

MEDULLAR TYPE AND CUTICULAR SCALE PATTERNS OF HAIRS OF RODENTS AND SMALL MARSUPIALS FROM THE MONTE SCRUBLAND (SAN LUIS PROVINCE, ARGENTINA)

Gustavo J. Fernández* and **Silvia M. Rossi**

Area de Zoología, Facultad de Química, Bioquímica y Farmacia, Universidad Nacional de San Luis. Chacabuco y Pedernera (5700). San Luis. Provincia de San Luis. Argentina.*Present address: Instituto de Biología y Medicina Experimental (CONICET). Vuelta de Obligado 2490. (1428) Capital Federal. Argentina. E-mail mermoz@proteus.dna.uba.ar

ABSTRACT: Hair characteristics are often used to identify mammalian prey in guts, feces or pellets of predators when other more easily identifiable remains, such as bone fragments or teeth are not available. Indeed, hair can provide qualitative data about prey species. By using guard hair cuticular scale patterns and medullar types, we built a key which enabled us to accurately identify nine of thirteen rodents and small marsupials found in San Luis Province (Argentina). Our results support the use of hairs to identify mammalian prey but emphasize that at least two criteria must be examined to accurately distinguish among species.

Key words: hairs, guard hairs, medullar type, cuticular scale pattern, hair identification, rodents, Monte scrubland, San Luis.

INTRODUCTION

Several studies analyzing mammalian hair structure have shown that it is generic and possesses species-specific characteristics. Hair analysis allows the identification of prey items from remains in feces, guts or pellets when other identifiable remains such as teeth or bones are missing or too fragmented (Day, 1966; Gurini, 1985; Capurro et al., 1988). Excessive fragmentation of remains is very common where small carnivores (Day, 1966; Gurini, 1985) and scavengers (Capurro et al., 1988) are involved.

The fur of most mammalian species is composed by two kinds of hairs. Guard hairs which are long, straight and heavily pigmented, and fine hairs which are shorter and less pigmented than the former. Both show three layers of keratin: an external cuticle surrounding the hair, a cortex, and an internal layer named medulla, which is made up of loosely packed cells, often

containing air. Only guard hairs show cuticular and medullar patterns consistent enough to allow reliable species identification (Day, 1966; Gurini, 1985).

Cuticular scale patterns, types of medulla and pigmentation and shape are the most useful features for identifying mammalian hairs (Day, 1966; Gurini, 1985; Busch, 1986; Capurro et al., 1988; Chehébar and Martín, 1989). Indeed, such characteristics do not vary with sex, diet or age (Gurini, 1985). Hence they have an important diagnostic value as systematic or phylogenetic elements as well as for predator diet analysis.

Several authors have attempted to develop identification keys for mammalian prey in Argentina based on some of their hair features. For instance, based on cuticular scale patterns only, Piantanida and Petriella (1976) unsuccessfully tried to build a species specific hair identification key for cricetids of Buenos Aires. Using cuticular scale patterns and med-

ullar types Busch (1986) and Capurro et al. (1988) found that these two hair features were satisfactory for the identification of some mammalian prey. In turn, Chehébar and Martín (1989) suggested that the same two hair characteristics were not enough to identify all mammalian species from Patagonia.

In this report, we study the differences in cuticular scale patterns and types of medulla for twelve species of rodents and one small marsupial (**Table 1**) from the north and central region of San Luis Province (Monte scrubland). Using these differences we built a hair identification key for the most common predators' food items within this region.

METHODS

We used only guard hairs, because they show constant features for any species. Fine hairs, instead, are less constant and have simplified versions of those features found in guard hairs (Day, 1966). Further, the digestive process frequently destroys fine hairs, whereas guard hairs are remarkably more resistant.

Mammalian guard hairs usually have a narrow proximal region, followed by a broad shield section, which narrows towards the distal portion of the hair. The nomenclature for cuticular scale patterns and medulla types follows Hausman (1924, 1932), and later modifications by Benedict (1957) and Gurini (1985).

We took hairs from the head, neck, back and belly of the species listed in **Table 1**. Sampled animals came from the Zoology Area Mammalian Collection of San Luis University (Argentina), and from live animals kept at the Laboratory of Eco-physiology (San Luis University, Argentina).

