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TRICHOTAXONOMY OF INDIAN SPECIES OF GENUS *RATUFA GRAY* (MAMMALIA : RODENTIA : SCIURIDAE)

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INTRODUCTION

Oriental giant squirrels (Genus *Ratufa*) belong to subfamily Ratufinae and are found in parts of South and South-east Asia. There are four species of oriental giant squirrels : *Ratufa affinis* (Raffles) (Pale Giant Squirrel), *Ratufa bicolor* (Sparrman) (Malaya Giant Squirrel), *Ratufa indica* (Erxleben) (Indian Giant Squirrel) and *Ratufa macroura* (Pennant) (Grizzled Giant Squirrel). *Ratufa affinis* (Raffles) (Pale Giant Squirrel) is found in Brunei, Indonesia, Malaysia, Singapore and Thailand (Krapp 1998).

The Malayan Giant Squirrel, *Ratufa bicolor* (Sparrman) is at home on the Indian subcontinent, north of the Ganges in Nepal, Sikkim, Bhutan and Assam; farther to the east it lives in Burma, Malaya and upto Southern China and on Java. It is deep dark brown, almost black on the back and a light beige on the underside. They are very shy and they live exclusively in forest in the highest trees. They are very agile and jump in great leap from tree to tree, over a distance of almost 22 ft (Krapp 1998). *Ratufa bicolor* (Sparrman) is a Schedule II species under IWPA 1972, and has category Lc IUCN (Kumar and Khanna 2004).

Ratufa indica (Erxleben), Indian Giant Squirrel has been listed as, VU(IUCN Alacd.Cl ver 2.3 ,1994), (CAMP)VU A2c, 3c, 4c, (IWPA) Schedule II, CITES Appendix II, endemic population (Kumar and Khanna 2006).*Ratufa macroura* (Pennant) Grizzled Giant Squirrel, Sri Lankan Giant squirrel is a large species of squirrel found in Sri Lanka and in the forests of southern India. The species is found in patches of riverine forest along the Kaveri river in south India and in hill forests in peninsular India. and in parts of Sri Lanka. The Sri Lankan race is *R. macroura dandolena* (Menon 2003*).*

Abbreviations : SP : Scale pattern, SM : Scale margin, DS : distance between scales.

Ratufa macroura (Pennant) Grizzled Giant Squirrel, is listed as IUCN VU Alc ver 2.3 (1994), CAMP VU A2c, 3c,4c; D; IWPA I, CITES Appendix II, population trend indeterminate (Kumar and Khanna 2006).

Very little study so far has been done on the trichotaxonomy of the species of family Sciuridae (Bahuguna, 2007), a group largely being poached throughout world for its skin. Trichotaxonomy is well known for its utility in wildlife forensic science (Anon 1995, Chakraborty and De 1995, De *et al* 1998, Bahuguna and Mukherjee 2000), for ecological study of the animals, in wildlife management and conservation (Mathiak 1938, Nath and Joseph 1981, Bahuguna 2007). Williams in 1938 reported the characteristics of hair of mole and shrew for wildlife management.

The present study describes the characteristic of primary guard hair of different regions of species of genus *Ratufa i.e. Ratufa indica* (Erxleben), Indian Giant Squirrel, *Ratufa bicolor* (Sparrman) Malayan Giant Squirrel and *Ratufa macroura* (Pennant) Grizzled Giant Squirrel.

MATERIAL AND METHODS

Hair samples were collected randomly from dorsal, ventral, head and tail regions of the specimens {male *Ratufa indica* (Erxleben) (subspecies *indica*), loc : Devikop, Dharwar, Bombay Prov. 24.xi.1911., Collector. G. C. Shortridge. Collection . No. 166, Reg no 15090;

male *Ratufa bicolor* (Sparrman) subspecies *gigantea*, loc : Darjeeling, Bengal, Date 19.viii. 1916., Collector N. A. Baptista Collection no. 2149, Reg no 15163; *Ratufa macroura* (Pennant), Indian Museum, Sri Lanka, Collector : J. L. F. Kelaart, ASBR, Reg no 9472, Date of collection not available) from National Zoological Collection of Mammal and Osteology section, Zoological survey of India, Kolkata. For each type of the study (Medulla type, Cross section, Cuticular and SEM examination) about 10 primary guard hair from dorsal, ventral, head and tail regions of each specimen were examined .The samples were washed in graded series of acetone i.e. 50%, 70%, 80%, 90% and 95% for 30 min.in each grade and finally kept in pure acetone overnight.

Medulla

To study the type of medulla, the cleaned hair was mounted in DePeX (Gurr) for whole mount. When mounting, the hair tuft, it is necessary to ensure that the individual hair is well separated. For temporary mounting Paraffin oil is a most convenient medium (Appleyard, 1960).

Longitudinal sections were also prepared for clear picture of medulla type.

Cross section : For the present study**,** hair cross sections were obtained by simple hand sectioning after mounting the hair in paraffin wax, the method followed as given in reference guide Bahuguna *et al* 2010. For longitudinal section of medulla, the blocks of hair were prepared in paraffin wax and hand sectioning was done longitudinally. The technique is useful for clear picture of medulla type (Bahuguna 2008) as the presence of pigments generally hides the structure.

Scale casts : Procedures for studying scale pattern usually involve the use of special media to obtain a cast or impression of the actual hair surface. For getting the cast, the cleaned hair was kept with the help of the fine forceps on thin film of the gelatin (3%) medium on slide for some time till the medium was air-dried. After drying of gelatin the hair was removed gently. For very long hair they can be cut into sections to have complete picture of scales at tip, mid and basal region of hair. Another medium polyvinyl acetate (PVA in 50% distilled water) can also be used for this purpose (Appleyard, 960).

For cuticle studies different parts of hair i.e. distal (tip), mid and proximal part (base) of hair were examined.

Photomicrographs were taken for cross section, medulla type and cuticular studies at x100 to x200 (total magnification) under compound light microscope, Olympus CX41.

Scanning electron microscope study

This was performed for studying details of cuticular pattern. After cleaning the hair, small mid section of hair were kept on adhesive on stub. The stubs were coated with thin film (15-20 Å) of gold and kept in the chamber to view details of scale pattern. The electron micrographs thus obtained from Zeiss EVO40 were used to find out scale index, scales types and scale margins.

Hair measurements : Hair measurements were noted for calculating mean of thickness of medulla and total thickness of hair and their ratios for medullary index. Ratios of length of hair and thickness of hair were also taken into account to get length index .The measurements were shown under observations as mean ± SD

Nomenclature of medulla type was adopted after Wildman (1954) and the same for cuticular scale pattern and cross section types after Brunner and Coman (1974.)

