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Aspects of skin morphology and morphometry of the giant anteater (*Myrmecophaga tridactyla*, LINNAEUS, 1758)

*Aspectos da morfologia e morfometria da pele do tamanduá bandeira (*Myrmecophaga tridactyla*, LINNAEUS, 1758)*

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ABSTRACT: The aim of the present study is to describe the skin morphology and morphometry of the giant anteater (*M. tridactyla*), based on comparative analysis applied to skin segments from central metacarpal torus (palmar pad), dorsal thorax, ventral cervical, ventral abdomen, medial carpal and nasal regions. In order to do so, eight adult specimens of *M. tridactyla* were used for macroscopic studies and four for microscopic assessments. Microscopy was used to assess fur general features that were macroscopically assessed through visual analysis. Fragments (2.0cm²) were collected from the selected regions for microscopic studies. Samples were fixed on McDowell solution, processed through routine histology techniques and subjected to semi-serial cuts (5 µm). The cuts were stained in HE, Alcian blue and periodic acid Schiff. General morphology of different skin layers was described, as well as their architecture and composition; mesoscopy of the epidermis, dermis and stratum corneum was also carried out. There was difference in skin morphometry between males and females, and between different skin regions in the same animal, based on the statistical evaluation of the recorded values. All epidermis layers were assessed for the selected regions. Dermis encompassed surface and deep layers; it presented sweat and sebaceous glands, as well as hair follicles. Findings also allowed reporting that epidermis components are easily identified given its thickness, and the large amount of sweat glands in it – it contrasts its physiological features.

KEYWORDS: anatomy; skin; histology, integument; xenarthra.

RESUMO: O objetivo deste estudo foi descrever a morfologia e morfometria da pele do Tamanduá-bandeira (*M. tridactyla*), mediante a análise comparativa de segmentos cutâneos das regiões central do toro metacarpal (coxim palmar), dorsal do tórax, cervical ventral, ventral do abdome, medial do carpo e nasal. Para tanto, foram utilizados oito exemplares adultos de *M. tridactyla* para o estudo macroscópico, e quatro destes para o estudo microscópico. Macroscopicamente estudou-se, por meio de análise visual, as características gerais do pelo e pelagem. Para o estudo microscópico, foram coletados fragmentos de 2,0 cm² das áreas selecionadas. As amostras foram fixadas em solução de McDowell, processadas pelas técnicas rotineiras de histologia e submetidas a cortes semi-seriados de 5 µm. Os cortes foram corados com HE, azul de Alcian e ácido periódico de Schiff. Descreveu-se a morfologia geral, a arquitetura e a composição das diferentes camadas da pele e ainda realizou-se a mesoscopia da epiderme, derme e estrato córneo. De acordo com a avaliação estatística dos valores obtidos, houve diferença na morfometria cutânea entre machos e fêmeas, e entre as diferentes regiões cutâneas de um mesmo animal. Nas regiões estudadas observou-se todas as camadas da epiderme. A derme compôs-se das camadas superficial e profunda, apresentado glândulas sudoríferas e sebáceas e folículos pilosos. Dentre os achados também pode-se relatar que os componentes da epiderme são facilmente identificáveis pela sua maior espessura, além da grande quantidade de glândulas sudoríferas presentes, o que contrasta com suas características fisiológicas.

PALAVRAS-CHAVE: anatomia; cútis; histologia; tegumento; xenarthras.

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INTRODUCTION

The integumentary system includes the skin and its attachments, such as nails, furs, hooves, claws, horns, as well as mammary, sweat and sebaceous glands (SILVA; SILVA; HERNANDEZ-BLAZQUEZ, 2008). Skin is described as the major tactile organ of the body and it exerts several functions like protection, dehydration prevention, sensory property, among others (NITZ et al., 2006; LEITE et al., 2011). The skin and its attachments are highly specialized based on the way of life of different domestic animal species (DYCE; WENSING; SACK, 2014; JUNQUEIRA; CARNEIRO, 2017).

The skin presents a surface layer, the epidermis, and a deeper layer known as dermis. The dermis has sweat glands, sebaceous glands, hair and hair follicles, as well as cells that perform specific functions. Several general functions of the skin are known; however, different functions based on anatomic variations can be determined (SCOTT; MILLER; GRIFFIN, 2012; JUNQUEIRA; CARNEIRO, 2017).

Giant anteaters have low metabolic rate, low body temperature and thick skin; these features give them effective thermal isolation. Expenses with energy are limited due to these animals' eating habit, which is based on low caloric index. Therefore, they move too slow and are limited to tropical environments (MCNAB, 1984; CAMILO-ALVES; MOURÃO, 2006).

The relevance given to studies focused on wild animal species that are potentially endangered is growing; on the other hand, it is possible observing shortage of information about some organic systems, among them, one finds the integumentary system. These studies may assess peculiar features and, yet, contribute to future phylogenetic studies applied to representatives of superorder xenarthra. Therefore, after observing the shortage of information about the skin of *M. tridactyla,* the aim of the present study was to describe the morphological and morphometric aspects of giant antearter' (*M. tridactyla*) skin.

