soriculus nigrescens* ■ and *Soriculus nigrescens minor* □.

Hoffman (1985) and Motokawa (2003) demonstrated a distinct size difference between the larger *S. nigrescens* and the smaller *S. n. minor*. The latter may represent a distinct species but because it is known from very few specimens it has been retained as a subspecies (Hutterer, 2005).

Tribe Soricini

***Sorex bedfordiae* Thomas, 1911**

Recorded from central Nepal as *Sorex cylindricauda* Milne Edwards, 1872a by Abe (1982).

***Sorex minutus* Linnaeus, 1766**

Recorded from Nepal (Ingles et al., 1980; Abe, 1982) (see Fig. 5). Reported variously as *Sorex minutus* or *S. thibetanus* Kastschenko, 1905. Hoffman (1996) mapped the distribution on the Xizang Plateau as *S. thibetanus*. Reported from Xizang, China (Zhang et al., 1997).

***Sorex planiceps* Miller, 1911**

Type specimen from Dachin, Khistwar, Kashmir. The taxonomic status of three small species of *Sorex* in the Himalayas: *S. minutus*, *S. thibetanus* and *S. planiceps* remains unresolved (see Hutterer, 2005; Hoffman & Lunde, 2008).

Subfamily Crocidurinae

***Suncus etruscus* (Savi, 1822)**

Recorded variously as *S. hodgsoni* (Blyth, 1855a), *S. micronyx* (Blyth, 1855a), *S. perrotteti* (Duvernoy, 1842) and *S. etruscus* from Himachal Pradesh (Lindsay, 1926a); Uttarakhand (Wroughton, 1914); Nepal (Fry, 1925; Mitchell & Punzo, 1976; Ingles et al., 1980; Abe, 1982), Sikkim (Wroughton, 1916a) to West Bengal (Wroughton, 1916b, 1917a). Also

in Meghalaya (Hinton & Lindsay, 1926). For distribution of specimen localities see Fig. 5.

Altitude: 183–2591 m.

***Suncus murinus* (Linnaeus, 1766)**

Throughout the Himalayan region, and also Meghalaya and Nagaland (see Fig. 5). Not recorded in this study from the Indian state of Arunachal Pradesh, nor is it reported from Xizang state in China. Two specimens of *Suncus*, most likely belonging to this species, were however recorded from the Mishmi Hills, Arunachal Pradesh (Hinton & Lindsay, 1926).

Altitude: 61–2286 m.

***Suncus stoliczkanus* (Anderson, 1877)**

Recorded from Nepal (Mitchell & Punzo, 1976; Abe, 1982) and by a few specimens from Himachal Pradesh (Lindsay, 1926a, as unidentified *Suncus*), Sikkim and West Bengal. For the sparse distribution of this species see Fig. 1.

Altitude: A single specimen was recorded at 195 m.

Abe (1982) commented that this species was confined to the Terai of central Nepal, which falls within Ecoregion 35 Terai-Duar savanna and grasslands at the base of the Himalayas (Wikramanayake et al., 2002).

***Crocidura attenuata* Milne Edwards, 1872b**

Recorded from Nepal (Hinton & Fry, 1923, as *C. rubricosa*; Mitchell & Punzo, 1976 and Ingles et al., 1980, as *C. attenuata*); Sikkim (the type of *C. kingiana* Anderson, 1877; Wroughton, 1916a); West Bengal (the type of *C. rubricosa* Anderson, 1877; Anderson, 1881); Arunachal Pradesh and