OBSERVATIONS

Genus *Raufa* Gray, 1867

Ratufa bicolor (Sparrman), Malayan Giant Squirrel

Status IWPA : Schedule II, Part II, CITES : Appendix II; CAMP : VU (Nationally), DD (Globally)

Dorsal

A **Physical characteristics**

Colour : Both light brown and dark brown

Total thickness (T) : 86.3 ± 1.5 µm

Length index (L/T) : 30.3 ± 0.09

Shape and Nature : Straight and thin

B **Cuticular Scale Pattern**

At mid : SP regular wave ,SM rippled, DS near; at proximal, SP regular wave SM rippled , DS near; At distal : SP regular wave, SM rippled, DS near Scale index: 6.0 ± 0.0

C **Medulla**

Medullary configuration : Wide Aeriform Lattice

Medulla thickness 60.9 ± 1.0 : µm

Medullary index (M/T) : 0.70 ± 0.66

D **Cross section**

Type of cross section : Oblong

Medulla size in cross section : Large

Ventral

A **Physical characteristics**

Colour : light brown

Total thickness (T) : 49.8 ± 0.0 µm

Length index : 24.5 ± 0.0

Shape and Nature : Straight and thin

B **Cuticular Scale Pattern**

At mid : SP regular wave, SM rippled, DS near; at proximal, SP regular wave SM rippled, DS near; At distal: SP regular wave, SM rippled, DS near

Scale index : 5.3 ± 0.01

C **Medulla**

Medullary configuration : Wide Aeriform Lattice

Medulla thickness : 29.8 ± 0.06 µm

Medullary index (M/T) : 0.59 ± 0.0

D **Cross section**

Type of cross section : Oblong

Medulla size in cross section : medium

Head

A **Physical characteristics**

Colour : dark brown with light brown tips

Total thickness (T) : 109.0 ± 1.0 µm

Length index : 16.88 ± 0.0

Shape and Nature : Straight and thin

B **Cuticular Scale Pattern**

At mid : SP regular wave, SM scalloped margin, DS near; at proximal, SP regular wave SM scalloped, DS near; At distal : SP regular wave, SM scalloped, DS near, Scale index : 4.17 ± 0.0

C **Medulla**

Medullary configuration : Wide Aeriform Lattice

Medulla thickness : 89.0 ± 1.0 : µm

Medullary index : 0.51 ± 0.25

D **Cross section**

Type of cross section : Oblong

Medulla size in cross section : Large

Tail

A **Physical characteristics**

Colour : Dark brown

Total thickness (T) : 92.7 ± 0.4 µm

Length index : 51.7 ± 0.25

Shape and Nature : Straight and thin

B **Cuticular Scale Pattern** At mid : SP Irregular wave, SM rippled, DS near; at proximal, SP Irregular wave SM slightly rippled, DS near; At distal: SP Irregular wave, SM smooth, DS near

Scale index : 2.86 ± 0.01

C **Medulla**

Medullary configuration : Wide Aeriform Lattice

Medulla thickness : 82.7 ± 0.4 µm

Medullary index : 0.89 ± 0.01

D **Cross section**

Type of cross section : Oblong

Medulla size in cross section : Large

Ratufa indica (Erxleben, 1777) (Indian Giant Squirrel, Malabar Squirrel)

Status : IWPA : Schedule II, Part II; CITES : Appendix II : CAMP : VU (Nationally), DD (Globally).

Dorsal

A **Physical characteristics**

Colour : dark brown or black

Total thickness (T) : 85.4 ± 0.52 µm

Length index : 39.22 ± 0.1

Shape and Nature : Straight and thin

B **Cuticular Scale Pattern**

At mid : SP regular wave, SM rippled, DS near; at proximal, SP regular wave SM rippled, DS near; At distal : SP regular wave, SM rippled, DS near

Scale index : 6.0 ± 0.45

C **Medulla**

Medullary configuration : Simple medulla

Medulla thickness 65.4 ± 0.52 : µm

Medullary index : 0.76 ± 0.0

D **Cross section**

Type of cross section : Oblong

Medulla size in cross section : Large

Ventral

A **Physical characteristics**

Colour : light brown and beige

Total thickness (T) : 84.5 ± 0.32 µm

Length index : 14.6 ± 0.16

Shape and Nature : Straight and thin

B **Cuticular Scale Pattern**

At mid : SP regular wave, SM slightly rippled, DS near; at proximal, SP regular wave SM slightly rippled, DS near; At distal : SP regular wave, SM rippled, DS near Scale index: 6.5 ± 0.01.

C **Medulla**

Medullary configuration : Wide Aeriform Lattice

Medulla thickness : 44.5 ± 0.52 µm

Medullary index : 0.52 ± 0.01

D **Cross section**

Type of cross section : Oblong

Medulla size in cross section : Medium

Head

A **Physical characteristics**

Colour : light brown at tips, mid dark brown and black

Total thickness (T) : 69.6 ± 0.08 µm

Length index : 17.81 ± 0.06

Shape and Nature : Straight and thin

B **Cuticular Scale Pattern**

At mid : SP regular wave, SM rippled, DS near; at proximal, SP regular wave SM rippled, DS near; At distal : SP regular wave, SM rippled, DS near

Scale index : 7.3 ± 0.0

C **Medulla**

Medullary configuration : Wide Aeriform Lattice

Medulla thickness : 49.2 ± 0.21 µm

Medullary index : 0.706 ± 0.026

D **Cross section**

Type of cross section : Oblong

Medulla size in cross section : Large

Tail

A **Physical characteristics**

Total thickness (T) : 79.2 ± 0.16 µm

Length index : 57.19 ± 0.25

Shape and Nature : Straight and thin

B **Cuticular Scale Pattern**

At mid : SP regular wave, SM rippled, DS near; at proximal, SP regular wave SM rippled, DS near; At distal : SP regular wave, SM rippled, DS near Scale index : 6.5 ± 0.01

C **Medulla**

Medullary configuration : Wide Aerifom Lattice

Medulla thickness : 60.7 ± 0.16 µm

Medullary index : 0.76 ± 0.01

D **Cross section**

Type of cross section : Circular, Oblong

Medulla size in cross section : Large

Ratufa macroura (Pennant, 1769) (Grizzled Indian (Giant) Squirrel)

Status : IWPA : Schedule 1, Part 1; RDB : EN; CITES : Appendix II; CAMP : EN (Nationally), DD (Globally)

Dorsal

A **Physical characteristics**

Colour : Dark brown/black with light brown tips

Total thickness (T) : 69.72 ± 0.06 µm

Length index : 46.04 ± 0.05

Shape and Nature : Straight and thin

B **Cuticular Scale Pattern**

At mid : SP regular wave, SM rippled, DS near; at proximal, SP regular wave SM rippled, DS near; At distal : SP regular wave, SM rippled, DS near

