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Pelage variation in *Marmosa incana* (Didelphidae, Marsupialia) with notes on taxonomy

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Abstract

Described and analysed pelage patterns of *Marmosa incana*, on the basis of museum specimens over the whole geographic range of the species. Three pelage types were identified by the length and texture of the dorsal hairs. Consistent occurrence of these pelage types in different age and sex classes along the year refute previous hypotheses of geographic variation and pelage seasonality and point to an intrinsic determination of the pelage types. The taxonomic status of the forms formerly included in TATE's (1933) *incana* section is discussed and possible causes of sexual dimorphism in pelage are surveyed.

Introduction

With forty-seven recognized species (HONACKI et al. 1982), the genus *Marmosa* is the most diverse taxon of Neotropical marsupials. In TATE's (1933) classical revision the genus *Marmosa* was defined comprising five major species groups, each one subdivided in sections. Although recent authors (e.g. PINE 1972; KIRSCH 1977) have suggested that *Marmosa* could be split into different genera, this taxon has remained undivided, as formerly claimed by TATE, except by the brief proposition of GARDNER and CREIGHTON (1989), in which *Marmosa* (s. l.) was divided in five genera coincident to a great extent with the five species groups of TATE (1933). At the specific and subspecific levels the study of TATE (1933) remains the only detailed description of the variation in *Marmosa*, especially in what concerns the forms analysed in the present study. For this reason, TATE's (1933) assignment of species and species groups will be followed hereafter.

The *incana* section of TATE's (1933) *noctivaga* group comprises two species that occur in eastern Brazil: *Marmosa incana* (Lund, 1841), which is the genotype of the genus *Marmosops* according to GARDNER and CREIGHTON (1989), and *M. scapulata* (Burmeister, 1856). These two forms are mainly distinguished by the presence of conspicuous stiffened hairs in the scapular regions of the latter species. In addition to the modified pelage of *M. scapulata*, TATE (1933) also identified sexually dimorphic long and short pelages to characterize subspecies of *Marmosa incana*. In a recent interpretation of the same pelage variation, EMMONS (1990) identified the long and short furs of *Marmosops incanus* as seasonal coats, and ascribed a third pattern showing a “collar” of new hair to a molt stage.

The first intend of this study is to bring a more comprehensive description of pelage patterns in the *incana* section. In order to understand the determinants of the pelage variation we also analyse the occurrence of the pelage patterns in relation to age, sexual and seasonal variation.

Material and methods

A total of 311 museum specimens was analysed in this study. Localities, sample sizes, and museum acronyms are as follows: MN = Museu Nacional, Rio de Janeiro; UFMG = Departamento de Zoologia, Universidade Federal de Minas Gerais; MBML = Museu de Biologia Mello-Leitão; MHNCI = Museu de História Natural "Capão da Imbuia".

Bahia: Feira de Santana (1, MN); Ilhéus (83, MN); Jaguaquara (2, MN); Jequié (3, MN); Serrinha (6, MN). – Minas Gerais: Além Paraíba (64, MN); Almenara (1, UFMG); Caratinga (1, UFMG); Conceição do Mato Dentro (9, MN); Grão Mogol (5, MN); Juiz de Fora (6, MN); Lagoa Santa (15, MN); Parque do Ibitipoca, Lima Duarte (1, UFMG); Mociminho, Manga (8, MN); Parque Florestal do Rio Doce, Marliéria (4, UFMG); Ponte Nova (2, MN); Caraça, Santa Bárbara (21, UFMG); Rio Casca (1, UFMG); Sete Lagoas (3, UFMG); Várzea da Palma, Serra (2, UFMG); Parque Nacional da Serra da Canastra (1, UFMG); Turmalina (1, MN) Vargem da Lapa (2, UFMG); Volta Grande (6, MN). – Espírito Santo: Campinho (1, MN); Cariacica (6, MBML); Castelo (3, MBML); Nova Lombardia (1, MN); Santa Tereza (13, MBML). – Rio de Janeiro: Ilha Grande, Angra dos Reis (4, MN); Poço das Antas, Silva Jardim (2, MN); São João Marcos (1, MN); Teresópolis (10, MN); Tijuca, Rio de Janeiro (5, MN); Tinguá, Nova Iguaçu (1, MN). – Paraná: Piraquara (2, MHNCI). – No locality: (14, MN).