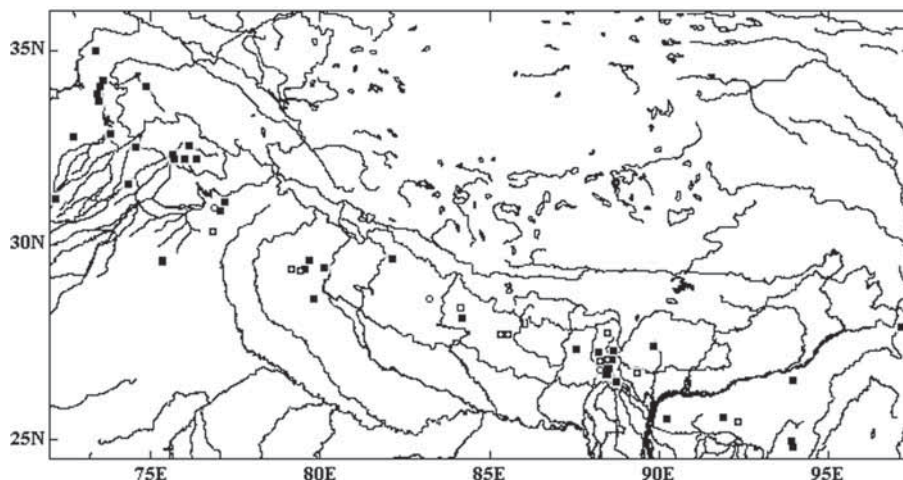


Fig. 5. Distribution map of specimen localities of *Suncus etruscus* ○; *Suncus murinus* ■; *Sorex minutus* □. Localities where *S. etruscus* and *S. murinus* occur sympatrically are indicated by ■.

Table 1. Comparison of four species of *Crocidura*. Measurements in millimetres are presented as the mean, standard deviation and range with the number of specimens in parentheses. Key to dental notations: I-Un3, length from anterior of first upper incisor to posterior border of the third upper unicuspid; M2, second upper molar; UTL, upper tooththrow length.

	<i>Crocidura pullata</i> Jammu and Kashmir, India; Pakistan	<i>Crocidura attenuata</i> Darjeeling, West Bengal, India	<i>Crocidura gathornei</i> Uttarakhand and Himachal Pradesh, India	<i>Crocidura dracula</i> Yunnan, China
Head and body length	70.7 ± 5.0 60–78 (21)	67.6 ± 4.8 61–77 (16)	82.8 ± 4.5 77–91 (5)	88.7 ± 4.2 78–95 (19)
Tail length	45.7 ± 3.3 40–51 (20)	62.4 ± 2.9 57–67 (16)	67 ± 5.1 57–70 (5)	73.1 ± 4.6 65–80 (18)
Percentage of tail length to head and body length	65 ± 6.5 54.8–76.1 (20)	92.5 ± 5.4 82.6–101.6 (16)	80.9 ± 4.6 74–85.4 (5)	82.5 ± 3.9 73–89 (18)
Condylolincisive length	19.4 ± 0.8 18–20.4 (10)	20.5 ± 0.6 19.5–21.2 (13)	23.6 ± 0.1 23.5–23.7 (3)	23.6 ± 0.7 22.3–24.9 (15)
Upper tooththrow length	8.5 ± 0.3 7.9–9.0 (21)	8.9 ± 0.2 8.5–9.3 (21)	10.8 ± 0.1 10.6–11 (4)	10.3 ± 0.3 9.7–11.1 (21)
Maxillary breadth at level of M2	5.7 ± 0.3 5.0–6.0 (21)	5.9 ± 0.2 5.5–6.1 (22)	6.5 ± 0.1 6.4–6.7 (4)	7.0 ± 0.2 6.7–7.3 (21)
Braincase breadth	8.8 ± 0.3 8.1–9.3 (10)	9.0 ± 0.3 8.7–9.5 (12)	9.7 ± 0.2 9.5–9.9 (3)	10.3 ± 0.2 9.9–10.6 (15)
Ratio of I-Un3 to UTL	0.5 ± 0.02 0.45–0.55 (18)	0.45 ± 0.02 0.41–0.48 (21)	0.52 ± 0.01 0.5–0.53 (4)	0.46 ± 0.01 0.43–0.48 (21)

hill regions of Assam, and also in Megalaya and Nagaland (Anderson, 1881; Hinton & Lindsay, 1926, as *C. rubricosa*) (see Fig. 6). Reported from Xizang, China (Zhang et al., 1997).

Altitude: 91–2438 m.