MATERIAL AND METHODS

In total, 12 corpuses of *M. tridactyla* were used in the study. Eight of them were sent to macroscopic assessment: four male and four female specimens, at different age groups. The four remaining animals were adults, two were male and two were female; they were sent to histological assessment. The project was approved by CEUA/UFG, under process n. 018/2014.

Macroscopic and microscopic examination of the following skin regions were performed for skin morphological analyses: ventral cervical, dorsal thorax and medial carpal, based on ISOLA et al. (2013), in addition to the ventral regions of the abdomen and the caudal nasal region (glabrous skin), and the central region of the metacarpal torus (INTERNATIONAL COMMITTEE ON VETERINARY GROSS ANATOMICAL NOMENCLATURE, 2017) (Figure 1).

Fur general features, such as the presence or absence of primary/secondary fur, color, fur direction and the presence of specific features of the species, were macroscopically analyzed.

Fragments (2.0cm²) were collected, fixed on McDowell solutions for 24h and, subsequently, processed for inclusion in plastic paraffin (Histosec® - Merck-, Brazil). Histological preparations were found through semi-serial cuts (5 µm); interval of 100µm between them was respected and it led to the total of five cuts per region for the morphological analysis of this material. The conventional histological routine was carried out for material inclusions, based on the methodology by Tolosa et al. (2003).

The cuts were stained in hematoxylin and eosin (HE), besides Periodic Acid Schiff (PAS), for basal membrane visualization. Slides were also stained in Alcian's blue in order to

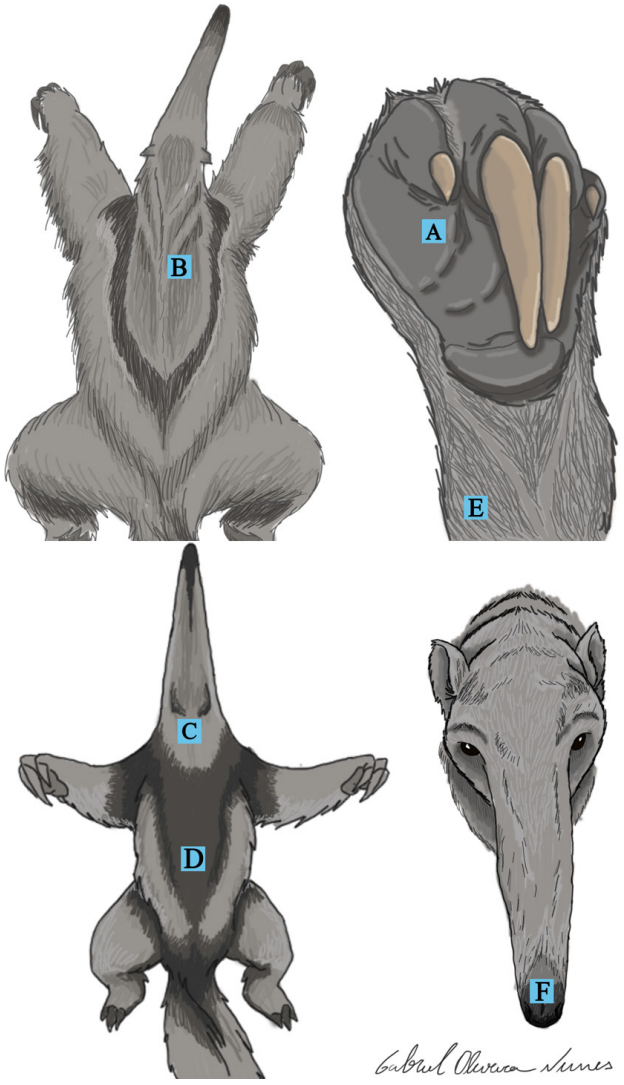

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Figure 1. Schematic drawings depicting an adult giant anteater (*Myrmecophaga tridactyla);* they show rectangular marks over the collected skin regions for histological evaluation: (A) central region of the metacarpal torus; (B) dorsal region of the thorax; (C) ventral cervical region, (D) ventral region of the abdomen, (E) medial region of the carpus; (F) nasal region.

highlight the stratum lucidum. Histological preparations were analyzed and images were captured in photomicroscope (Leica®, DM5000 B) coupled to digital camera (Leica® DFC300 FX). Software ImageJ® was used for morphometric analyses. One slide encompassing five cuts was prepared for each analyzed region; three fields were observed in each cut and it totaled 50 measurements taken for each parameter. The assessed parameters were dermis, epidermis and stratum corneum thickness.

The study followed a completely randomized design, at 2x3x6 factorial arrangement, with options sex (male or female), stratum (dermis, epidermis and stratum corneum) and anatomic region (metacarpal, dorsal, cervical, ventral, carpal and nasal torus). Sampling 'n' is represented by field reading of five fragments from the same anatomic region, from four animals, two males and two females. Measurement results were subjected to normality (Shapiro-Wilk test) and homoscedasticity test; subsequently, they were subjected to analysis of variance, which was followed by Student test to compare sexes, and by Tukey test for the other analyses. Significance level was set at 0.05, for all tests.