Scale index : 6.24 ± 0.32

C **Medulla**

Medullary configuration : Wide Aeriform Lattice

Medulla thickness : 60.3 ± 0.08 µm

Medullary index : 0.86 ± 0.013

D **Cross section**

Type of cross section : Oblong

Medulla size in cross section : Large

Ventral

A **Physical characteristics**

Colour : dark brown/black and light brown

Total thickness (T) : 29.9 ± 0.03 µm

Length index : 35.45 ± 0.01

Shape and Nature : Straight and thin

B **Cuticular Scale Pattern**

At mid : SP regular wave, SM rippled, DS near; at proximal, SP regular wave SM rippled, DS near; At distal : SP regular wave, SM rippled, DS near Scale index : 6.3 ± 0.0

C **Medulla**

Medullary configuration : Simple medulla

Medulla thickness : 20.0 ± 0.0 µm

Medullary index : 0.66 ± 0.0

D **Cross section**

Type of cross section : Oblong

Medulla size in cross section : Medium

Head

A **Physical characteristics**

Colour : Slightly light brown at tips, mid is dark

Total thickness (T) : 87.27 ± 1.0 µm

Length index : 13.76 ± 0.047

Shape and Nature : Straight and thin

B **Cuticular Scale Pattern**

At mid : SP regular wave, SM rippled, DS near; at proximal, SP regular wave SM rippled, DS near; At distal : SP regular wave, SM rippled, DS near Scale index : 4.4 ± 0.0

C **Medulla**

Medullary configuration : Wide Aeriform Lattice

Medulla thickness : 67.2 ± 1.0 µm

Medullary index : 0.77 ± 0.01

D **Cross section**

Type of cross section : Oblong

Medulla size in cross section : Large

Tail

A **Physical characteristics**

Colour : black/dark brown throughout

Total thickness (T) : 102.7 ± 0.46 µm

Length index : 39.4 ± 0.07

Shape and Nature : Straight and thin

B **Cuticular Scale Pattern**

At mid : SP regular wave, SM smooth, DS distant; at proximal, SP regular wave SM smooth, DS distant; At distal : SP regular wave, SM smooth, DS distant

Scale index : 4.25 ± 0.01

C **Medulla**

Medullary configuration : Wide Aeriform Lattice

Medulla thickness : 86.3 ± 0.50 µm

Medullary index : 0.84 ± 0.01

D **Cross section**

Type of cross section : Oblong

Medulla size in cross section : Large

RESULTS AND DISCUSSION

Physical characteristics : Coat color is known to vary from juveniles to adults in many mammals. However, it has been reported by Menon (2003), that color of coat varies from different regions of distribution in case of *Ratufa indica* (Erxleben) an endemic squirrel. The dorsal region is a mixture of maroon and black with under parts cream and buff. In the northern Western Ghats this squirrel is brownish-maroon in appearance, with an all brown and white tail. In south it is black and dark maroon with a black and brown tail, whereas in the central and Southeastern Indian forms has brown color coat on the back with black hair on forelegs and have black tail with a pale tip. Malayan or Black Giant squirrel, *Ratufa bicolor* (Sparrman), is deep brown or black on the back and buff beneath. It has large black ears with hairy tufts, a black tail and black marks on its chin. The forelegs are black in front and buff on the back. Grizzled giant squirrel *Ratufa macroura* (Pennant), this endangered squirrel is comparatively smallest and has brownish gray coat with pale hair tips giving it a grizzled look. Its ventral surface is dirty white and tail has white bands. Ears and head are dark brown

or black. Thus the color of hair from all body regions of the species of *Ratufa* although noted for the record in the present study but not taken into consideration for the key for identification of species. However, in case of Indian species of *Ratufa*, the banding is not the characteristic feature of the primary guard hair from all regions examined. But, bandwidth was noted to be characteristics of the genus *Callosciurus* of family Sciuridae and has been utilized in development of the key for identification of the species (Bahuguna 2008) as one of the important physical features. Length indices for all three species for primary guard hair from all body regions were: for *Ratufa bicolor* (Sparrman) 30.3 ± 0.0 (for dorsal), 24.5 ± 0.0 (for ventral), 16.80 ± 0.0 (for head) and 51.7 ± 0.25 (for tail); for *Ratufa indica* (Erxleben) they were 39.2 ± 0.1 (for dorsal), 14.6 ± 0.16 (for ventral), 17.81 ± 0.06 (for head), 57.19 ± 0.25(for tail). In case of *Ratufa macroura* (Pennant) length indices were 46.04 ± 0.5 (for dorsal), 35.45 ± 0.016 (for ventral), 13.76 ± 0.04 (for head) and 39.4 ± 0.07 (for tail). Length indices were noted to be maximum of *Ratufa macroura* (Pennant) for dorsal hair , of *Ratufa bicolor* (Sparrman) for ventral , of *Ratufa indica* (Erxleben) for head and tail. Length indices were used as an additional physical characteristics of hair (Bahuguna 2008) to know its consistency in identification of the species. In the present study the species of *Ratufa* examined showed the interspecific variability in length indices as noted in case of Indian species of *Callosciurus* (Bahuguna 2008).

Medulla characteristics : In all three species examined for hair characteristics of primary guard hair, medulla type was Wide Aeriform Lattice (figs 1, 6, 11, 17, 28, 33, 38, 43, 53, 58) from all body regions except simple medulla type in ventral guard hair of *Ratufa macroura* (Pennant) and dorsal guard hair of *R. indica* (Erxleben) (fig 23, 49,). Medulla type was also noted to be characteristics of the orders of mammals so far examined with only few variations (Bahuguna *et al* 2007). Medullary indices of the species examined were : for *Ratufa bicolor* (Sparrman) 0.70 ± 0.6 (dorsal), 0.59 ± 0.0 (for ventral), 0.51 ± 0.25 (for head), 0.89 ± 0.01 (for tail); for *Ratufa indica* (Erxleben), 0.76 ± 0.01 (for dorsal), 0.52 ± 0.01 (for ventral), 0.70 ± 0.02 (for head), 0.76 ± 0.01 (for tail); for *Ratufa macroura* (Pennant) 0.86 ± 0.01 (for dorsal), 0.66 ± 0.0 (for ventral), 0.77 ± 0.01 (for head), 0.84 ± 0.01 (for tail). The medullary indices, thus recorded were the characteristics of the species for hair of all body regions, hence considered an important characteristic of hair for the identification of species of Genus *Ratufa*.

Cross-section types in all hair examined were oblong with large sized medulla (figs 3, 8, 14, 21, 25, 30, 36, 40, 44, 49, 54, 59) except in case of hair from ventral region, which was medium sized for all the species examined.

Cuticular characteristics : In case of *Ratufa macroura* (Pennant) (figs 45-47, 50-52, 55-57, 60, 61), the pattern was regular wave with rippled margin and near in all dorsal, ventral and head. But in tail region pattern is regular wave with smooth margin and distant.