*Crocidura rubricosa* and *C. kingiana* were regarded as synonyms of *C. attenuata* by Ellerman & Morrison-Scott (1951).

#### *Crocidura pullata* Miller, 1911

Western Himalayas. Recorded from Jammu and Kashmir (Miller, 1911, type material of *C. pullata*; Hinton & Thomas, 1926, as *C. rubricosa*; Jiang & Hoffman, 2001, as *C. pullata*)

and from Pakistan (Lindsay, 1926b, as *C. rubricosa*) (see Fig. 6).

Altitude: 1829–2652m.

This species was included with western European populations of *C. russula* (Hermann, 1780) (Ellerman & Morrison-Scott, 1951; Jenkins, 1976). It was recognised as a distinct species and discussed in relation to *C. attenuata* by Jiang & Hoffman (2001), who provided morphometric data in support of their conclusions.

The following species of *Crocidura* was recorded from Himachal Pradesh (Lindsay, 1926a) and Uttarakhand (Wroughton, 1914), by both authors under the name of *Crocidura kingiana*, a synonym of *C. attenuata*. It is here recognised as a distinct species and described below.

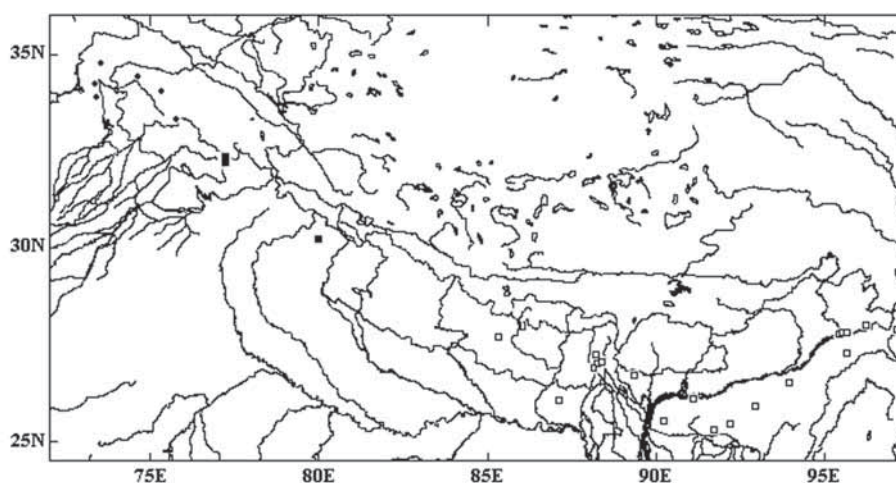


Fig. 6. Distribution map of specimen localities of *Crocidura attenuata* □; *Crocidura pullata* ●; *Crocidura gathornei* ■.

***Crocidura gathornei*, new species**

**Holotype.** — BMNH 2013.30 adult male, skin and skull, collector's number 3630, collected 30 Aug.1913 by C. M. Crump.

**Type locality.** — Phurkia, Kumaon, United Provinces [Uttarakhand], India, 30°14'33"N, 79°59'38"E, altitude 10,700 feet above sea level (asl) [3261 m].

**Paratypes.** — BMNH 2013.29 adult male, skin and skull, collector's number 3629, collected 30 Aug.1913; BMNH 2013.31 adult male, skin and skull, collector's number 3648, collected 2 Sep.1913 both collected by C. M. Crump from the same locality as the holotype. BMNH 1926.9.2.10 adult male, skin and skull, collector's number 2367, collected 3 Jun.1922 by H. W. Wells from Rahla, Kulu Valley, Kangra District [Himachal Pradesh], India, 32°21'0"N, 77°12'0"E, altitude 9,000 feet asl [2743 m].

**Other material.** — BMNH 1926.9.2.11 skin, collector's number 2375, collected 8 Jul.1922 by H. W. Wells from Jagatsukh, Kulu Valley, Kangra District [Himachal Pradesh], India, 32°12'N, 77°12'E, altitude 11,000 feet asl [3353 m].

