



Rec. zool. Surv. India : 104 (Part 3–4) : 13-21, 2005

IDENTIFICATION OF DORSAL GUARD HAIRS OF NINE INDIAN SPECIES OF THE FAMILY VIVERRIDAE (CARNIVORA : MAMMALIA)

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INTRODUCTION

Study of hair structure of a number of mammalian species had been worked out (Hausman 1920, Brunner and Coman 1974, Moore *et al.* 1974, Koppiker and Sabnis 1976, 1977, Keller 1981, Debrot *et al.* 1982, Teerink 1991, Wallis 1993, Venkatraman *et al.* 1994, De and Chakraborty 1995, 2002, Chakraborty *et al.* 1996, 1999, De *et al.* 1998, Chakraborty and De 2001, 2002, Toth, A. M. 2002) but knowledge on trichotaxonomy of many species is still wanting. Study of hairs of the species belonging to the family Viverridae have almost not been worked out except cuticular structure of *Arctogalidia fusca* by Hausman 1920.

Nine species of Viverrids have been identified from the Indian region (Alfred *et al.* 2002) and commercial exploitation and habitat destruction accelerate their enlistment as Schedule I and II in the list of Wildlife (Protection) Act., 1972 as well as appendices of CITES (Table 2). Of the nine species *Paradoxurus hermaphroditus* (Pallas) and *Viverricula indica* (Desmarest) are distributed almost throughout the country in suitable habitat, but the former is not reported from desert part of Rajasthan and Gujarat. *Paradoxurus jerdoni* Blanford and *Viverra civettina* Blyth are endemic to southern India. The other species *Arctictis binturong* (Raffles), *Arctogalidia trivirgata* (Gray), *Prionodon pardicolor* Hodgson, *Viverra zibetha* Linnaeus and *Paguma larvata* (Hamilton-Smith) are mostly denizens of north eastern Himalayan region and the distributional range of *Paguma larvata* is extended through Uttar Pradesh upto Himachal Pradesh and also in Andaman Islands.

Of the nine species *Prionodon pardicolor*, *Arctictis binturong* and *Viverra civettina* are placed under Schedule I of Wildlife (Protection) Act., 1972 and the status is given as 'Endangered'

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All the other species are placed under Schedule II (Table 2). Though Pocock (1939) provided identification keys to the different species of the Indian carnivores yet it is not sufficient for identification of pieces of skins or products for which the animals are poached. In the present paper an attempt has been made to reveal the structure of dorsal guard hairs of the above mentioned species.

MATERIAL AND METHODS

Five tufts of guard hairs were collected from the mid-dorsal region of three dry preserved specimens of each species present in the National Zoological collection of the Zoological Survey of India, Kolkata. Samples were processed for study according to the method of Chakraborty *et al.* (1996). The surface structure, medullary configuration and cross sectional details of dorsal guard hairs were studied microscopically followed after Brunner and Coman (1974), Teerink (1991) and Chakraborty *et al.* (1996). Diameter and length of hair were measured with dial callipers, measuring scale (mm) respectively. Medullary index was calculated as $k = m/h$ where m = width of medulla and h = width of hair. It is also to be noted that, in case of 'Transitional' scale pattern, 'PD' and 'SS' were measured only at shield region.

Nomenclature of colour is followed after Ridgway (1886) and structural nomenclature of cuticular as well as medullary configuration is followed after Brunner and Coman (1974), Moore *et al.* (1974) and Teerink (1991). Classification was followed after Alfred *et al.* (2002).

OBSERVATION

Findings have been summarised in Table 1 and 2 and Plates I–IX.

RESULT AND DISCUSSION

From the observations it could be said that hair profiles of the Indian Viverrids is 'Spatulate' and 'Shielded' except in *A. binturong* which is 'Rod' like. At the same time the basic coat colour of the body possess different shades of 'Brown' whereas the same in *A. binturong* is 'Black'. Average hair length varies greatly among the species of the family Viverridae being (18 ± 6.82) mm as minimum in *P. pardicolor* and (76 ± 8.2) mm as maximum in *A. trivirgata*. Similarly average diameter varies from (52 ± 8.08) μ as minimum in *A. trivirgata* to (120 ± 10.6) μ as maximum in *V. indica* (Table 1). From the study, it is clear that in all the species, range of hair length and diameter vary greatly not only in between the species of the family Viverridae but among the same species also. So, these two characters may not be treated exclusively as family or species characters but it may be considered along with other characters at the time of identification.