Date of collecting and sex were obtained from original tags. In order to determine the age of specimens we used a modification of the system proposed by TRIBE (1990) which is based on the sequence of eruption of molariform teeth (classes 1 to 6) and wearing of M4 (classes 6 and 7). We noted that the angle of placement of M4 is individually variable, sometimes resulting in abnormal wearing of this tooth. Consequently, we analysed additional wearing of M1–M3. Beginning of class 6 is readily identifiable by incompletely erupted PM3; to classify individuals with fully erupted PM3, scores were attributed to three consecutive stages of M1–M4 wearing, the first being posteriorly allocated to age classe 6 and the last two stages to age class 7 (7^I and 7^{II}).

Types of pelage were identified on the basis of length and texture of dorsal fur. Medium pelage



Fig. 1. Dorsal view of individuals of each pelage pattern described. a: type A; b: type B; c: type C

length was measured with a millimetric ruler at the mid-dorsum of each specimen. The texture was estimated by touch and classified in soft, coarse and stiffened categories. Hairs from the back, scapular and throat region of representative individuals of each sex and pelage pattern were observed under a binocular microscope with a drawing tube to assess gross morphologic differences and to draw the distinct hair types.

Samples from states of Bahia, Minas Gerais and from combined localities from the states of Rio de Janeiro, Espírito Santo and Paraná, congruent with geographical distances and ranges of the subspecies of *M. incana* proposed by TATE (1933), were examined separately. Distributions of pelage patterns by age, sex and month were found to be similar in the three samples, but the respective sample sizes became much reduced when analysed monthly. Therefore, we tabulated the frequencies at each pelage pattern by age, sex and by month for all specimens. Animals that had been kept in captivity were excluded from the analyses.

The occurrence of an orange to rust brown stain around the mammary area is an indication of pregnancy and nursing (BARNES 1977), and was used to determine reproductive status in females. Reproductive condition in males is more difficult to determine from external markings, and was assessed by histological examination of testes for spermatogenic activity in two available males (MN 29 006 and MN 29 007).

Results

The following three patterns were identified in the analysis of the hairs of the back. Type A (Fig. 1a) shows a uniform dorsal fur, shiny, brownish gray, with soft and long hairs, length 8–12 mm (Fig. 2a). In type B (Fig. 1b) the dorsal pelage is also uniform and brownish gray, but coarse, dull and short, hairs length 5–8 mm (Fig. 2b). The most conspicuous pattern, type C (Fig. 1c), exhibits an heterogeneous dorsal coat: the scapular region shows modified broadened and stiffened yellowish hairs, length 5 mm (Fig. 2c), extending backwards, reaching the mid-dorsal region in some specimens. In the interscapular area the fur is shorter (4 to 9 mm long) and dull grayish, with some modified hairs mixed to the normal ones; the remainder dorsal pelage is similar to type A, with hairs 10 to 12 mm long.



Fig. 2. Hair types associated with each pelage pattern. a: dorsal hair of pelage types A and C; b: dorsal hair of pelage type B; c: scapular hair of pelage type C

Pelage type A comprises individuals ranging from age classes 3 (the younger individuals of our sample) to 6 in both sexes, as well as 61 % of the males of age class 7^I (Fig. 3). Only females showed pelage type B, which occurred in 13 % of the individuals of age class 6, and in the entire age class 7 (7^I and 7^{II}). Pelage type C was found only among males, in 6 % of age class 6, 39 % of age class 7^I and 100 % of age class 7^{II}.