RESULTS

Slight variations in fur patterns were found; six animals showed dark-grey body color mixed with white, whitish thoracic limbs and black pelvic limbs; two male specimens presented slightly dark color all over the body. All animals have shown a black cross-sectional strip with white edges on their backs (its intensity changed from individual to individual).

The skin in the ventral cervical, dorsal thorax and ventral abdomen regions was coated with very long and thick bristles (dark brown with light brown edges) implanted at craniocaudal direction – it was macroscopically assessed. The naked eye inspection did not allow observing the presence of secondary hair; thus, fur was only formed by primary hair.

Hair was shorter in the nasal region; nose tip presented glabrous skin; tactile hair was not observed on the face. Hair was significantly longer in the dorsal region of the thorax; it formed a kind of dorsal hairy cirrus from nuchal region to withers. The entire ventral region presented a smaller amount of shorter and thicker bristles in comparison to the ventral cervical and dorsal regions of the thorax. The midlines of the thoracic and pelvic limbs presented shorter and thicker bristles between each other; however, thoracic limbs presented more bristles on the medial face in comparison to the pelvic limbs. Long bristles were found from tail base to the distal extremity; they reached 32 cm in length.

Regions evaluated in the epidermis presented differences in thickness (μm), regardless of sex; they can be observed in Table 1. The dorsal thorax, ventral cervical, ventral abdomen and medial carpal regions showed similar epidermis and stratum corneum measurements, whereas these layers were thicker in the metacarpal torus region, which was followed by the nasal

Table 1. Means and standard deviations in giant anteater's (*Myrmecophaga tridactyla)* skin dermis, epidermis and stratum corneum measurements - stratified by anatomic region.

Anatomic Region	Stratum	n	Measurement (μm)
Metacarpal torus center	Dermis	200	$4,505.80 \pm 864.20^{A,c}$
	Epidermis	200	$638.76 \pm 119.16^{B,a}$
	stratum corneum	200	$578.67 \pm 191.72^{C,a}$
Dorsal Thorax	Dermis	200	$5,158.51 \pm 743.64^{A,a}$
	Epidermis	200	$187.12 \pm 39.40^{B,c}$
	stratum corneum	200	$118.72 \pm 20.99^{C,c}$
Ventral Cervical	Dermis	200	$4,808.44 \pm 596.78^{A,b}$
	Epidermis	200	$153.32 \pm 20.27^{B,c}$
	stratum corneum	200	$11.15 \pm 20.99^{B,c}$
Ventral abdomen	Dermis	200	$3,072.77 \pm 306.76^{A,d}$
	Epidermis	200	$168.44 \pm 21.86^{B,c}$
	stratum corneum	200	$118.56 \pm 18.80^{B,c}$
Carpal Medial	Dermis	200	$2,898.67 \pm 517.00^{A,e}$
	Epidermis	200	$142.93 \pm 32.60^{B,c}$
	stratum corneum	200	$97.13 \pm 25.65^{B,c}$
Caudal Nasal (glabrous skin)	Dermis	200	$1,636.04 \pm 213.59^{A,f}$
	Epidermis	200	$451.84 \pm 64.82^{B,b}$
	stratum corneum	200	$247.03 \pm 47.65^{C,b}$

Different uppercase letters point out difference ($p<0.05$) between strata to set the anatomic region through Tukey Test. Different lowercase letters point out difference ($p<0.05$) between anatomic regions to set the stratum through Tukey Test. The 'n' corresponds to the total of measurements taken for each parameter.

region. Dermis measurements were not similar in any of the assessed regions; the dorsal region presented the thickest dermis and the nasal region accounted for the thinnest dermis. Mean skin total thickness values were recorded for male specimens in most of the assessed regions, except for the medial region of the carpus, which did not present difference between males and females (Table 2). Male and female's stratum corneum did not present differences in measurements; however, males recorded high dermis and epidermis values (Table 3). Therefore, it is possible stating that males' skin is thicker than females', regardless of the region (Table 4).

There was only one layer of Cuboid-shaped cells with intensely basophilic nuclei in the stratum basale in all assessed regions. There were some isolated cells with bright eosinophilic cytoplasm and fragmented nucleus, typical of apoptotic cells, in the stratum basale of the metacarpal torus. Rare melanocytes, many of them going towards the spinous stratum, were observed in all assessed regions. Metacarpal tours and nasal regions presented reticulated epidermis; however, the metacarpal torus region showed the most significant patterns for this feature (Figure 2).

All assessed regions showed stratum spinosum . Cells in this layer presented paved shape; they communicated to each other through inter-cell bridges, and it provided prickly aspect typical of this stratum. There was also variation in the number of layers in different assessed regions; the ventral region of the abdomen presented from one to two cell layers, the cervical ventral region was thicker and showed from two to three cell layers; the dorsal region of the thorax, in its turn, was discrete, and only had one cell layer. The nasal and central regions of the metacarpal torus presented great variation in the quality of cell layers; there were from one to ten cell layers in the nasal region and from three to ten layers in the central region of the metacarpal torus. There were cell layers in the medial region of the carpus. It was possible observing the presence of dendritic cells (formerly known as Langerhans cells) INTERNATIONAL COMMITTEE ON VETERINARY HISTOLOGICAL NOMENCLATURE, 2017) and of rare melanocytes in all assessed regions; however, the amount of melanocytes was more evident in the nasal region than in the other assessed regions.