Hairs sampled were rinsed in a sulfuric acid-alcohol 70% solution and were mounted on microscope slides. The medulla was observed throughout. When the medulla could not be identified easily, we cleared the hair with peroxide (Gurini, 1985). In order to identify the cuticular scale pattern, once identified the medullar type, we made a cast of each hair on a thin layer of correction fluid which had been previously extended on a microscope slide (Schemnitz, 1980). Hairs were laid on this film, allowing for the correction fluid to dry. Then, hairs were peeled off, leaving behind a cast of the scales.

Hairs were observed through a microscope at 100x and 400x.

RESULTS

Guard hairs of different body areas showed coloration, length and diameter differences but similar cuticular scale patterns and medullar types for the same individual. Further, hair structure was similar for individuals of the same species, but differences were detected between species, enabling us to identify most of the species studied. Cuticular scale pattern and medullar type of each species are described below.

Cuticular scale patterns

Hair cuticular scale patterning from the different species were similar at the shield area, but major variation was noted at the proximate and distal portions of them. The different cuticular scale patterns observed are shown in **Fig. 1**.

The cuticular scales of tip and shield portions of *M. pusilla*'s hairs showed a mosaic-like pattern. Their basal portion, however, presented a pectinate pattern which merged into diamond petal in the proximal parts of the shaft.

Ctenomys's hairs had only the basal and mean portions pigmented. Guard hairs showed a mosaic scale pattern at the shield, turning into a wavy crenated one at the top of the shield and at the tip. At the basal portion, the scales appeared to be pointing backwards showing an oblique mosaic pattern.

Like *Ctenomys* sp., *Microcavia australis* showed an oblique mosaic pattern on the basal portion, turning to mosaic at the shield, and to a wavy crenated pattern at the tip. Their hairs, although shorter than *Ctenomys*'s, are heavily pigmented. *Lagostomus maximus* and *Pediolagus salinicola* showed similar cuticular scale patterns for the shield and tip regions, but their basal portion had a regular polygonal pattern. Pigment in *Lagostomus*'s hairs was concentrated in the medial zone, whereas *Pediolagus* showed a more uniform pigmentation.

Cricetid species also presented uniformly pigmented hairs. Hairs of *Eligmodontia typus* and *Graomys griseoflavus* appeared to be identical. Guard hair of *Graomys* were slightly longer than those of *Eligmodontia*, but their

Table 1. List of species, number of specimens and total samples taken used for hair analysis.

Species	Order, family	Number of individuals	Sample size
<i>Lagostomus maximus</i>	Rodentia, Chinchillidae	2	12
<i>Pediolagus salinicola</i>	Rodentia, Caviidae	1	8
<i>Microcavia australis</i>	Rodentia, Caviidae	3	18
<i>Ctenomys</i> sp.	Rodentia, Ctenomyidae	2	14
<i>Phyllotis darwini</i>	Rodentia, Cricetidae	2	14
<i>Graomys griseoflavus</i>	Rodentia, Cricetidae	6	14
<i>Eligmodontia typus</i>	Rodentia, Cricetidae	8	24
<i>Akodon molinae</i>	Rodentia, Cricetidae	8	24
<i>Calomys laucha</i>	Rodentia, Cricetidae	6	20
<i>Calomys venustus</i>	Rodentia, Cricetidae	6	20
<i>Calomys musculinus</i>	Rodentia, Cricetidae	10	26
<i>Marmosa pusilla</i>	Marsupialia, Didelphyidae	2	12

cuticular scale patterns were similar. The proximal portion of hairs had a lanceolate pattern with the shield and tip portions displaying a mosaic-like pattern. *E. typus* occasionally showed, in the basal portion of the proximal region, a coronal sheathed cuticular scale pattern. This pattern was not observed in *Graomys*'s hairs, but it was restricted to the narrowest part of *Eligmodontia*'s hairs. However, less than 10% of its hair presented this pattern, and so it is possible that sometimes identification may be hindered as this region could be missing.