In case of *Ratufa indica* (Erxleben), the cuticular pattern was regular wave, with rippled margin and near in case of hair from all body regions (figs 23, 24, 26, 27, 29, 31, 32, 34, 35, 37, 39, 41, 42). The cuticular pattern of *Ratufa bicolor* (Sparrman), was regular wave, with rippled margin and near in case of primary guard hair of dorsal, ventral but in tail regions it is irregular wave with rippled margin and near at proximal and mid but at distal it was with smooth margin (figs 2-5, 7, 9, 10, 12-15). However hairs from head showed regular wave pattern with scalloped margin and distance between scales were near (figs 18-20, 22). Cuticular characteristics are known to be species specific in many studies (Chakraborty and De 1995, De *et al* 1998, Bahuguna and Mukherjee 2000, Pradhan *et al* 2005, Bahuguna 2007). Scale indices of dorsal primary guard hair of *R. indica* and *R. bicolor* were noted to be almost same but in *R. macroura* it was noted to be 6.24 ± 0.32 in all species examined for dorsal primary guard hair. However they were noted to be different in case of primary guard hair from other body regions. Scale index of the guard hair of ventral region of *R. bicolor* was noted to be 5.3 ± 0.01 and of *R. indica* was 6.5 ± 0.01 and that of *R. macroura* was 6.3 ± 0.0 . Scale index of primary guard hair of head of *R. bicolor* was 4.17 ± 0.0 and of *R indica* was 7.3 ± 0.0 and of *R. macroura* was 4.4 ± 0.0. Scale index of tail of *R. bicolor* was 2.86 ± 0.01 , *R. indica* 6.5 ± 0.01 and of *R. macroura* was 4.25 ± 0.01.

Same type of results have been obtained by the SEM, so far cuticular pattern, scale margin etc.are concerned.

Dorsal guard hair has been utilized since the history of trichotaxonomy for identification of species and development of key for identification because of the consistency in hair characteristics as reported by Mayer (1952), Appleyard (1960), Brunner and Coman (1974), Chakraborty and De 1995, Pradhan *et al.* (2005). However it has been realized that hair characteristics of primary guard hair from other body regions are equally important and should also be recorded. Since it is difficult to collect hair samples from large number of specimens, (especially for threatened and endangered species), thus it is recommended to have the record of hair characteristics from all body regions for further comparisons from other samples. This is required for dealing with wildlife forensic cases.

Based on characteristics of primary guard hair from all body regions, key was prepared, which is useful in identification of species of Genus *Ratufa* for various biological studies including Wildlife forensic.

Key for identification of Indian species of *Ratufa* based on characteristics of primary guard hair :

Dorsal

1 Medulla type : Wide Aeriform Lattice, cross section : oblong , large size medulla; Scale Pattern : regular wave, Scale Margin : rippled, Distance between scales near; mean scale indices range : 6.0 to 6.2 .....
Medullary index : 0.70 ± 0.66, length index 30.3 ± 0.09*Ratufa bicolor*; Medullary index > 0.70, length index : > 30.3 2

2a. Medullary index 0.86 ± 0.01, length index 46.04 ± 0.5 ..... *Ratufa macroura* (Pennant)

2b. Medullary index 0.76 ± 0.01, length index 39.2 ± 0.1 *Ratufa indica* (Erxleben)

Ventral

1. Cross section : Oblong, Medium sized medulla; Scale pattern : regular wave, Scale margin : rippled, Distance between scales : near-,
Medulla Wide Aeriform lattice 2

Medulla simple 3

2a Meduallary index 0.59 ± 0.0, Length index 24.5 ± 0.0, Scale index 5.3 ± 0.01 ..... *Ratufa bicolor* (Sparrman)

2b Medullary index 0.52 ± 0.01, Length index 14.6 ± 0.16, Scale index 6.5 ± 0.01*Ratufa indica* (Erxleben)

3 Medullary index 0.66 ± 0.0, Length index 35.4 ± 0.0, Scale index 6.3 ± 0.0 ..... *Ratufa macroura* (Pennant)

Head

1. Cross section : Oblong, Large sized medulla; Medulla : Wide Aeriform Lattice .....
Scale pattern : regular wave, Scale margin : rippled, Distance between scales : near 2
Scale margin scalloped 3

2a. Length index : 13.7 ± 0.0, Medullary index 0.77 ± 0.04. Scale index 4.4 ± 0.0 ..... *Ratufa macroura* (Pennant)

2b. Medullary index 0.70 ± 0.0,Length index 17.8 ± 0.0, Scale index 7.3 ± 0.0..... *Ratufa indica* (Erxleben)

3. Medullary index 0.51 ± 0.2, length index 16.8 ± 0.0, Scale index 4.17 ± 0.0 ..... *Ratufa bicolor* (Sparrman)

Tail

1. Cross section : oblong, large medulla, Medulla : Wide Aeriform Lattice, medullary index < 0.80 .....
..... 2
Medullary index > 0.80 3

2a. Scale pattern : regular wave, Scale margin : rippled, Distance between scales near; Medullary index 0.76 ± 0.0; Length index 57.2 ± 0.2, Scale index 6.5 ± 0.01 *Ratufa indica* (Erxleben)

2b. at proximal : Scale pattern : Irregular wave, Scale margin : rippled, Distance between scales : near; at mid : Scale pattern : Irregular wave, Scale margin : slightly rippled, Distance between scales : near; at distal : Scale pattern Irregular wave, Scale margin : smooth, Distance between scales near ; Medullary index 0.89 ± 0.01, Length index 51.7 ± 0.2; Scale index 2.86 ± 0.01 ..... *Ratufa bicolor* (Sparrman)

3. Scale pattern : regular wave, Scale margin : smooth, Distance between scales : distant; Medullary index: 0.84 ± 0.01; Length index: 39.0 ± 0.0, Scale index 4.25 ± 0.01 .... *Ratufa macroura* (Pennant)

SUMMARY

The paper describes the characteristics of primary guard hair of dorsal, ventral, head and tail regions of Indian species of Genus *Ratufa* Gray namely *Ratufa macroura* (Pennant), *Ratufa indica* (Erxleben) and *Ratufa bicolor* (Sparrman) which have been listed under Indian Wildlife Protection Act (1972 as amended upto 2006). It was noted that medulla of hair was of Wide Aeriform Lattice type for all the species examined except that of primary guard hair of ventral region of *Ratufa macroura* (Pennant), in which it was simple medulla type. Cuticular architecture was same in all species i.e. Scale pattern : regular wave, Scale margin: rippled, Distance between scales: near, except in case of hair of head and tail of *Ratufa bicolor* (Sparrman) and tail of *R. macroura* (Pennant). Hair cross-section types were also same i.e. oblong. Various dimensions studied in case of all the three species indicated interspecific variations in medullary indices (M/T) and length indices (L/T). Scale indices (max. length of scale/ max.width of scale) were noted to be of range 6.0-6.2. The key was prepared for identification of species by utilizing the characteristics of primary guard hair from all body regions.

Key words **:** Trichotaxonomy, *Ratufa bicolor* (Sparrman), *Ratufa indica* (Erxleben), *Ratufa macroura* (Pennant), light microscopic study, Scanning electron microscopic study.