There was stratum granulosum in all assessed regions; cells in this layer presented rhomboid shape with keratohyaline granules. There was also variation in layers in different assessed regions; the ventral regions of the abdomen, and the thoracic, ventral cervical and nasal regions presented from one to two cell layers. The medial region of the carpus showed stratum granulosum with two to three cell layers, and the central region of metacarpal torus presented well-developed stratum granulosum – it showed eight cell layers.

Stratum lucidum was observed in all assessed regions; cells in this layer presented paved and anucleated shape. Besides lack of granule core, there was a thin layer of eosinophilic cells between the granulosum and the stratum corneum. This layer was more evident in the central region of the metacarpal torus than in the other assessed regions. This stratum was visible

Table 2. Means and standard deviations measured in the anatomic regions of giant anteater's (*Myrmecophaga tridactyla)* skin, based on stratification through animal sex.

Sex	Anatomic Region	n	Measurement (μm)
Male	Torus	300	$2,099.27 \pm 2,095.69^{A,a}$
	Dorsal	300	$1,974.43 \pm 2,599.92^{B,a}$
	Cervical	300	$1,820.88 \pm 2,397.44^{C,a}$
	Ventral	300	$1,185.91 \pm 1,477.40^{D,a}$
	Carpal	300	$1,144.76 \pm 1,479.26^{D,a}$
	Nasal	300	$828.25 \pm 656.62^{E,a}$
Female	Torus	300	$1,746.21 \pm 1,665.75^{A,b}$
	Dorsal	300	$1,668.46 \pm 2,176.59^{B,b}$
	Cervical	300	$1,561.06 \pm 2,051.26^{C,b}$
	Ventral	300	$1,053.93 \pm 1,303.42^{D,b}$
	Carpal	300	$947.74 \pm 1,189.56^{E,a}$
	Nasal	300	$728.35 \pm 592.22^{F,b}$

Different uppercase letters point out difference (P<0.05) between the anatomic regions to a given sex through Tukey Test. Different lowercase letters point out difference (P<0.05) between sexes to set the stratum through Students t test. The 'n' corresponds to the total of measurements taken for each parameter.

Table 3. Means and standard deviations recorded for dermis, epidermis and stratum corneum of giant anteater's (*Myrmecophaga tridactyla)* skin, which were stratified based on animals' sex.

Sex	Stratum	n	Measurement (μm)
Male	Dermis	600	$3,983.18 \pm 1,489.21^{A,a}$
	Epidermis	600	$317.64 \pm 229.58^{B,a}$
	stratum corneum	600	$225.93 \pm 205.25^{C,a}$
Female	Dermis	600	$3,376.90 \pm 1,178.18^{A,b}$
	Epidermis	600	$278.16 \pm 189.93^{B,b}$
	stratum corneum	600	$197.81 \pm 172.15^{C,a}$

Different uppercase letters point out difference (P<0.05) between strata to a given sex through Tukey Test. Different lowercase letters point out difference (p>0.05) between sexes to set the stratum based on Student T test. The 'n' corresponds to the total of measurements taken for each parameter.

Table 4. Means and standard deviations recorded for measurements taken for giant anteater's (*Myrmecophaga tridactyla)* skin separated by sex; the measurement was set by the sum of dermis and epidermis measurements, regardless of the anatomic region.

Sex	n	Measurement (μm)
Male	1800	$4,300.82 \pm 1,718.79^{a}$
Female	1800	$3,655.06 \pm 1,368.11^{b}$

Different lowercase letters point out difference (p<0.05) through Student t test. The 'n' corresponded to the total of measurements taken for each parameter.

either in the slides stained in HE, as shown in Figure 2, or in slides stained in Alcian blue, as shown in Figure 3.

The stratum corneum was observed in all assessed regions; keratinized cells (corneocytes) in this layer were anucleated. All regions have shown some degree of cell peeling, but the cervical ventral and ventral regions of the abdomen presented higher degree of peeling. This stratum changed among different assessed regions; it was significantly thicker and keratinized in the central region of the metacarpal torus.

The basal membrane was visualized in all assessed regions; however, it was more evident in the central region of the metacarpal torus. This layer was between the basal layer of the epidermis and the surface dermis; it was only observed in slides stained in PAS. Figure 4 shows the basal membrane of the cervical ventral region.

Surface dermis in the six assessed regions was thin, there were papillary projections in the nasal region and in the metacarpal torus; however, they were more significant in the metacarpal torus. This skin layer also showed blood vessels and scarce mast cells, lymphocytes and plasma cells (inflammatory infiltrate), in addition to rare eosinophils. The metacarpal torus region also presented loose surface, highly vascularized dermis, with thin, amorphous collagen.

The deep dermal layer presented differences between regions. The deep dermis was thick in the ventral region of the abdomen in comparison to that in the surface dermis and lesser vascularized than the others. There was a large amount of thick collagen fibers, organized in fascicles, similar to muscle fibers. There were deep hair follicles close to the adipose tissue, with erector pili muscle, in addition to a large number of sweat glands; however, it was not possible differentiating apocrine from eccrine. Sebaceous glands were observed in the assessed areas, except for the metacarpal torus and the nasal regions, as shown in Figure 5.