The average scale count per millimeter of hair length was noted (205 ± 12.86) as minimum in *P. pardicolor* as well as (400 ± 17.6) and (400 ± 10.7) as maximum in *V. indica* and *P. jerdoni* respectively. Though the average scale count among the species varies greatly yet it hardly exceed 240 (212–267) in five species, only the same in *A. trivirgata* and *P. hermaphroditus* is 331 ± 18.72 and 325 ± 16.47 respectively (Table 1).

Among the nine species 'Scale Pattern' is 'Irregular wave' in *P. larvata*, *A. binturong*, *A. trivirgata*, *V. civettina*, *P. jerdoni* and *P. hermaphroditus* and in other three species it is 'Transitional' In shield region, it is 'Regular Petal', 'Narrow Diamond Petal' and 'Regular mosaic' in *V. indica*, *P. pardicolor* and *V. zibetha* respectively as well as in basal region, the same is 'Irregular wave' in *P. larvata* and 'Regular wave' in *P. pardicolor* and *V. zibetha* (Table 1, Plates I–IX). Hausman (1920) noted 'Intermediate-ovate' type cuticular scale in *Arctogalidia fusca* but nothing was mentioned about scale pattern. Thus, it may be opined that, the above mentioned characters may be one of the key character for identifying Viverrid hairs.

The scale margin is 'Crenate' in *P. larvata*, *A. binturong*, *A. trivirgata*, *V. civettina*, *P. jerdoni* and *P. hermaphroditus* where as scale margin distance is 'Close' only in *P. larvata* and *P. hermaphroditus* and 'Intermediate' in other four species. It is also noted that the scale margin is 'Dentate' at shield region and 'Crenate' and 'Smooth' at basal in *V. indica* and *P. pardicolor* respectively. Where as in *V. zibetha* scale margin is 'Smooth' throughout but scale margin distance is same as *P. pardicolor* (Table 1).

The mean 'SS' were observed maximum in *V. civettina* as (80.75 ± 9.21) μ and minimum in *P. pardicolor* as (18.5 ± 2.52) μ (Table 2). It was noted that 'SS' varied greatly not only in between the different genera but also in between the species of the same genus. Likely, the maximum 'SS' observed in *V. civettina* while the same in the other species *V. zibetha*, it is only (37 ± 2.04) μ . The same is true in *P. jerdoni* and *P. hermaphroditus*, where mean 'SS' measured (45.25 ± 4.8) μ and (35.5 ± 3.1) μ respectively. It is obvious that, owing to the scale pattern and arrangement, 'PD' differs greatly from species to species. It was measured maximum as (62.5 ± 5.21) μ in *P. pardicolor* and minimum as (8.75 ± 2) μ in *P. hermaphroditus* (Table 2). The proximodistal measurements vary so greatly, probably because mostly of 'Transitional' scale pattern. But in those species where the scale pattern is 'Irregular wave', the average 'PD' ranges from (8.75 ± 2) μ to (16.5 ± 3.46) μ only (Table 2).

Except *A. binturong*, the medullary configuration in all the species is 'Unbroken vacuolated' and tranverse section is 'Ovate' or 'Circular' But in *A. binturong* the medullary configuration is 'Simple' and tranverse section is 'Reniform' (Table 2, Plates I–IX). It is also noted that, medullary index is > 0.80 in *P. larvata* and *V. zibetha* whereas the same is < 0.80 in the rest of the Indian species of the family Viverridae except *A. binturong* which is > 0.90 (Table 2). In *A. binturong* the cortex is so thin that it makes a different identifying character for the species. Usually the medullary index is always species specific but while the same overlaps, like in *P. pardicolor* and *P. jerdoni*, then the other characters become of great support for the identification of the species.

From the study it is clear that the identification of species from the hair sample of the family Viverridae could not be possible with one or two characters but obviously it could be done with a group of characters. Again, from the hair profile, colour, medullary configuration, tranverse section and medullary index of *A. binturong*, it seems quite different from the other species of the family Viverridae. Pocock (1939) placed *A. binturong* under sub-family Paradoxurinae along with the species *A. trivirgata*, *P. larvata*, *P. hermaphroditus* and *P. jerdoni*. But from the present study, it could be opined that *A. binturong* may demand a different taxonomic status, at least at sub-family level.