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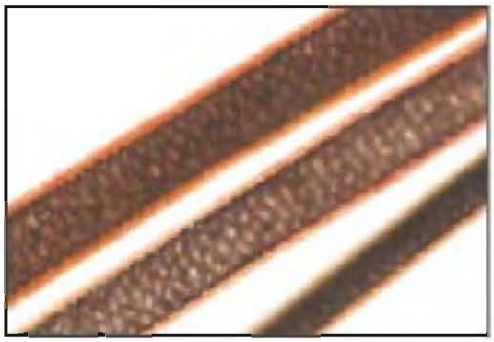
PLATE 1

Ratufa bicolor (Sparrman, 1778) (Large Malaya squirrel)

Dorsal



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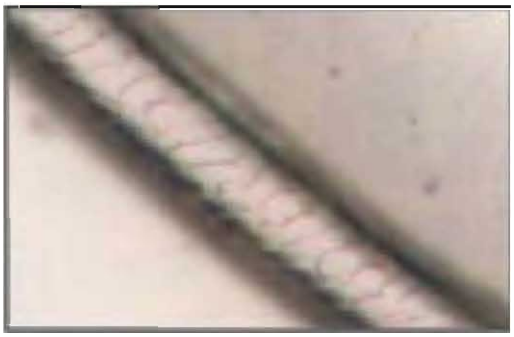

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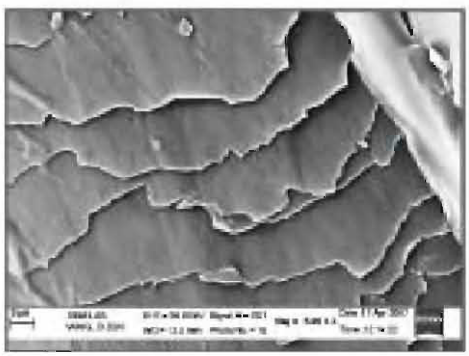

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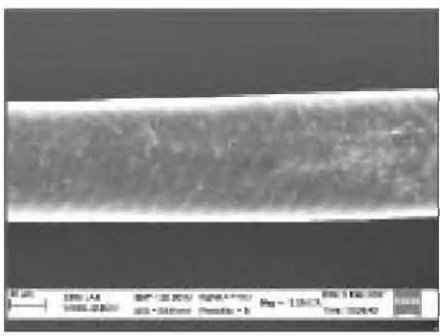

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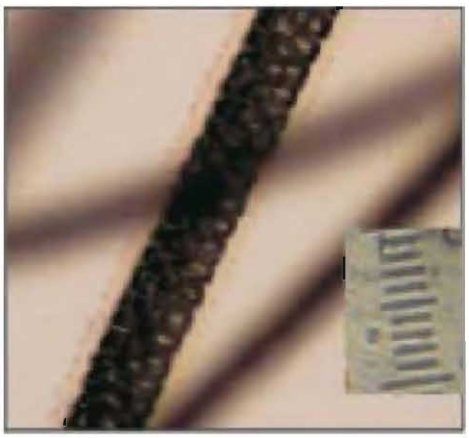
Figs. 1-3. Photomicrographs using compound light microscope
1 : Medulla type : Wide Aeriform Lattice, x200
2 : Cuticular pattern at distal portion of the hair x200
3 : Cross section : Oblong type with large medulla, x200

Figs. 4-5. Scanning electron micrographs
4, 5 : Cuticular scale pattern at mid of hair : SP regular wave, DS : near, SM rippled

PLATE 2

Ratufa bicolor (Sparrman, 1778) (Large Malaya squirrell)

Ventral



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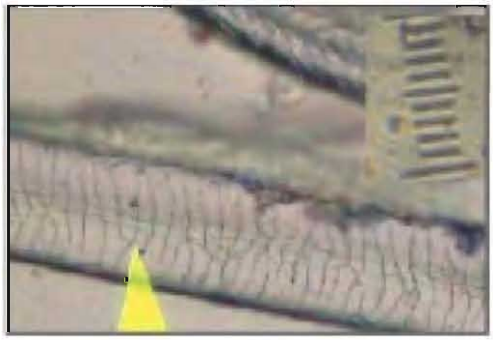

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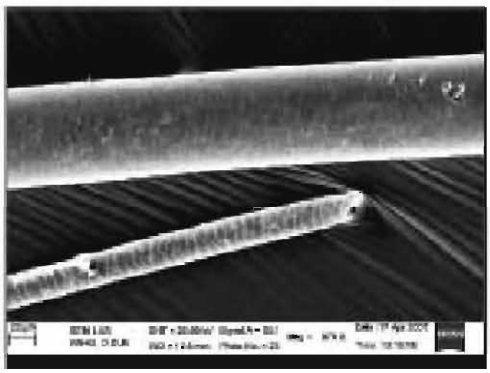

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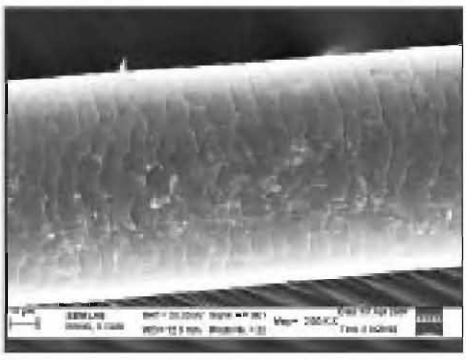

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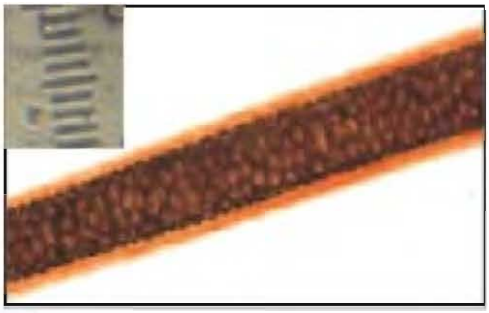
Figs. 6-8. Photomicrographs using compound light microscope
6 : Medulla type Wide Aeriform Lattice with indentations in cortex x200
7 : Cuticular pattern : SP : regular wave, DS near, SM : rippled x200
8 : Cross section type : oblong with medium sized medulla x200

Figs. 9,10. Scanning electron micrographs
9 : Cuticular pattern at mid and proximal portion SP: regular wave, DS near, SM : rippled
10 : Cuticular pattern towards distal portion

PLATE 3

Ratufa bicolor (Sparrman, 1778) (Large Malaya squirrell)

Head



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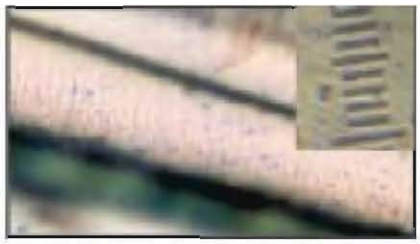