Calomys musculinus and *C. laucha* presented mosaic scale patterns at the shield and tip region of hairs. In the proximate portion of hairs *C. musculinus* had a pectinate scale pattern, whereas *C. laucha* had a lanceolate one, which turned into a chevron-like pattern towards the shield area. *Calomys venustus* and *C. callosus* presented a similar cuticular scale pattern at the shield and tip portions of hairs. At the shield, they have a mosaic-like pattern which turned into a wavy crenated one at the tip. However, in *C. venustus* the mosaic pattern was more reduced than in *C. callosus*. Proximate regions of hairs of these species were lanceolate in the latter and pectinate in the former.

Akodon molinae showed a hair cuticular scale pattern similar to that of *C. callosus*. However, as observed in *C. venustus*, shield mosaic patterns were shorter than those present

in *C. callosus*. *Phyllotis darwini*'s hairs showed a lanceolate pattern at the proximate region which turned into mosaic at the shield area and to wavy crenated at the tip.

Medullar pattern

In almost all the species, medullar types varied from cells in an uniseriate (i.e. in a single row) to multiseriate arrangement (i.e. in two or more parallel rows), depending on hair diameter (**Fig. 2**). For most species, proximal and distal regions of hairs frequently had an uniseriate pattern. Only *Ctenomys*'s hairs had a fragmented medulla at the tip. On the other hand, shield regions of hairs showed the highest interspecific pattern variation. It was insufficient, however, to separate most species.

Almost all cricetids presented a triseriate medulla at the shield region (*Eligmodontia typus*, *Calomys musculinus*, *C. laucha*, *C. venustus*, *C. callosus*, *Akodon molinae* and *Graomys griseoflavus*). Only *Phyllotis darwini* had a multiseriate medullar type. On the other hand, *Ctenomys* sp. and *Lagostomus maximus* had hairs with a lattice-like medulla at the shield areas, whereas *Pediolagus salinicola* showed a reticulate medullar pattern. *Microcavia australis* showed heavily pigmented hairs, instead of the peroxide-washing process. It made identification difficult, but it appears to be of lattice type.

In *Marmosa pusilla*, shield portions were poorly defined and there was little difference