Accordingly, based on the characteristics of the dorsal guard hairs, keys to the identification of different species of the Indian Viverridae are presented below.

Key to the Indian species of the family VIVERRIDAE

- 1a. Colour Black; medullary configuration 'Simple'; T. S. Reniform; hair 'Rod' like; length (55 ± 11.21) mm; diameter (110 ± 8.76) μ ; scale pattern 'Irregular wave'; scale margin distance 'Intermediate'; scale margin 'Crenate'; 'SS' (56.5 ± 6) μ ; 'PD' (15 ± 2.96) μ ; medullary index 0.93 ± 0.001 *Arctictis binturong*
- 1b. Colour Claret Brown, Bay or Burnt Sienna; medullary configuration 'Unbroken vacuolated'; T. S. Ovate or circular 2
- 2a. Medullary index > 0.80 ; T. S. Ovate 3
- 2b. Medullary index < 0.80 4
- 3a. Buff band at subshield; scale pattern 'Irregular wave'; scale margin 'Crenate'; scale margin distance 'Close'; 'SS' at shield (47.7 ± 3.94) μ ; 'PD' at shield (16.5 ± 3.46) μ ; medullary index 0.826 ± 0.01 *Paguma larvata*
- 3b. Band if present at subshield, not more than 4 mm in width; scale pattern 'Transitional'; 'Regular mosaic' at shield and 'Regular wave' at basal; scale margin 'Smooth'; scale margin distance 'Distant' at shield and 'Intermediate' at basal; 'SS' at shield (37 ± 2.04) μ ; 'PD' at shield (39 ± 3.52) μ ; medullary index 0.89 ± 0.01 *Viverra zibetha*
- 4a. T. S. Ovate 5
- 4b. T. S. Circular 6
- 5a. Buff band at shield; length (23.83 ± 2.12) mm; diameter (120 ± 10.6) μ ; scale count (400 ± 17.6); scale pattern 'Transitional', 'Regular Petal' at shield, 'Irregular wave' at basal; scale margin and scale margin distance 'Dentate' and 'Distant' at shield and 'Crenate' and 'Close' at basal respectively; 'SS' (22 ± 1.6) μ ; 'PD' (53.5 ± 4.66) μ ; medullary index 0.769 ± 0.02 *Viverricula indica*

- 5b. Length (34 ± 3.42) mm; diameter (100 ± 6.18) μ ; scale count (240.8 ± 14.12); scale pattern 'Irregular wave'; scale margin distance 'Intermediate'; scale margin 'Crenate'; 'SS' (80.75 ± 9.21) μ ; 'PD' (11.25 ± 1.85) μ ; medullary index 0.62 ± 0.09 *Viverra civettina*
- 5c. Length (31 ± 7.25) mm; diameter (92 ± 10.76) μ ; scale count (325 ± 16.72); scale pattern 'Irregular wave'; scale margin distance 'Close'; scale margin 'Crenate'; 'SS' (35.3 ± 3.1) μ ; 'PD' (8.75 ± 2) μ ; medullary index 0.72 ± 0.02 *Paradoxurus hermaphroditus*
- 6a. Length (18 ± 6.82) mm; diameter (63 ± 5.21) μ ; scale count (205 ± 12.86); scale pattern 'Transitional', 'Narrow Diamond Petal' at shield; 'Regular wave' at basal; scale margin and scale margin distance 'Dentate' and 'Distant' at shield and 'Smooth' and 'Intermediate' at basal respectively; 'SS' (18.5 ± 2.52) μ at shield; 'PD' (62.5 ± 5.21) μ at shield; medullary index 0.64 ± 0.08 *Prionodon pardicolor*
- 6b. Length (76 ± 8.2) mm; diameter (52 ± 8.08) μ ; scale count (331 ± 18.72); scale pattern 'Irregular wave'; scale margin 'Crenate'; scale margin distance 'Intermediate'; 'SS' (68.6 ± 8.96) μ ; 'PD' (13.8 ± 2.35) μ ; medullary index 0.66 ± 0.02 *Arctogalidia trivirgata*
- 6c. Length (30 ± 8.81) mm; diameter (90 ± 12) μ ; scale count (400 ± 10.7); scale pattern 'Irregular wave'; scale margin 'Crenate'; scale margin distance 'Intermediate'; 'SS' (45.25 ± 4.8) μ ; 'PD' (11.25 ± 1.16) μ ; medullary index 0.64 ± 0.03 *Paradoxurus jerdoni*