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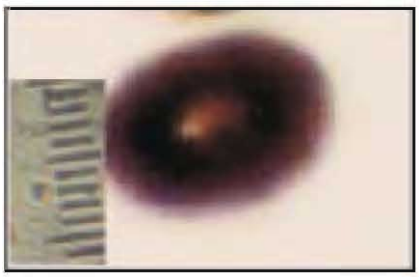

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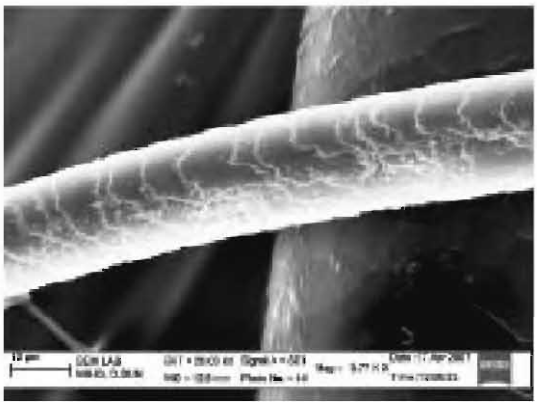

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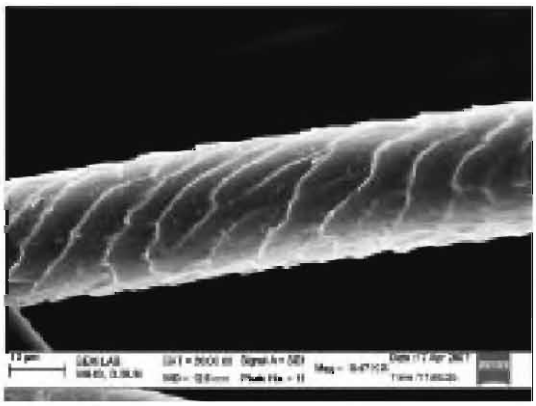


16

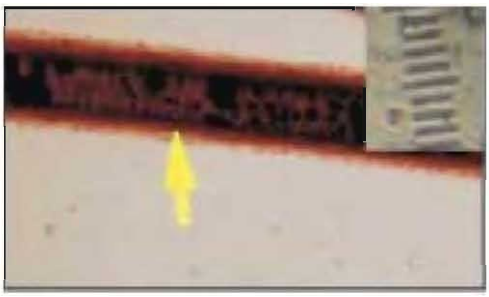
Figs. 11-14. Photomicrographs using compound light microscope
11 : *Medulla type : Wide Aeriform Lattice with indentations in cortex , x200*
12 : *Cuticular pattern at proximal portion of hair, x200*
13 : Cuticular pattern at mid of hair x200
14 : Cross section : oblong, large sized medulla x200

Figs. 15-16. Scanningelectronmicrographs
15 : at mid and proximal end of hair
16 : at distal portion

PLATE 4

Ratufa bicolor (Sparrman, 1778) (Large Malaya squirrell)

Tail



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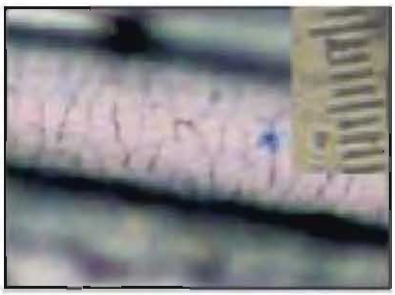

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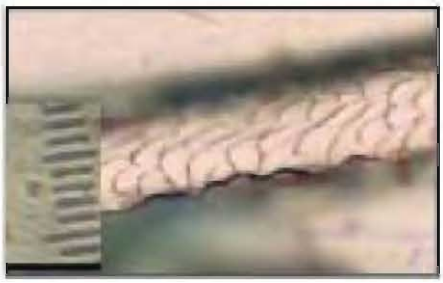

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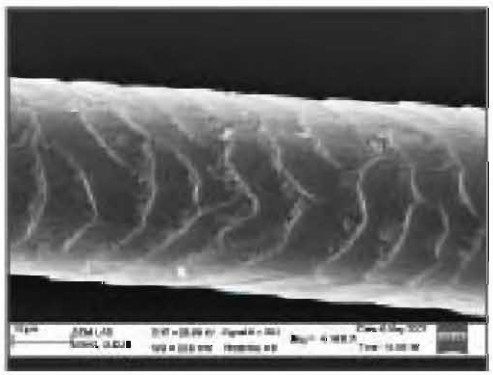


22

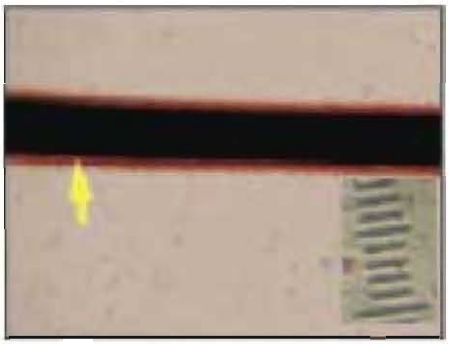
Figs. 17-21. Photomicrographs using compound light microscope
17 : Medulla type : Wide Aeriform Lattice without indentations , x200
18 : Cuticular pattern at mid SP regular wave, DS near, SM rippled x200
19 : at proximal SP Irregular wave, DS near, SM slightly rippled x200
20 : at distal SP Irregular wave, DS near, SM smooth x200
21 : Cross section : oblong type, large medulla x200

Fig. 22. Scanning electron micrograph Cuticular pattern at mid SP Irregular wave, DS near, SM smooth

PLATE 5

Ratufa indica (Erxleben, 1777) (Indian giant squirrel, Malabar squirrel)

Dorsal



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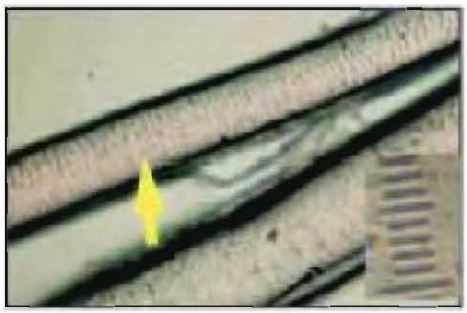

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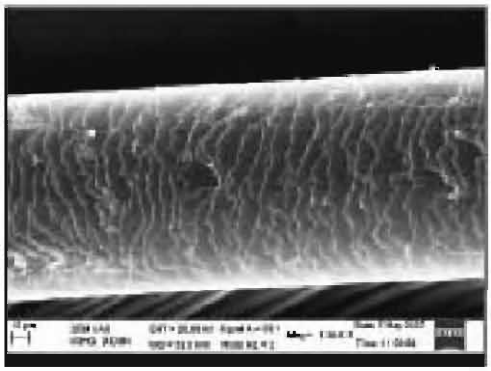