**Diagnosis.** — First upper incisor (I) large; first upper unicuspid (Un1) large, breadth greater than the intervening palatal distance; third upper molar (M3) small; first lower antemolar (a1) large, lower premolar (p4) robust and broad; third lower molar (m3) small, talonid reduced to small hypoconid; maxillary region narrow relative to upper tooththrow length.

**Description.** — A large shrew, head and body length 77–91, tail length 57–70, hindfoot length 15–16. Dorsal pelage brown, individual hairs with grey bases and rufous brown tips, ventral pelage grey brown, individual hairs with grey bases and buff tips. Tail 74–85% of head and body length, brown above, slightly paler below, bristle hairs on approximately 70% of the tail. Fore and hind feet buffy brown.

Skull (see Fig. 7) with a long, narrow, shallow rostrum; narrow, sub-vertical zygomatic plate; narrow maxillary region relative to length and long interorbital region; braincase short and shallow with angular superior articular facets and moderately well developed lambdoid crest. Mandible with broad coronoid process.

First upper incisor (I) robust with a very large curved principal cusp and deep posterior cusp. First upper unicuspid (Un1) very large, significantly larger than second and third unicuspids, broader than the distance between the two teeth and partially obscuring the paired anterior palatal foramina; third upper unicuspid (Un3) long and broad, markedly larger than second unicuspid (Un2). Upper premolar (P4) large, with prominent paracone and protocone and well developed talon. Upper molars small relative to tooththrow length; second upper molar (M2) markedly smaller than first molar (M1). Third upper molar (M3) very small, with small talon. Lower incisor (i1) robust, long and deep; antemolar (a1) broad; lower premolar (p4) robust, very broad with a low but distinct posterolingual cuspid; second lower molar (m2) small; third lower molar (m3) small, talonid reduced to a small hypoconid.

**Comparisons.** — Comparisons are made with two species of *Crocidura* recorded from the Himalayan region, namely *C. pullata* and *C. attenuata*, both of which are smaller than *C. gathornei*. No comparable large sized species are recorded from the region, so comparisons are made with *C. dracula* Thomas, 1912 from Yunnan, southern China and Vietnam, a taxon recently removed from the synonymy of *C. fuliginosa* Blyth, 1855b (see Bannikova et al., 2011).

The skull of *Crocidura gathornei* is larger than that of *C. pullata* and *C. attenuata*, both of which are also generally smaller in head and body length (see Table 1). *Crocidura pullata* has a shorter tail than that of *C. gathornei*, while that of *C. attenuata* averages longer relative to head and body length.

*Crocidura gathornei* and *C. dracula* from Yunnan are similar in body size and external proportions and also in skull and upper tooththrow length, however the skull of *C. gathornei* is narrower (see Table 1) and the dental proportions of the two species differ considerably. The skull is more gracile than that of *C. dracula*, with a longer, narrower and shallower rostrum, narrower zygomatic plate, narrower maxillary region, and longer, narrower interorbital region (see Fig. 7). The angular superior articular facets of *C. gathornei* contrast with the more rounded facets of *C. dracula* and the braincase is narrower, less rounded and shallower. In lateral view the skull is more linear in profile, increasing gradually in depth from the rostrum to the occipital region, with a slight depression in the posterior part of the interorbital region, in comparison to *C. dracula* in which the deeper rostrum, increases in depth through the interorbital region to the deeper, more rounded braincase. Anteriorly the sinus canal of *C. gathornei* rises steeply then traverses more or less parallel to, and closer to, the squamosal than does that of *C. dracula* in which the sinus canal is deeply curved anteriorly.



Fig. 7. Comparison of the crania of *Crocidura gathornei* and *Crocidura dracula*. Top row from left to right: dorsal views of the skulls of *C. gathornei* (BMNH 2013.30) and *C. dracula* (BMNH 1912.7.25.8); ventral views of the skulls in the same order. Lower row from left to right: left lateral view of the skull (BMNH 2013.30) and mandible (BMNH 2013.29) of *C. gathornei* and *C. dracula* (BMNH 1912.7.25.8).