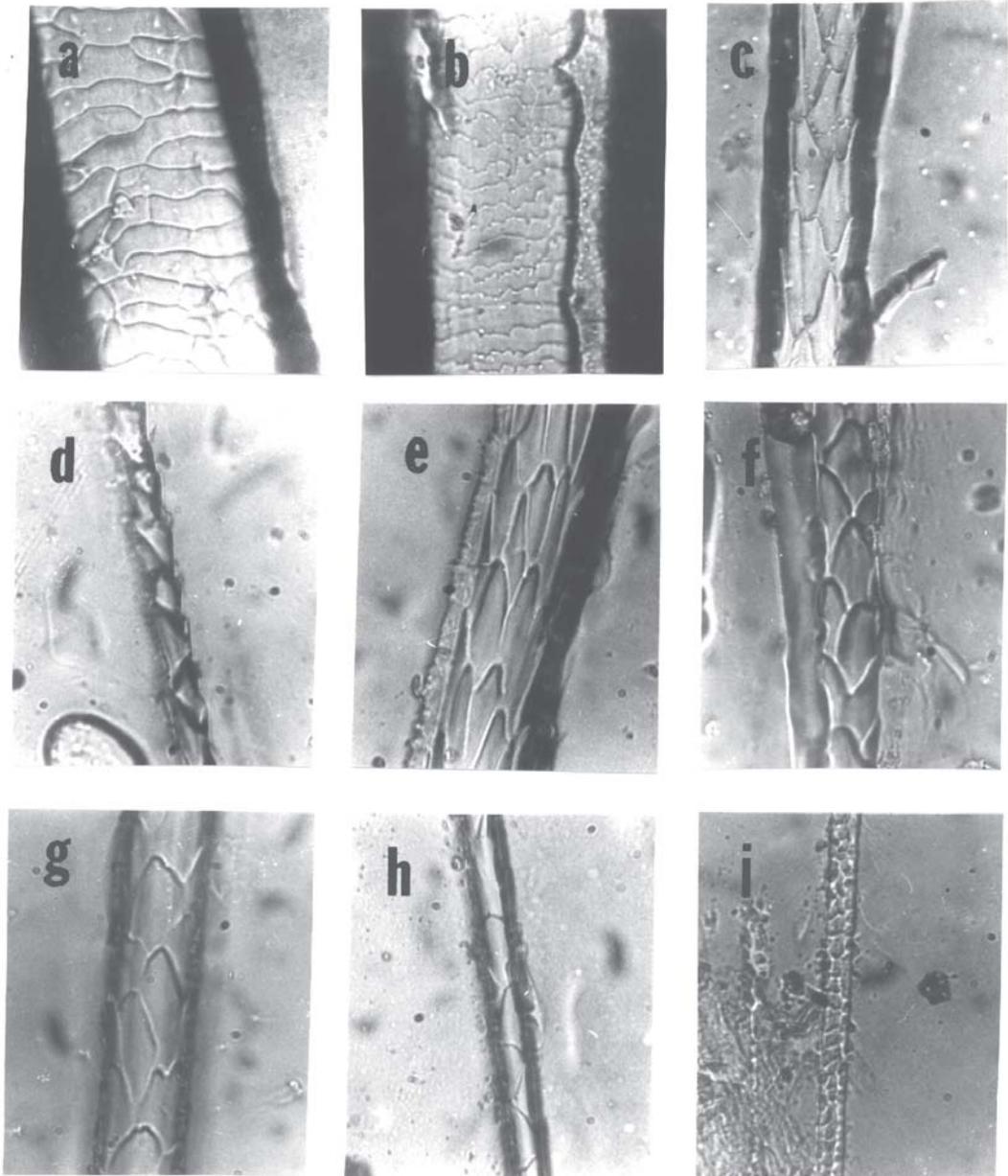


Fig. 1. Cuticular scale patterns of some small mammals from the Monte scrubland (San Luis Province, Argentina). a) Mosaic (*Microcavia australis*); b) wavy crenated (*Microcavia australis*); c) chevron (*Calomys laucha*); d) coronal (*Calomys laucha*); e) pectinate (*Calomys musculinus*); f) and g) lanceolate (*Eligmodontia typus* and *Graomys griseoflavus*, respectively); h) diamond petal (*Marmosa pusilla*); i) regular polygonal (*Pediolagus salinicola*). a), b) scale 100x (1 cm: 2.5 mm); c)-i) scale 400x (1 cm: 0.08 mm).