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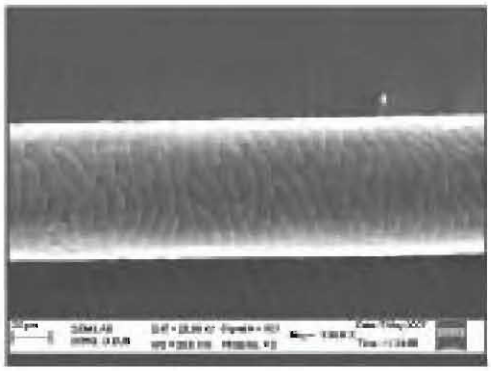


27

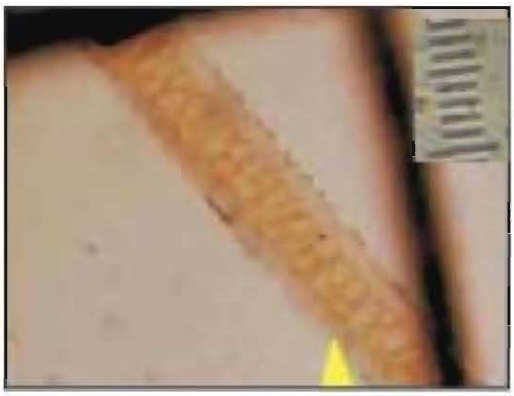
Figs. 23-25. Photomicrographs using compound light microscope
23 : Medulla type : Simple medulla (highly pigmented) x200
24 : Cuticular pattern at mid, SP regular wave, SM rippled and DS close x200
25 : Cross section type : oblong, medulla size: large x200

Figs. 26-27. Scanning electron micrograph
26 : Cuticular pattern at mid of hair
27 : towards proximal portion

PLATE 6

Ratufa indica (Erxleben, 1777)

Ventral



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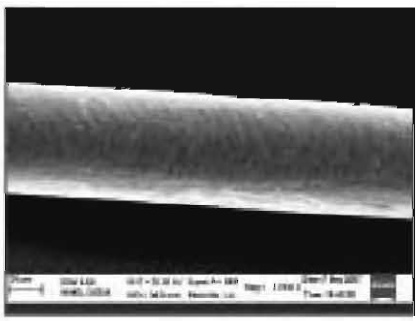

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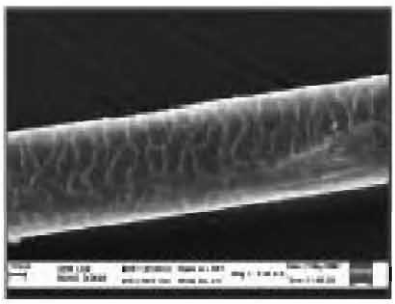

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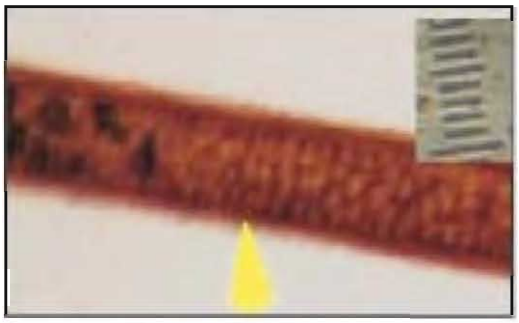
Figs. 28-30. Photomicrographs using compound light microscope
28 : Medulla type : Wide Aeriform Lattice x200
29 : Cuticular pattern at proximal end, SP regular wave, SM rippled and DS near x200
30 : Cross section : oblong, medium sized medulla x200

Figs. 31-32. Scanning electron micrographs
31 : at mid SP regular wave, SM rippled and DS near
32 : at proximal SP regular wave, SM rippled and DS near

PLATE 7

Ratufa indica (Erxleben, 1777)

Head



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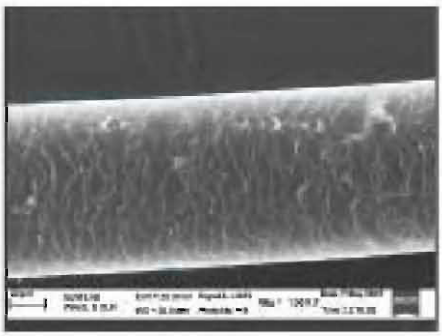


37

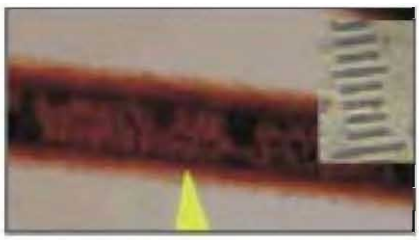
Figs. 33-36. Photomicrographs using compound light microscope
33 : Medulla type : Wide Aeriform Lattice x200
34 : Cuticular pattern at distal portion (transitional type) x200
35 : Cuticular pattern at mid of hair x200
36 : cross section oblong, large sized medulla x 200

Fig. 37. Scanning electron micrograph
37 : Cuticular pattern at mid of hair: SP regular wave, SM rippled and DS near

PLATE 8

Ratufa indica (Erxleben, 1777)

Tail



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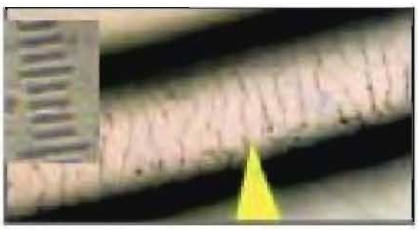

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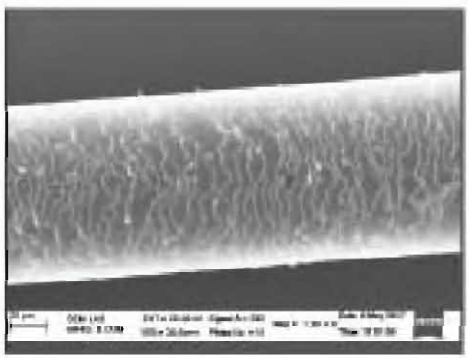

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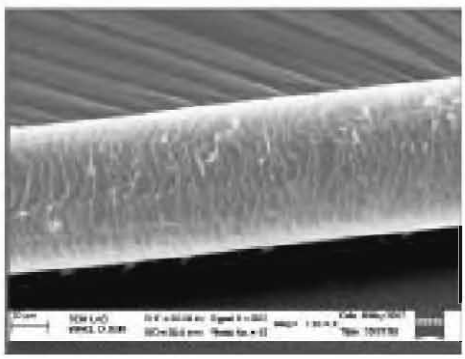


42

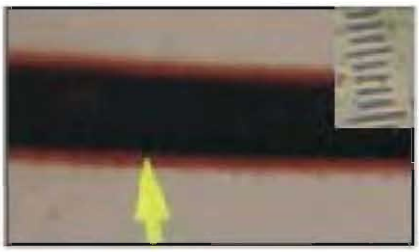
Figs. 38-40. Photomicrographs using compound light microscope
38 : Medulla type Wide Aeriform Lattice x200
39 : Cuticular pattern at mid of hair x200.
40 : Cross section : oblong x200