Table 2. Species distribution patterns amongst Himalayan Soricidae.

	Pakistan	India Punjab	India Jammu & Kashmir	India Himachal Pradesh	India Uttarakhand	Nepal	India Sikkim	India West Bengal	Bhutan	China Xizang	India Arunachal Pradesh	India Assam	India Meghalaya	India Nagaland
<i>Suncus murinus</i>	+	+	+	+	+	+	+	+	+			+	+	+
<i>Suncus etruscus</i>				+	+	+	+	+					+	
<i>Suncus stoliczkanus</i>				+		+	+	+						
<i>Chimarrogale himalayica</i>			+	+	+	(1)	(2)	+			+			+
<i>Nectogale elegans</i>							+		+	+	+			
<i>Soriculus nigrescens</i>					+	+	+	+	+	(3; 4)				
<i>Soriculus nigrescens minor</i>											+			
<i>Episoriculus baileyi</i>						(1; 5)	+				+			
<i>Episoriculus caudatus</i>					+	+	+	+		(3; 4)				
<i>Episoriculus macrurus</i>						+	+							
<i>Crocidura attenuata</i>						+	+	+			+	+	+	+
<i>Crocidura pullata</i>			+											
<i>Crocidura gathornei</i>				+	+						+		+	+
<i>Anourosorex assamensis</i>														
<i>Sorex minutus</i>						+								
<b>Number of species</b>	2	1	3	5	6	10	10	7	3	3	6	2	4	4

(1) Abe, 1982; (2) Wroughton, 1916a; (3) Zhang, 1997; (4) Hoffman &amp; Lunde, 2008; (5) Hoffman, 1985.

Table 3. Patterns of species associations of Himalayan shrews (Soricidae) at selected localities.

Country and State	Locality	<i>Soriculus nigrescens</i>	<i>Episoriculus baileyi</i>	<i>Episoriculus caudatus</i>	<i>Episoriculus macrurus</i>	<i>Chimarrogale himalayica</i>	<i>Nectogale elegans</i>	<i>Crocidura attenuata</i>	<i>Suncus etruscus</i>	<i>Suncus murinus</i>	<i>Ancurosores assamensis</i>
India: Himachal Pradesh	Chamba					+				+	
India: Uttarakhand	Dharkuri, Kumaon	+		+							
India: Uttarakhand	Naini Tal								+	+	
Nepal	Katmandu							+		+	
Nepal	Palpa District, S. of Dhaulagiri, Lumsum, Dara Khola	+		+	+						
Nepal	NW of Dhaulagiri, 2 km S. of Tarakot	+		+							
Nepal	W of Dhaulagiri, Saure Khola, 13 km NNE of Ramnagaon	+		+							
Nepal	SW of Dhaulagiri, 3 km E. of Dhorpatan	+		+							
India: Sikkim	Chuntang	+	+	+	+						
India: Sikkim	Lachen	+	+	+							
India: Sikkim	Rongli					(1)				+	
India: West Bengal	Gopaldhara, Darjeeling	+								+	
India: West Bengal	Pashok, Darjeeling	+				(2)			+	+	
India: West Bengal	Ghoom, Darjeeling	+								+	
India: West Bengal	Hasimara, Bhutan Duars			+					+	+	
India: Arunachal Pradesh	Dening, Mishmi Hills							+			+
India: Arunachal Pradesh	Dreyi, Mishmi Hills	+									+
India: Assam	Angara Khata									+	
India: Assam	Golaghat									+	
India: Assam	North Kamrup									+	
India: Meghalaya	Shangpung, Jaintia Hills								+	+	+
India: Meghalaya	Tura, Garo Hills									+	+

(1) Wroughton, 1916a; (2) Wroughton, 1916b.