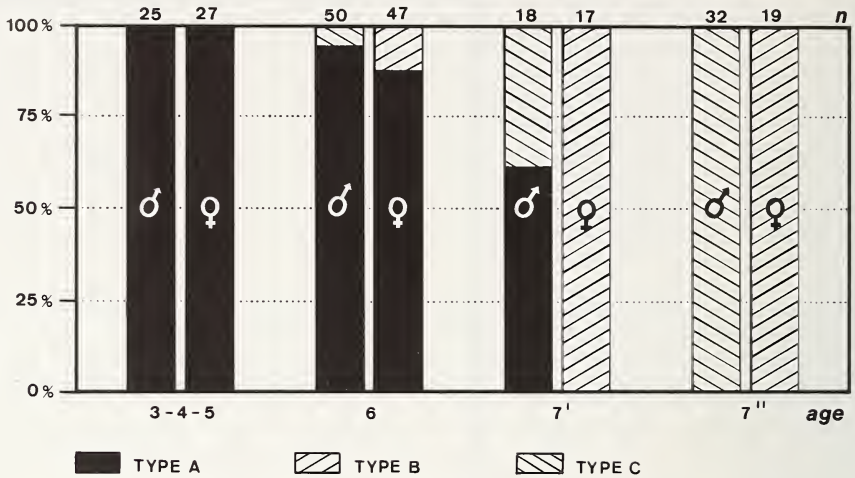


Fig. 3. Frequency (percent) of pelage patterns by age classes

The ventral pelage is ivory white in the three patterns described, with soft and long hairs in type A and C, whereas short and coarse in type B. In the throat region all males of pelage type C show modified hairs similar to that of the scapular region. In pelage type A, although occupying a much smaller area, the modified throat hairs are also present in 12 % (n = 6) of the individuals of age class 6 and in 40 % (n = 4) of age class 7.

In four males (MN 8296, 11 147, 13 367 and 24 684) of pelage type A and age classes 6 and 7^I, we observed a very small area of modified stiffened hairs on both sides of the neck, near the scapular region. One class 7^I female (MN 17 158) showed an atypical condition of pelage with venter and anterior half of dorsum with pelage type B and posterior half with pelage type A. This pattern was also found in another female specimen (MN 11 157, skin only).

Tabulation of the occurrence of pelage patterns by month (Fig. 4) reveals that type A occurs throughout the year, more often from January to August and decreases toward the end of the year. Pelage type B shows low frequencies between January and July, and shows higher frequencies from September to November. Type C is seldom present from February to May and its frequency increases from July on.

Discussion

Pelage patterns

The patterns of pelage identified here have already been partially described in the literature. Type A is the most often mentioned, possibly because it is the most common in nature, occurring in both sexes from age class 3 (at least) to age class 6. This is the basic pelage pattern of *Marmosa incana* according to TATE (1933), reported for both sexes of *M. incana paulensis* and for males of *M. incana bahiensis* and *M. incana incana*. This pelage type was referred to by EMMONS (1990) as the winter coat, occurring from May to August.

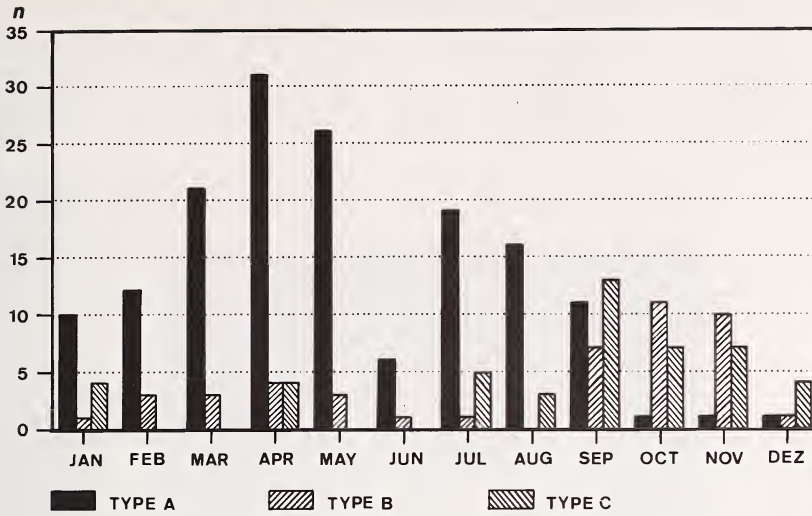


Fig. 4. Frequency of pelage patterns by month

TATE (1933) was the first to identify pelage type B, and related it to females of *M. incana incana* and *M. incana bahiensis*. EMMONS (1990) described this short fur as a summer coat, occurring between January and April.