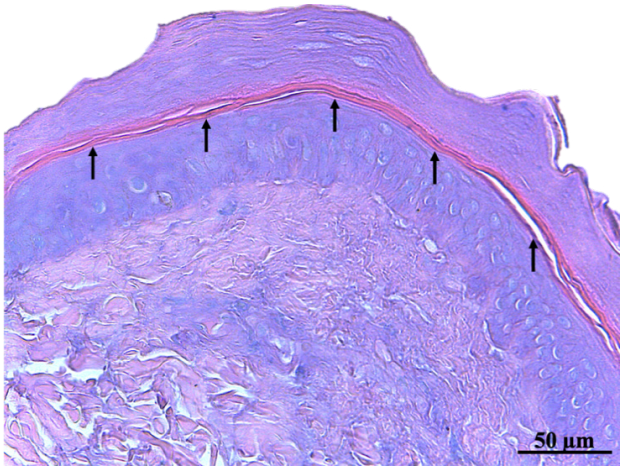

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Figure 3. Skin from the ventral region of giant anteater's (*Myrmecophaga tridactyla)* abdomen stained in Alcian blue. Arrows pinpoint the stratum lucidum, which is the layer between the granulosum and the stratum corneum.

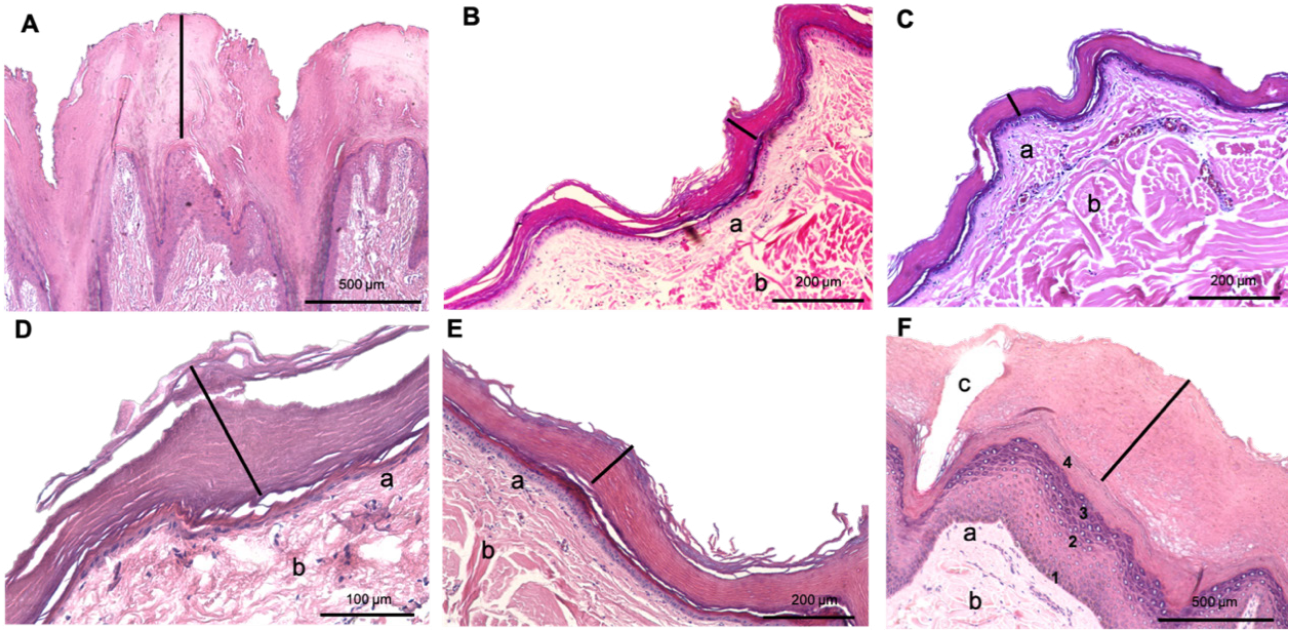

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Figure 2. Photomicrographs of giant anteater's (*Myrmecophaga tridactyla)* skin stained in HE; the following regions were observed: (A) metacarpal torus; (B) dorsal thorax; (C) ventral cervical; (D) ventral abdomen; (E) medial carpal; (F) nasal. In the caudal nasal region (F) one could observe the epidermis strata identified by numbers: (1) stratum basale; (2) spinous stratum; (3) stratum granulosum and (4) stratum lucidum and the stratum corneum observed in the black bars. The collection of material involving both glabrous and hirsute skin in the nasal region (F) allowed observing hair follicle in it (c). Lowercase letters (a) and (b) identify the superficial and deep dermis, respectively. The deep dermis was thick in comparison to the superficial dermis. A large amount of thick collagen fibers was observed in the deep dermis, they were organized in fascicles, similar to muscle fibers; however, differences were observed in the organization of these fibers in different regions. The metacarpal (A) and nasal (F) torus regions showed reticulated dermis; however, it was more evident in (A).