There are marked differences in the dentition of the two species. The first upper incisor and Un1 are considerably larger than those of *C. dracula*, in which Un1 is narrower and shorter, not significantly larger than the other two unicuspid, and the paired anterior palatal foramina are clearly visible between the two teeth. In addition Un3 is subequal or only slightly larger in size than Un2. In *C. gathornei* P4 is slightly larger, but the upper molars are considerably smaller than those of *C. dracula*, and in *C. dracula* M2 is only slightly smaller than M1. The third upper molar is much smaller than that of *C. dracula*, in which the talon is well developed. In *C. gathornei* i1 is more robust and much longer than that of *C. dracula*; a1 is subequal in breadth to length, whereas in *C. dracula* this tooth is longer than broad; p4 is considerably larger and broader than that of *C. dracula*. The first lower molar is similar in size in both species, however m2 and m3 are considerably smaller in *C. gathornei*, and in *C. dracula* the talonid of m3 is not reduced and an entoconid ridge and talonid basin are present.

**Distribution and ecology.** — Known only from a single locality in Uttarakhand and from two localities in Himachal Pradesh, all at altitudes greater than 2700 m. According to Wroughton (1914) the type locality of Phurkia is located 69 miles from Almora and about 3 miles below the Pindari Glacier. Wroughton states that: “There is no village or cultivation. The collection was made on steep and open ground with a deep and dark soil, clothed with long grass, balsams and stunted bushes. Rhododendrons are abundant in large isolated patches; but heavy forest ceases a mile or so below.” This high altitude locality is within the Western Himalayan alpine shrub and meadows ecoregion.

The other localities where this species was found, Rahla and Jagatsukh, are both in the Kulu sub-division of the Kangra District. Jagatsukh is described as: “...the largest valley in the Kulu..., is well wooded up to 10,000 ft, [3048 m] then it narrows being more open with here and there patches of forest...” (Lindsay, 1926a). From the description, these localities may fall within Ecoregion 27 Western Himalayan broadleaf forests but from the altitude, may be bordering on Ecoregion 37 North-Western Himalayan alpine shrub and meadows (Wikramnayake et al., 2002).

*Soriculus nigrescens* and *Episoriculus caudatus* occur sympatrically with *C. gathornei* at Phurkia, however no other shrews were collected with this species at the other two localities in the Kulu Valley.

**Etymology.** — The name of this species has been chosen to mark the contributions of Gathorne, Earl of Cranbrook, to the study of mammals in Southeast Asia.

#### SPECIES ASSOCIATIONS AND PATTERNS OF SPECIES DISTRIBUTION

Interesting distribution patterns and species associations are evident in the Himalayas. The highest numbers of soricid species are recorded from Nepal and Sikkim in the central

Himalayas (see Table 2), with ten of the 11 species common to both locations. The seven species recorded in West Bengal are also common to Nepal and Sikkim. The large number of species in these areas, in part reflects the intensity of collection in the region (Wroughton, 1916a, 1916b, 1917a, 1917b; Hinton & Fry, 1923; Fry, 1925; Mitchell & Punzo, 1976; Abe, 1977, 1982). Relative to these central locations of Nepal, and the Indian states of Sikkim and West Bengal, the number of species decreases gradually to the east and more noticeably to the more challenging conditions to the west and to the north. The nature of the species associations also changes, most noticeably from the central locations towards those in the west.

The Kali Gandaki Gorge in Nepal [c. 28.7068°N, 83.6453°E] which serves as a principal east/west floristic division respectively between three western and three eastern ecoregions (Wikramnayake et al., 2002), has no apparent influence on the species distribution of some species of shrews, as may be seen on the maps (Figs. 3, 4) showing the distribution of *E. caudatus* and *S. nigrescens* to both east and west of the gorge in Nepal. Perhaps unsurprisingly, the semi-aquatic *C. himalayica* occurs in both western and eastern Himalayas, as do all three species of *Suncus* (see Table 2 and Figs. 1, 2, 5). However some species of shrew do indeed appear to be restricted either to the western or eastern Himalayas. For example *E. baileyi*, *Nectogale elegans*, *Anourosorex assamensis*, and *Crocidura attenuata* and the subspecies *Soriculus nigrescens minor* occur in the eastern Himalayas (see Figs. 1, 3, 4, 6). Only two species of shrews, *Crocidura pullata* and *C. gathornei* are apparently endemic to the western Himalayas (see Fig. 6).