SUMMARY

Nine Indian species of the family Viverridae, *Viverricula indica*, *Paguma larvata*, *Prionodon pardicolor*, *Arctictis binturong*, *Arctogalidia trivirgata*, *Viverra zibetha*, *Viverra civettina*, *Paradoxurus jerdoni* and *Paradoxurus hermaphroditus* had been worked out. From the study it is clear that identification of the species from the hair sample is possible, with the help of a group of characters. However, no character could be placed as family character but except *A. binturong* all the other eight species possess 'Unbroken vacuolated' medullary configuration, shielded and spatulate hair profile as well as 'ovate or circular' T. S. But the same characters in *A. binturong* noted as 'Simple' medullary configuration, 'Rod' like hair profile and 'Reniform' T. S. Thus, from this study, it could be reveal that *A. binturong* is little different from the other eight Indian species of the family Viverridae. So, it may demand a different taxonomic status at least at sub-family level.

ACKNOWLEDGEMENTS

Authors are thankful to Dr. J. R. B. Alfred, Director, Zoological Survey of India for his kind permission and facilities provided for this work and also to Dr. S. Chakraborty Jt. Director (Retd.) for critically going through the manuscript.

Table 1. : Comparative account of the characteristics of the guard hairs of nine Indian species of the family Viverridae (Mean and SD given in Parenthesis); 'SS' = Side to side cuticular scale length; 'PD' = Poximodistal cuticular scale length; B = Basal; S = Shield; Sh = Subshield; EN = Endangered; Sch = Schedule; VU = Vulnerable.

Sl. No.	Name of the Species	Profile	Colour	Length (mm)	Diameter (μ)	Scale count/mm of hair length	Scale Pattern	Scale margin distance	Scale margin
1.	<i>Viverricula indica</i> Desmarest	Spatulate, Straight, Shielded, Banded	Claret Brown with Buff Band and Shield	20–29 (23.83 \pm 2.12)	100–150 (120 \pm 10.6)	372–418 (400 \pm 17.6)	Transitional S : Regular Petal B : Irregular wave	S : Distant B : Close	S : Dentate B : Crenate
2.	<i>Paguma larvata</i> Hamilton-Smith	Spatulate, Straight or little wavy, shielded, Banded	Claret Brown with lighter basal, dark apical and single broad Buff band at subshield	30–45 (38 \pm 3.86)	50–80 (60 \pm 8.72)	221–247 (231 \pm 8.71)	Irregular wave	Close	Crenate
3.	<i>Prionodon pardicolor</i> Hodgson	Spatulate, Straight, Shielded, Band may or may not present	Claret Brown, Broad Buff band at subshield, if present	10–25 (18 \pm 6.82)	50–70 (63 \pm 5.21)	176–221 (205 \pm 12.86)	Transitional S : Narrow Diamond Petal B : Regular wave	S : Distant B : Intermediate	S : Dentate B : Smooth
4.	<i>Arctictis binturong</i> Raffles	Rod like, Little wavy, non banded	Black	40–70 (55 \pm 11.21)	100–130 (110 \pm 8.76)	204–236 (218 \pm 10.38)	Irregular wave	Intermediate	Crenate
5.	<i>Arctogalidia trivirgata</i> Gray	Spatulate, Straight or little wavy, Shielded, non-banded	Burnt Sienna, lighter at basal	60–85 (76 \pm 8.2)	40–60 (52 \pm 8.08)	287–356 (331 \pm 18.72)	Irregular wave	Intermediate	Crenate
6.	<i>Viverra zibetha</i> Linnaeus	Spatulate, Straight, Shielded, Band may or may not present	Claret Brown, narrow Buff band not more than 4 mm at sub shield, if present	30–40 (33 \pm 5.8)	80–110 (95 \pm 9.36)	217–254 (234 \pm 11.72)	Transitional S : Regular mosaic B : Regular wave	S : Distant B : Intermediate	Smooth
7.	<i>Viverra civettina</i> Blyth	Spatulate, Straight Shielded, Band may or may not present	Dark Bay, Broad Buff band at sub shield, if present	30–40 (34 \pm 3.42)	80–110 (100 \pm 6.18)	212–267 (240 \pm 14.12)	Irregular wave	Intermediate	Crenate
8.	<i>Paradoxurus jerdoni</i> Blanford	Spatulate, Straight, Shielded, non banded	Claret Brown, lighter at basal	20–40 (30 \pm 8.81)	70–110 (90 \pm 12)	396–423 (400 \pm 10.7)	Irregular wave	Intermediate	Crenate
9.	<i>Paradoxurus hermaphroditus</i> Pallas	Spatulate, Straight, Shielded, non-banded	Dark Bay, either in whole or at apical, basal lighter	20–40 (31 \pm 7.25)	70–110 (92 \pm 10.76)	291–347 (325 \pm 16.47)	Irregular wave	Close	Crenate