The dorsal region of the thorax presented patterns similar to those in the ventral region of the abdomen. There was a large amount of thick collagen fibers organized in fascicles, similar to muscle fibers, but they were less organized; a nervous vascular plexus was also observed, as shown in Figure 6.

The cervical ventral region presented pattern similar to that of the ventral region of the abdomen; however, collagen fibers, which were organized into fascicles, were thicker. Hair follicles were abundant in this region; however, hair was less thick and deep, it went all the way to the middle third of the dermis.

The caudal nasal region presented pattern similar to that in the ventral region of the abdomen, but collagen fibers were organized into fascicles, which were more numerous and thin; there was no adipose panicle, as shown in Figure 2F.

The medial region of the carpus presented a large amount of glandular epithelium (gl. sudoriferous), which were distributed in the form of agglomerates close to the adipose panicle. It was also possible observing erector pili muscle and blood vessels interspersing the glandular tissue.

The central region of the metacarpal torus showed deep dermis organized into thick and intertwined fascicles and a large number of eccrine sweat glands (Figure 7).

DISCUSSION

All assessed animals showed primary hair organization; this feature was different from what was described for *Cuniculus paca* (ISOLA et al., 2013) and similar to what was described for bovines and equines (SOUZA et al., 2009). Hair direction in giant anteater followed patterns described either for domestic or wild animals, thus, it is possible admitting its craniocaudal and dorsoventral direction. Such a distribution makes these animals' moves easier, as well as water leak (MCNAB, 1984; AFFOLTER; MOORE, 1994; LUCAS, 2020). It was also observed that ant-bear's hair was thick and long in specific regions, such as in withers and tail regions.

Overall, ant-bears' skin was structured into two layers, epidermis and dermis, as described for mammals, in the literature (BANKS, 1992; HIB, 2003; KIERSZENBAUM, 2016; JUNQUEIRA & CARNEIRO, 2017). In histological terms, the epidermis in all giant anteater' assessed regions presented the following layers: basal, spinous, granular, lucidum and corneal, and it evidenced keratinized stratified squamous epithelial tissue. This structure is consistent with the existing records for mammals, in general (BANKS, 1992; HIB, 2003; KIERSZENBAUM, 2016; JUNQUEIRA & CARNEIRO, 2017).

Mean skin thickness in the dorsal region of male ant-bears was 5.46mm. This mean is considerably thick based on these animals' body proportions; it is thicker than that recorded

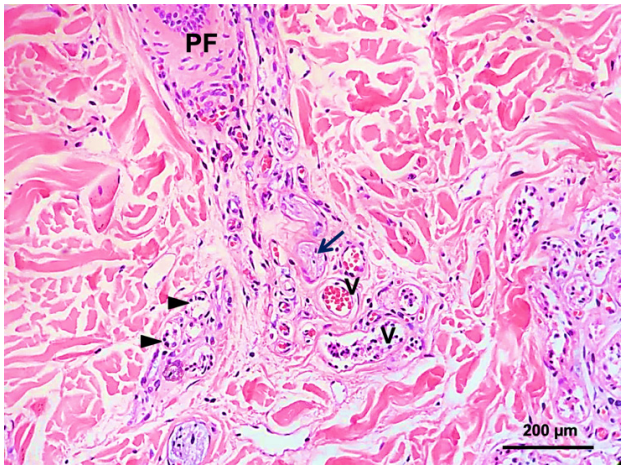

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Figure 5. Skin from the ventral region of giant anteater's (Myrmecophaga tridactyla) abdomen stained in HE. Hair follicle bulb (PF) and some adenomeres of sweat (arrowheads) and sebaceous glands (arrow), in addition to blood vessels (V).

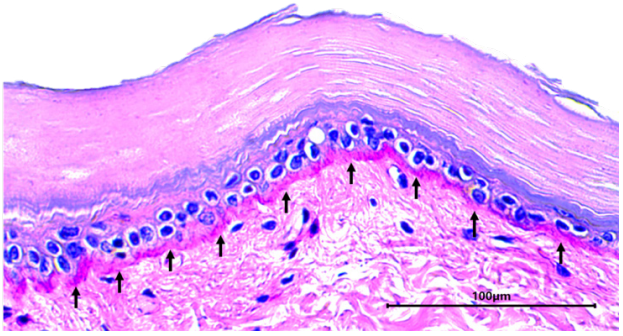

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Figure 4. Skin from the cervical ventral region of giant anteater's (*Myrmecophaga tridactyla)* body stained in periodic acid Schiff (PAS). Arrows pinpoint the basal membrane, which is the layer between the surface layer and the stratum basale of the epidermis.