*Suncus murinus* was the commonest shrew throughout the Himalayas, recorded from all countries and states, with the exception of Arunachal Pradesh, India and Xizang. It was often found at the same localities as other shrews, most frequently with the smaller *Crocidura attenuata* and also with the very small *Suncus etruscus* and the semi-aquatic *Chimarrogale himalayica* (see Table 2 and Fig. 5). More commonly occurring at lower altitudes, perhaps because of its association with human habitation, it was also encountered at higher elevations from the same localities as *Soriculus nigrescens* in the Darjeeling region of West Bengal. Other than for food, direct ecological competition between *S. murinus* and other species of soricids seems unlikely because of the disparity in size and differences in choice of habitat. However, smaller species could risk predation from this large and voracious shrew.

*Soriculus nigrescens* and *Crocidura attenuata* were the species most often associated with other soricids (see Tables 2 and 3). *Soriculus nigrescens* and *Episoriculus caudatus* were most commonly found in association from Uttarakhand, through Nepal to Sikkim and West Bengal (see Table 2). These two species were also most frequently reported in sympatric association in central Nepal (Abe, 1982), where their respective life-styles are complementary (unspecialised terrestrial, *E. caudatus* and semi-fossorial, *S. nigrescens*). According to Hoffman (1985) three species of *Episoriculus*:

*E. caudatus*, *E. leucops* (in which he included *E. baileyi*, now recognised as a distinct species, see species accounts) and *E. macrurus* are broadly sympatric over a large area extending from central Nepal to China and Myanmar. In the Himalayas, *S. nigrescens* and *E. baileyi*, *E. caudatus* and *E. macrurus* occur in direct sympatry at Chuntang, Sikkim, a locality at which *Nectogale elegans* was also collected (Wroughton, 1916a) (see Table 3). Furthermore, specimens of *E. caudatus* and *E. macrurus* from Nepal have been recorded at several localities in direct sympatry, at the same altitude and the same habitat. According to Abe (1982) *Soriculus nigrescens* and three species of *Episoriculus* are ecologically separated in central Nepal. Both *E. caudatus* and *E. leucops* (for which he used the name *S. baileyi*) are terrestrial, live in leaf litter and humus layers but the stomach contents of *E. caudatus* [n = 32] was predominantly insects (>90%, with a small percentage of spiders and earthworms), while the stomach contents of a single specimen of *E. leucops* was entirely earthworms, suggesting some semi-fossorial propensity. The stomach contents of a single specimen of *E. macrurus* was entirely insects; this species, which has a long tail and relatively long hind feet was mainly found to be ground-dwelling but was also sometimes found in bushes, so shows some scansorial tendencies. Abe (1982) observed that the large body size, short tail, short ears, small hind feet and large forefeet of *S. nigrescens* indicated some semi-fossorial adaptation. This species was collected in areas with thick layers of humus and the stomach contents [n = 122] consisted of approximately 65% insects, 26% earthworms, 8% other animals and just over 1% seeds and fruit. This species has the widest altitudinal range of all shrews in central Nepal and therefore has a broad degree of overlap with other soricine shrews. This observation is also true in other regions of the Himalayas, where *S. nigrescens* has an altitudinal range of 3200 m, far exceeding that of three of the species of *Episoriculus*: *E. caudatus* (2027 m), *E. baileyi* (1115 m) and *E. macrurus* (807 m), and also greater than *C. himalayica* and *N. elegans* both with an altitudinal range of 2438 m.