Pelage type C was first reported in the description of *Grymaeomys scapulatus* Burmeister, 1856, which is *Marmosa scapulata* for TATE (1933). EMMONS (1990) suggested that this pattern represents a moult stage between the summer and winter coats in *Marmosops incanus*, restricted from September to December, and pointed out that it was once described as a different species.

Our results do not indicate that pelage types A and B are alternate seasonal coats. Although pelage type A exhibited higher frequencies between January and August and type B was more common between September and December, we find types A and B concomitantly distributed along all the year. Moreover, absence of pelage type A among individuals exhibiting accentuated molar wearing (age class 7^{II}) and absence of pelage types B and C among individuals of age classes 3, 4, and 5 throughout the year are evidence that the change from long (type A) to short (type B) fur is a single and definitive event.

We have evidence, nevertheless, for a transition from pelage type A to B and from A to C. The six specimens stressed above, four males with incipient stiffened scapular pelage and the two females with short/long dorsal pelage, are thought to represent intermediate conditions between pelage types A and C and types A and B, respectively. These specimens were collected between August and September (males) and between September and October (females), periods in which we notice an inversion in the ratios between frequencies of pelage types A/C and A/B in the year (Fig. 4).

In contrast, ordinary moulting is represented in our sample in seven individuals of pelage type A, which show an incipient layer of new soft hairs under the long dorsal hairs. Close inspection of the associated hairs did not reveal the stiffened characteristic hair of type C, nor the individuals in moult were restricted to a determined part of the year.

In regard to the relation between sex and pelage, our results also do not corroborate the assertion by TATE (1933) that the long (type A) and short (type B) pelages are sexually dimorphic furs. In fact, type A represents the monomorphic pelage for both sexes, occurring from age 3 to 6. On the other hand, the available data demonstrate that pelage types B and C are related to secondary sexual dimorphism in the *incana* section. There is

also an apparent association between these pelage patterns and sexual maturity. Only pelage type B females showed the stained mammary region, which is an indication of reproductive activity. As for the males, it is interesting to note that the individuals of pelage type A examined, although as old as age class 7, did not show any spermatogenic activity. It seems, therefore, that pelage type C is achieved in concern with the sexual maturity.

These results indicate that the pelage patterns described represent distinct age and sex related stages in all studied populations of the *incana* section. Whereas only the age component is responsible for the distinct pelages of youngs and sub-adults, the age, sex and sexual maturity determine the dimorphic adult pelages B (females) and C (males). The "seasonal" component is but a function of different age fluctuations along the year, and cannot account for the determination of pelage variation in the *incana* section.

Taxonomic remarks

Some taxonomic implications result from the conclusion above. The modified scapular pelage, diagnostic of *Marmosa scapulata*, is in fact the adult (matured) male pelage observed in all populations of the *incana* section. Therefore, *Grymaeomys scapulatus* Burmeister, 1856, is a subjective junior synonym of *Marmosa incana* (Lund, 1841). The fact that adult males of *M. incana* match the *M. scapulata* pelage pattern was already noted by TRIBE (1987), who pointed out a possible conspecificity of these two forms.

Examining the holotype of *M. scapulata* (Berlin Museum 2330) TATE (1933) verified that the skin was faded to light brownish. In BURMEISTER's (1856) original description, hairs were "at base slate gray, then pale yellow-red, and last cinnamon". This banding pattern agrees very closely to that we found in specimens of *M. incana*, and results in a grayish dorsal colour, brownish washed above.