Figs. 41-42. Scanning electron micrographs, 41 at mid, 42 towards proximal

PLATE 9

Ratufa macroura (Pennant 1769)

Dorsal



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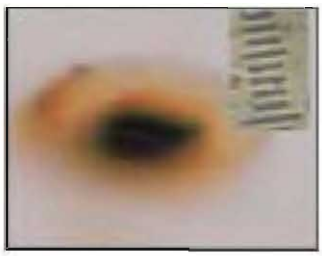

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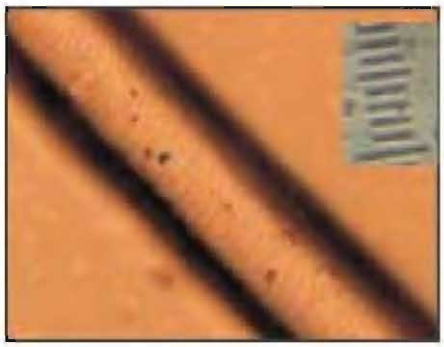

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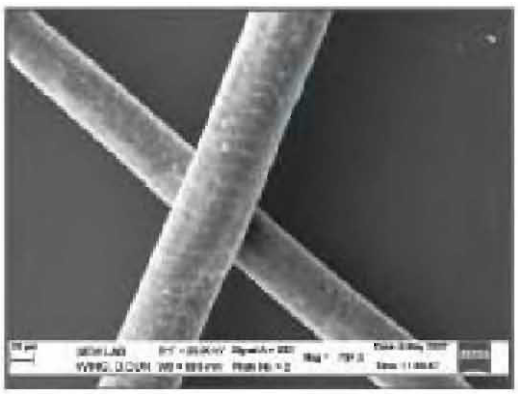


47

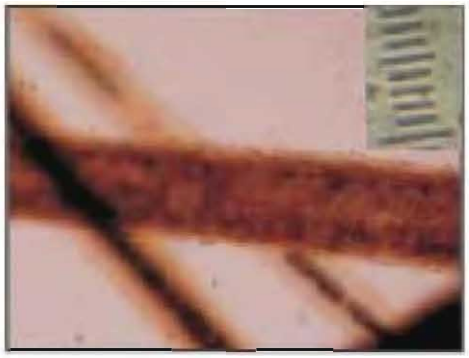
Figs. 43-47. Photomicrographs using compound light microscope
43 : medulla type : Wide Aeriform Lattice, with indentations in cortex x200
44 : cross section: oblong, large medulla x200
45-46 : cuticular patterns at proximal, 46 at mid SP regular wave, SM rippled DS near x200

Fig. 47. Scanning electron micrograph at mid

PLATE 10

Ratufa macroura (Pennant 1769)

Ventral



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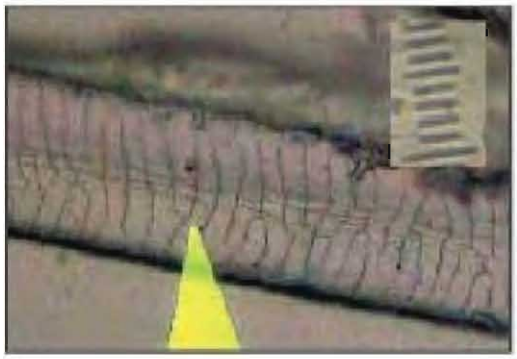

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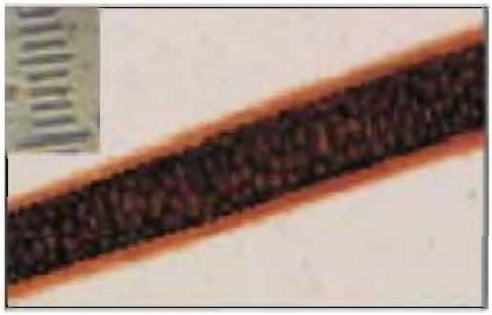
Figs. 48-52. Photomicrographs using compound light microscope
48 : Medulla type : Simple medulla x200
49 : Cross section : oblong x 100
50-52 : Cuticlar pattern at mid (50), at proximal (51), at distal (52) : SP regular wave, SM rippled, DS near x200.

PLATE 11

Ratufa macroura *(Pennant 1769)*

Head



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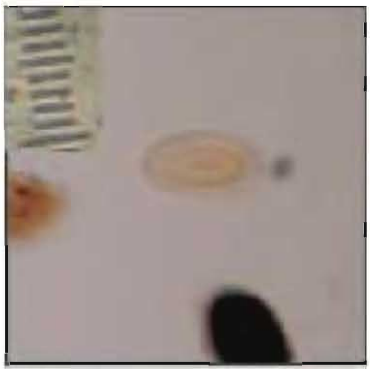

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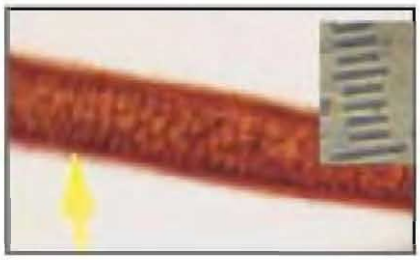
Figs. 53-57. Photomicrographs using compound light microscope
53 Medulla type: Wide Aeriform Lattice, with indentations (x200)
54 cross section: oblong (x200)
55-57 cuticular architecture : distal (55) SP Irregular wave, SM smooth, DS near, proximal (56) SP transitional type, SM smooth (slightly rippled) DS near and mid (57) SP Irregular wave, SM rippled, DS near x200.

PLATE 12

Ratufa macroura (Pennant 1769)

Tail



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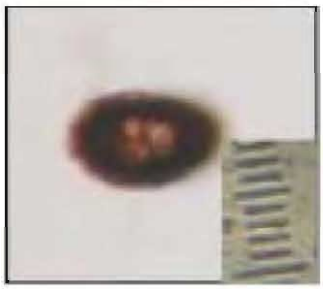

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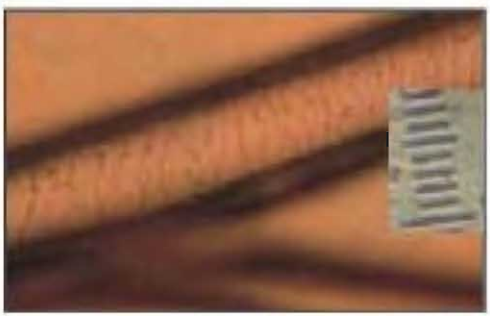

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Figs. 58-61. Photomicrographs using compound light microscope
58 : Medulla type : Wide Aeriform Lattice with indentations (x200)
59 : Cross section : oblong, large sized medulla (x200)
60-61 : cuticular pattern at mid (Fig 60) SP regular wave, SM rippled, DS near (x200), at distal (Fig 61) SP regular wave, SM rippled, DS near (x200)