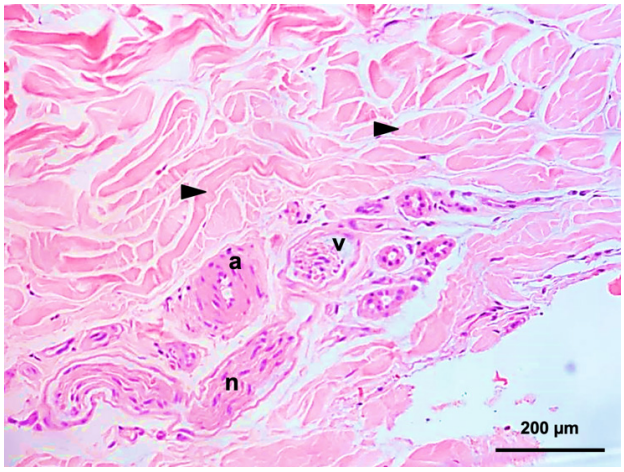

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Figure 6. Skin from the dorsal region of the thorax of giant anteater's (*Myrmecophaga tridactyla*) body stained in HE. Collagen fibers organized into fascicles (arrowheads) and nervous vascular plexus, vein (v), artery (a) and nerve (v) components.

for equines (from 1 to 5 mm) (ANDRIÃO et al., 2009) and lesser thick than that of bovines (from 3 to 7 mm) (DYCE; WENSING; SACK, 2014). The higher thickness measurements taken for these animals' skin, in addition to thick fur, have played relevant role in this species' survival given the lack of an elaborated defense mechanism against predators and their slow locomotion, as well as in likely defense mechanisms against insects' aggressions during these animals' search for food.

Despite differences observed between the assessed layers, all layers were well-marked in all assessed regions, and it was different from records by RAZVI et al. (2015), who did not observe the stratum lucidum in goats. This extract in domestic carnivores was only observed in the thickest regions of the skin, such as nasal pads and plane (BANKS, 1992; AFFOLTER & MOORE, 1994). Yet, there are authors who only see the stratum lucidum as a refractive artifact of young corneal cells (REESE et al., 2021). At first, this feature could be attributed to the thicker skin observed in this species; however, this layer was also observed in thin skin regions, such as the nasal region. Therefore, it is a particular feature of giant anteaters.

The spinous and granular layers were observed in all assessed regions, and this finding corroborates some classical histology treats (BANKS, 1992; HIB, 2003; JUNQUEIRA; CARNEIRO, 2017). However, they were different from those observed in 'lowland pacas', who present less distinguishable prickly and granular layers (ISOLA et al., 2013).

The epidermis in all assessed regions presented Langerhans cells, keratinocytes and rare melanocytes that, in most cases, were in the stratum basale. There was large amount of melanocytes in the nasal plane, likely because this is a glabrous skin region that is more exposed to sunlight – one of the functions of this cell is to protect the skin from ultraviolet light (CASTELLANOS, RODRÍGUEZ, IREGUI, 2005; SOUZA et al., 2009; JUNQUEIRA & CARNEIRO, 2017).

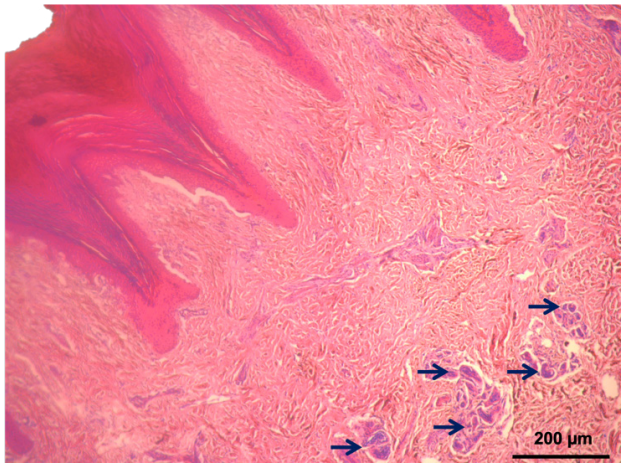

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Figure 7 . Skin from the central region of the metacarpal torus of giant anteater's (Myrmecophaga tridactyla) body stained in HE. Eccrine sweat glands (arrows).

Most Langerhans cells were observed in the spiny layer, as described in the literature (HIB, 2003; ISOLA et al., 2013; JUNQUEIRA & CARNEIRO, 2017; REESE et al., 2021). Glabrous skin, nasal and metacarpal torus regions presented thicker epidermis and stratum corneum; however, the metacarpal torus was the most developed region, as expected (YABUKI et al. 2007; ISOLA et al., 2013).

There was no basal membrane in any of the samples stained in HE. However, this zone could be easily observed in cuts stained in PAS, mainly in pass' regions; this finding corroborated that by AFFOLTER; MOORE (1994). However, lowland pacas (ISOLA et al., 2013) showed this layer in the neck, thorax and medial carpal regions, even in slides stained in hematoxylin-eosin; it was less evident in the pads' region – this finding is hypothetically justified by irregularities observed in the dermis-epidermis junction, in this region.

When it comes to giant anteater' skin dermis, it was possible observing that the analyzed regions presented surface and deep dermis, just as described for mammals, in general (BANKS, 1992; HIB, 2003; JUNQUEIRA; CARNEIRO, 2017).

Surface dermis was thin in all assessed areas; it showed papillary projections in the metacarpal torus and nasal regions, mostly in the metacarpal region. These findings met descriptions by other authors (SOUZA et al., 2009) who have described lack of dermal papillae on the furry skin of dogs and cats. Other authors have also described a larger amount of dermal papillae in the metacarpal torus region (LAVKER et al., 1991; YABUKI et al. 2007; ISOLA et al., 2013). The central region of the metacarpal torus presented loose and remarkably vascularized surface dermis. The largest amount of vessels in comparison to the other assessed regions is likely justified by the large amount of arteriovenous anastomoses observed in this region, since it allows blood deviation to the tips of the limbs that get in touch with the ground – this is an important thermoregulation mechanism (NINOMIYA et al., 2011).