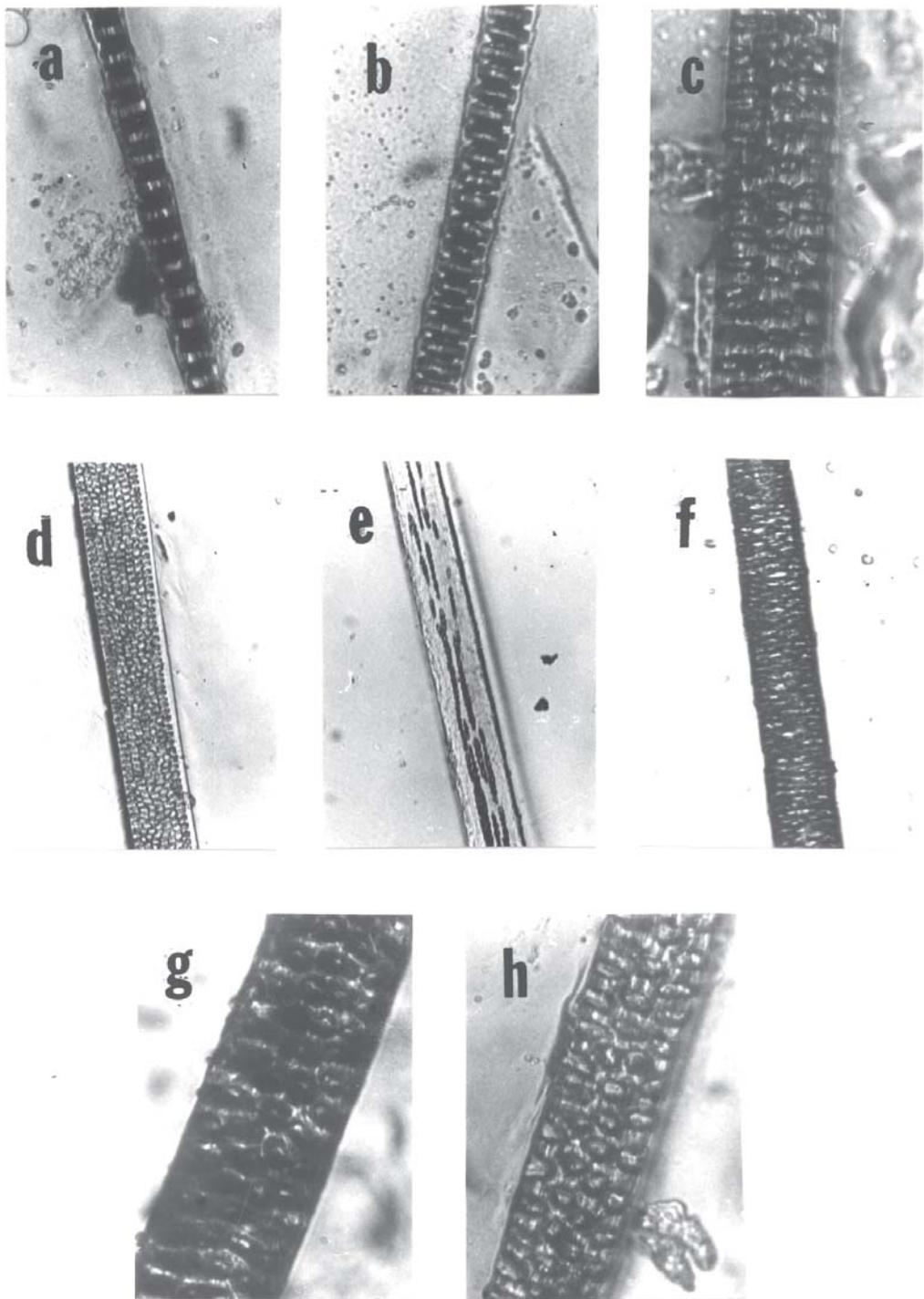


Fig. 2. Medullar types of some small mammals from the Monte scrubland (San Luis Province, Argentina). a) uniseriate (*Marmosa pusilla*, shield region); b) uniseriate (*Calomys laucha*, basal portion); c) triseriate (*Eligmodontia typus*); d) multiseriate (*Ctenomys* sp.); e) fragmented (*Ctenomys* sp.); f) lattice (*Lagostomus maximus*); g) triseriate (*Graomys griseoflavus*); h) multiseriate (*Phyllotis darwini*). a)-c), g) and h) scale 400x (1 cm: 0.08 mm); d)-f) scale 100x (1 cm: 2.5 mm).

between guard and fine hairs. Hair medulla in this species was totally uniseriate. Interestingly, Gurini (1985) found similar medullar types in other marsupials (*Didelphis albiventris*, *Lutreolina crassicaudata*, and *Marmosa agilis*).

Hair identification key

The differences in cuticular scale pattern and medullar type found among the studied species, allowed us to build a key for species identification. Since medullar patterns showed

to be similar at the extremes of the hair, we first used the patterns found at the shield area. We also used the differences in cuticular scale pattern at the proximate and distal regions of hairs. We discarded those cuticular patterns observed at the shield regions because they were similar for almost all the analyzed species.

The analysis of these hair features allowed us to clearly identify 9 of the 13 species studied. For the rest of them, hair features differed too little for unambiguous identification.