Table 2. : Comparative account of the characteristics of the guard hairs of nine Indian species of the family Viverridae (Mean and SD given in Parenthesis); 'SS' = Side to side cuticular scale length; 'PD' = Poximodistal cuticular scale length; B = Basal; S = Shield; Sh = Subshield; EN = Endangered; Sch = Schedule; VU = Vulnerable; T.S. = Transverse Section.

Sl. No.	Name of the Species	SS (μ)	PD (μ)	Medullary Configuration	Medullary Index	T. S.	Remarks
1.	<i>Viverricula indica</i> Desmarest	S : 20–25 (22 \pm 1.6)	S : 43–60 (53.5 \pm 4.66)	Unbroken vacuolated	0.76–0.78 (0.769 \pm 0.02)	Ovate	Sch. II CITES; APPENDIX III
2.	<i>Paguma larvata</i> Hamilton-Smith	42–57 (47.7 \pm 3.94)	13–21 (16.5 \pm 3.46)	Unbroken vacuolated	0.81–0.83 (0.826 \pm 0.01)	Ovate	Sch. II CITES; APPENDIX III
3.	<i>Prionodon pardicolor</i> Hodgson	S : 15–22 (18.5 \pm 2.52)	S : 56–71 (62.5 \pm 5.21)	Unbroken vacuolated	0.62–0.66 (0.64 \pm 0.08)	Circular	Sch. I; EN CITES; APPENDIX I
4.	<i>Arctictis binturong</i> Raffles	47–66 (56.5 \pm 6)	10–19 (15 \pm 2.96)	Simple	0.926–0.931 (0.93 \pm 0.001)	Reniform	Sch. I; EN CITES; APPENDIX III
5.	<i>Arctogalidia trivirgata</i> Gray	50–80 (68.6 \pm 8.96)	11–19 (13.8 \pm 2.35)	Unbroken vacuolated	0.60–0.69 (0.66 \pm 0.02)	Circular	VU
6.	<i>Viverra zibetha</i> Linnaeus	32–49 (37 \pm 2.04)	33–45 (39 \pm 3.52)	Unbroken vacuolated	0.88–0.896 (0.89 \pm 0.01)	Ovate	Sch. II CITES; APPENDIX III
7.	<i>Viverra civettina</i> Blyth	69–98 (80.75 \pm 9.21)	8–15 (11.25 \pm 1.85)	Unbroken vacuolated	0.60–0.65 (0.62 \pm 0.09)	Ovate	Sch. I; EN CITES; APPENDIX III
8.	<i>Paradoxurus jerdoni</i> Blanford	37–51 (45.25 \pm 4.8)	9–14 (11.25 \pm 1.16)	Unbroken vacuolated	0.60–0.68 (0.64 \pm 0.03)	Circular	Sch. II; VU CITES; APPENDIX III
9.	<i>Paradoxurus hermaphroditus</i> Pallas	28–39 (35.5 \pm 3.1)	6–11 (8.75 \pm 2)	Unbroken vacuolated	0.70–0.78 (0.72 \pm 0.02)	Ovate	Sch. II

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