The deep dermis presented similarities between the assessed areas; furry skin regions showed deeply arranged hair follicles close to the hypodermis. However, some regions, such as the cervical ventral region, evidenced less thick and deep hair, with hair follicles reaching the middle third of the dermis. Variations in the number and size of hair follicles, depending on the body region, were also described in domestic carnivores (SOUZA et al., 2009). There were deep dermis erector pili muscle, sebaceous glands, and a varying amount of eccrine and apocrine sweat glands. Overall, the amount of sweat glands was large if one takes into account that ant-bears are low metabolic rate and low body temperature animals who move quite slowly (CAMILO-ALVES; MOURÃO, 2006) – this features may require less sweating for thermoregulation.

Lowland pacas' pads showed eccrine sweat glands interspersed with adipose tissue clumps in the hypodermis (ISOLA et al., 2013). These same glands were observed in giant anteaters, but they were located deeper in the dermis, in this region. There were

also sweat glands in the skin of palm pads and of the nasal region in giant anteaters; this finding corroborates those by other authors (AFFOLTER; MOORE, 1994; SCOTT; MILLER; GRIFFIN, 2012) who have stated that sweat glands in domestic carnivores are observed in all skin surface, except for nasal pads and plan.

Sweat glands in mammals can be numerous and bigger in different regions of the body, depending on the species; they are odoriferous organs (BANKS, 1992; DYCE; WENSING; SACK, 2014; REESE et al., 2021). Giant anteaters showed sweat glands in cervical ventral regions, in the ventral region of the abdomen, in the dorsal region of the thorax and in the medial carpal region; however, none of these regions presented bigger or more numerous sebaceous glands in comparison to the other ones. Thus, it is possible stating that the assessed regions in giant anteaters do not have histological or macroscopic features similar to odoriferous organs. Apocrine sweat glands play important role in thermoregulation in domestic mammals, except for dogs and cats, whereas eccrine sweat glands would not primarily contribute to this role (REESE et al., 2021). Secretion in these glands could help protecting pads by keeping the necessary moisture in the stratum corneum (HAFFNER, 1998). Eccrine glands in primates account for the necessary moisture on pads' surface, since they stop animals from slipping (HASHIMOTO; HORI; ASO; 1986). Although this gland type is found in ant-bears' pads, this function seems to be little important, since this species does not present arboreal habits. Other functions could be attributed to these glands, such as to release odoriferous substances (STUMPF; WELSCH, 2002).

Hypodermis was observed in five of the six assessed regions, but it was not seen in the nasal region. These findings are different from those recorded by other authors who have assessed the integument in pigs and who described a thin hypodermis layer in the nasal plan (SUMENA et al., 2010).

Skin thickness increased towards the ventral-dorsal region of the thorax and in the distal-proximal direction of the limbs; therefore, differences in thickness between the assessed regions followed patterns described in the literature, except for the assessed metacarpal torus (SOUZA et al., 2009; FORNI; TROMBETTA-LIMA; SOGAVAR, 2012).

The nasal plan and metacarpal torus regions presented quite thick epidermis similar to that found in domestic mammals, except for equines, who did not present modified skin in this region (BANKS, 1992). With respect to epidermis thickness, it was possible observing that glabrous skin regions showed thicker epidermis than furry skin regions. Besides, it was possible observing that stratum corneum thickness has contributed to such a difference. Similar differences were found by other authors (AFFOLTER; MOORE, 1994; YABUKI et al., 2007) who have assessed the integument of domestic carnivores.

Several factors can determine skin thickness differences in individuals belonging to the same species. Some authors (SOUZA et al., 2009) have stated that variations in it can take place due to age; the exclusive collection of adult animals was herein adopted to mitigate such a factor. However, factors such as sex can also influence differences in skin measurements between individuals belonging to the same species. Two of the six assessed regions in males, the nasal and central metacarpal torus, presented thicker epidermis, stratum corneum and dermis. These findings are close to those found by other authors (ADRIÃO et al., 2009; ISOLA et al., 2013) who have assessed skin thickness in equines and lowland pacas, respectively; they observed that total thickness and differences in skin layers in most regions were more significant in males.

CONCLUSIONS

The herein recorded results allowed concluding that giant anteaters' architecture and hair color present species-specific anatomic features, just as observed for different animal species. In histological terms, their integument is similar to that of mammals, in general, except for its thickness, which is proportionally higher in the skin. Furthermore, all epidermis strata were well-marked in the assessed regions – this is a particular feature of this species. Giant anteaters have a large amount of sweat glands distributed throughout their bodies, and it contrasts their body temperature and peculiar metabolism. The morphometric analysis applied to different skin regions in giant anteaters allowed observing integument thickness differences between males and females, as well as differences between skin regions, in the same animal. Means recorded for epidermis and dermis in all assessed regions were higher for males.

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