Although both of the water shrews, *Chimarrogale himalayica* and *Nectogale elegans*, occur in Sikkim and Arunachal Pradesh, they have not been recorded in close proximity and would probably be ecological competitors. *Chimarrogale himalayica* is semi-aquatic and similar in body size but very distinct morphologically from the other, aquatic species of water shrew, *N. elegans*, and the habitat of swiftly flowing mountain streams is very similar for both species. *Chimarrogale himalayica* has a broader distribution throughout the Himalayas, whereas *N. elegans* is found in the central and eastern Himalayas. In the eastern Himalayas where both species occur, *N. elegans* appears to have a more northerly distribution (see Figs. 1, 2) and the elevational range is supposedly greater (Corbet & Hill, 1992; Molur, 2008b), however specimens of *C. himalayica* have been collected from localities as high as 3048 m, at considerably higher altitudes than previously reported and approaching that of *N. elegans* (see species accounts). In addition, there is an altitudinal overlap between 1524 m and 3048 m where

both species occur and both have a large altitudinal range of 2438 m. Both species have been recorded from Sikkim, although not from the same localities. Theoretically there is no reason why the two species should not co-exist, except that they would presumably be in direct ecological competition.

Little is known about *Anourosorex assamensis*, but from its morphological similarity to *A. squamipes* it is believed to be fossorial. It co-exists with the semi-aquatic *C. himalayica* and the terrestrial *S. nigrescens minor* and *C. attenuata* in the Mishmi Hills but also with *E. leucops*, which according to Abe (1982; under the name *E. baileyi* see species accounts) shows some semi-fossorial adaptations.

## DISCUSSION

The biodiverse soricid fauna of the Himalayas encompasses a broad range of ecomorphological adaptations from the fossorial *Anourosorex assamensis* and semi-fossorial *Soriculus nigrescens*; via terrestrial species exhibiting a range of less marked specialisations; to the semi-aquatic *Chimarrogale himalayica* and the aquatic *Nectogale elegans*. The terrestrial species, such as several species of *Episoriculus* range from *E. leucops* showing some semi-fossorial tendencies, via the generalised terrestrial *E. caudatus*, to *E. macrurus* which shows morphological adaptation to a terrestrial and scansorial lifestyle. Variations in body size also permit exploitation of a variety of ecological niches and this is evident in several different soricid groups in the Himalayas. The most obvious within-genus example is that of *Suncus*, where the very large bodied *S. murinus* is often encountered in close proximity to the very small *S. etruscus*. In Nepal, Sikkim and West Bengal, soricids vary in size from the very large *S. murinus* to the medium sized *S. stoliczkanus*, *S. nigrescens* and *C. attenuata*, then to the smaller *Episoriculus* species and *S. bedfordiae*, to the small *S. minutus* and the very small *S. etruscus*.

In addition to the decrease in the soricid fauna from the central Himalayas both to the eastern Himalayas and more noticeably to the western Himalayas, there are also observable altitudinal differences. *Suncus stoliczkanus* is apparently the only species restricted to low altitudes in the Himalayas, while most of those occurring at low altitudes also have a fairly broad altitudinal range: *S. murinus* (61–2286 m); *C. attenuata* (91–2438 m); *S. etruscus* (183–2591 m). Most species occur in the forested ecoregions, with fewer species found at altitudes greater than 2700 m, the altitude at which the forests transition to alpine shrub and meadows. Those species that occur at these higher altitudes include the two water shrews: *C. himalayica* (610–3048 m) and *N. elegans* (1524–3962 m); the terrestrial *E. caudatus* (1631–3658 m) and *C. gathornei* (2743–3353 m); and the semi-fossorial *S. nigrescens* (1067–4267 m). It appears likely that *S. nigrescens* is a generalist able to exploit different ecological niches when inhabiting the deep humus layers of forested regions at mid-altitude levels, as opposed to those in the open alpine shrub and meadows at high altitude.

The Himalayas are a topographically and ecologically complex region where the fauna converges with that of the southern Palaearctic to the north and west, with that of Indochina and Myanmar to the east and with that of the Gangetic Plains to the south. Problems of defining the soricid fauna of the region still abound, for example definition of the small species of *Sorex* remains problematic. To date, knowledge of the soricid fauna has been based largely on morphological and morphometric studies. Several recent studies of karyotypes in the genus *Episoriculus* have however considerably advanced knowledge of this group (see Motokawa et al., 2008, 2009) and the potential value of molecular analysis is revealed by studies such as that of Ohdachi et al. (2006).

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