Hair Identification Key for Rodents and Small Marsupials from the Monte Scrubland (San Luis, Argentina)

1	Hairs without visible medulla	<i>Microcavia australis</i>
1'	Hairs with visible medulla	2
2	Hairs with uni, bi or triseriate medulla	3
2'	Hairs with other medullar type	8
3	Hairs with uniseriate medulla	<i>Marmosa pusilla</i>
3'	Hairs with bi or triseriate medulla	4
4	Proximal portion of the hair with lanceolate cuticular scales	5
4'	Proximal portion of the hair with another cuticular scales pattern	6
5	Distal portion of the hair with wavy crenated cuticular scale pattern	<i>Akodon molinae</i> <i>Calomys callosus</i>
5'	Distal portion of the hair with mosaic cuticular scale patter	<i>Calomys laucha</i> <i>Graomys griseoflavus</i>
6	Proximal portion with coronal cuticular scale pattern	<i>Eligmodontia typus</i>
6'	Proximal portion of the hair with pectinate cuticular scale pattern	7
7	Distal portion of the hair with wavy crenated cuticular scale pattern	<i>Calomys venustus</i>
7'	Distal portion of the hair with mosaic cuticular scale pattern	<i>Calomys musculus</i>
8	Hairs with multiseriate medulla	<i>Phyllotis darwini</i>
8'	Hairs with other medulla type	9
9	Hairs with lattice medulla	10
9'	Hairs with reticulate medulla	<i>Pediolagus salinicola</i>
10	Distal portion of the hair with discontinuous medulla (fragmented type)	<i>Ctenomys</i> sp.
10'	Distal portion of the hair with medulla with uniseriate pattern	<i>Lagostomus maximus</i>

DISCUSSION

The cuticular scale patterns and types of medulla found in hairs of each of the studied species are similar to those reported in previous works in different regions (Busch, 1986; Capurro et al., 1988; Chehébar and Martín, 1989).

Types of medulla are related to hair diameter as suggested by Hausman (1932). Finer hairs can show an uniseriate pattern of cells in the medulla or even the total absence of them. The former is the case for *Marmosa pusilla*. This species shows the finest guard hair, with a very simple type of medulla (uniseriate). Cricetid rodents, instead, show medullar patterns which are frequently triseriate at the shield region and uniseriate at the narrowest extremes of hairs. Larger rodents have thicker guard hairs, with more complex medullar patterns. However, *M. pusilla*'s hairs show a medullar pattern similar to that of *Lutreolina crassicaudata*'s and *Didelphis albiventris*'s (Didelphidae) hairs, two larger marsupials (even similar to some of the larger rodents analyzed here), which is formed by only one cell series (Gurini, 1985). In these marsupials, hair diameters are very different (27 - 31 μ for *M. pusilla*; 51 - 61 μ for *L. crassicaudata*; and 75 - 109 μ for *D. albiventris*), but this has no effect on the medullar pattern. It is possible to consider that the uniseriate medullar pattern is a characteristic of the subclass.

Cuticular scale patterns can also be related to hair diameter. At the shield region, in almost all species, it shows a mosaic-like or wavy crenated scale pattern, whereas at the proximate region, it can become lanceolate, pectinate or show a regular polygonal scale distribution. However, the relationship between diameter and scale pattern is not so clear at the tip. Scale patterns are, in this case, related to the pattern present at the shield rather than to hair diameter.

In a previous work, Chehébar and Martín (1989) used mainly the proximal portion of hairs for identification of mammals at genus level, and only in few cases it was usefully for species identification. Accordingly, we must resort to the rest of the hair (i.e., the distal

portion) for the proper identification of the species here studied.

As Gurini (1985) has noted, species identification based on hair features is difficult within the Cricetidae family because there are only slight interspecific differences. We were not able to distinguish from one another, only two pairs of cricetids when using both the cuticular scale patterns and medullar types (*Calomys laucha* and *Graomys griseoflavus*, and *Calomys callosus* and *Akodon molinae*). In these cases, the species have hairs with a lanceolate scale pattern at proximate region, but *A. molinae* and *C. laucha* show sometimes a chevron pattern at the broadest region of the shield area which could enable their identification. These results are in accordance with those of Bush (1986) for cricetines from the Pampa region.

The use of this technique shows to be efficient enough to identify most mammalian prey species studied from the Monte region. It is possible that other hair features (e.g.: cross-sections) could yield more accurate identifications. However, this identification is eminently qualitative in content, fact which renders any attempt for quantification, not enabling us to tackle an estimate of prey numbers in a predators diet. On the other hand, phylogenetic or systematic implications of hair characteristics remain still unclear and need further study.

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