TATE (1933) was the first to recognize the close relationship between *M. scapulata* and *M. incana*, and notwithstanding cranial and distributional similarities between these taxa, the pelage differences convinced him of the distinctiveness of *M. scapulata*. Apparently, no male skins of age class 7^{II} (where all males show pelage type C) were available to TATE (1933). Noteworthy, the only male specimen of *Marmosa incana* referred by TATE (1933) to be very old (Copenhagen 132) had no skin. This insufficient sample probably contributed to the recognition of *M. scapulata* as a full species.

In his review, TATE (1933) recognized three subspecies of *Marmosa incana*, based mainly on pelage traits. *Marmosa incana incana* and *M. incana baihensis*, characterized by sexual dimorphism in pelage length (short in females and long in males) differed by the presence of gular stiffened hairs in males of the former subspecies. These forms were distinguished from *M. i. paulensis* in which both sexes showed long fur (type A). In our study, which covers the total geographic range of *M. incana*, and includes topotypic series of *M. incana incana* and *M. incana paulensis*, the pelage type B (short fur) and the gular stiffened hairs in males are present in all subsamples in some individuals of classes 6 and 7^I and in all representatives of age class 7^{II}. Consequently, as far as pelage is concerned, the subspecific structure of *M. incana* proposed by TATE (1933) is inconsistent and should be reconsidered, because it is based on age rather than on geographical differences. Apparently, the pelage diagnoses proposed by TATE (1933) for the subspecies of *Marmosa incana* result from young-biased samples of the populations described as *M. i. babilensis* and *M. i. paulensis* in relation to the nominal subspecies.

Sexual dimorphism

A further implication of our study relates to sexual dimorphism in pelage in *M. incana*. Pelage of adult males (type C) differs strikingly from that of adult females (type B), juveniles,

and subadults (type A). A less conspicuous difference is found between adult females and younger individuals of both sexes. As far as we know this is the first marsupial to show sexual dimorphism in pelage structure.

According to RALLS (1977), sexual selection is the most important mechanism affecting male's colour and structures used in displays. Although territorial and reproductive behavior in *M. incana* is unknown, the modified scapular pelage in males with upstanding, self-coloured and frontally positioned hairs (Fig. 5) may perform a role in social interactions among adult individuals, and could be related to sexual selection.



Fig. 5. Live adult male of *Marmosa incana* showing pelage type C. Note darker line formed by the gray bases of longer hairs adjacent to the modified scapular pelage

Apparently, the occurrence of differentiated adult pelage has not been referred to in female mammals. This may be due to either extreme rarity of this phenomenon in the wild, or to overshadowing by relatively greater distinctiveness of males. In the case of *M. incana*, the differentiated pelage type B could be a consequence of epigenetic interactions hindering the full manifestation on females of a fixed male trait. An alternative hypothesis would deal with selection upon pelage in females, the short fur possibly representing an advantage either in the heat improvement to the young in the teat attachment phase, or in the recognition of the female reproductive status. At any rate, the actual causes of the differentiated female pelage remain to be demonstrated.

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Zusammenfassung

Variation des Haarkleides von Marmosa incana (Didelphidae, Marsupialia) mit Anmerkungen zur Taxonomie

Die Haarkleider der südamerikanischen Beutelratte *Marmosa incana* werden beschrieben; nach der Länge und der Struktur der Rückenhaare können drei verschiedene Haarkleider (A, B, C) unterschieden werden. Alle drei Kleider treten zu fast jeder Jahreszeit auf; dies widerspricht früheren Theorien, die von geographischer Variation oder einem saisonalen Haarkleidwechsel ausgingen. Statt dessen besteht offenbar eine Relation zwischen dem Auftreten von Haarkleid B und der sexuellen Aktivität der Weibchen und dem von Haarkleid C und der sexuellen Aktivität der Männchen. Auf der Grundlage der neuen Befunde wird die Taxonomie verschiedener Formen der *incana*-Gruppe von TATE (1933) diskutiert, und die möglichen Ursachen eines Sexualdimorphismus im Haarkleid von Säugetieren werden besprochen.

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