COMPARATIVE STUDY OF THE HAIR OF THREE NEOTROPICAL MAMMAL SPECIES USING A SCANNING ELECTRON MICROSCOPE FOR MORPHOLOGICAL DETAIL AND ELEMENT COMPOSITION

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ABSTRACT

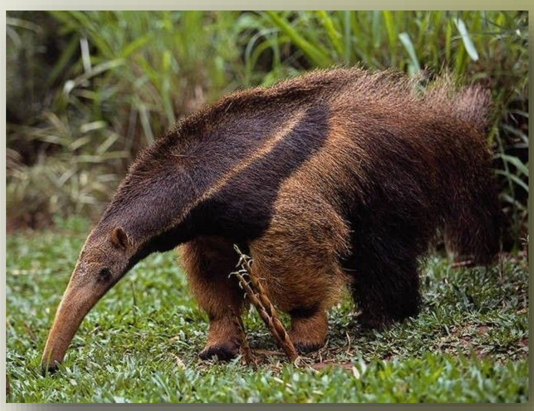
Dorsal hairs have been used in taxonomical and forensic studies to identify different animals. These differences in hair structure are closely related to their function and their respective animal´s habitat. The morphology and element composition of hairs of three mammals, the two-toed sloth, capybara and giant anteater, are compared macro- and microscopically. The hair shafts show substantial ultrastructural differences in cuticular pattern and presence of grooves, and quantity of earth accreted to them. The significance of these differences to separate ecological niches is discussed. A new generation scanning electron microscope (SEM) (ZEISS EVO 15©) is demonstrated easy to use in discriminating ultramicroscopic differences in hair structure. Furthermore, the microscope analysed by energy dispersive spectroscopy (EDS), the element composition of hairs and earth accretions, and the significance of the results is discussed.

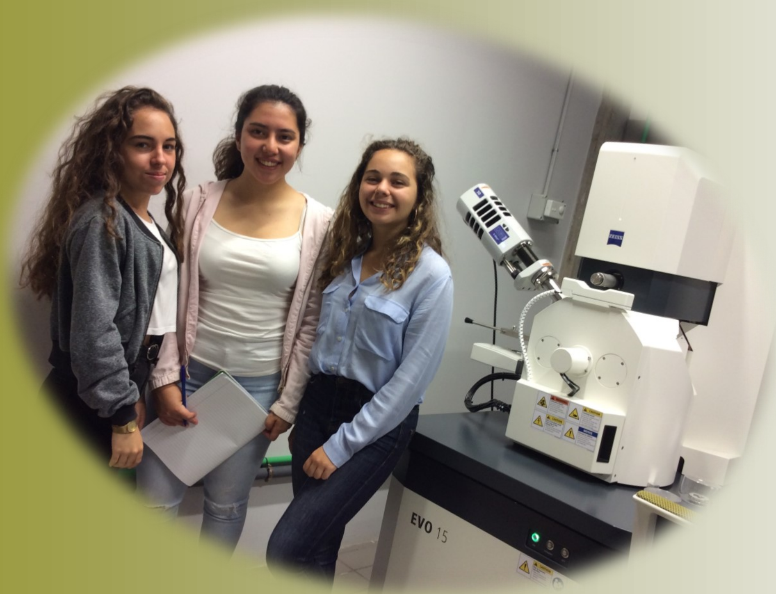
INTRODUCTION

Mammals of the world share some common external characteristics such as the presence of mammary glands (hence their name mammals) and fur composed by different types of hair covering their bodies. These hairs are the primary contact barrier with their environment and have a great importance in their thermoregulation. Furthermore, the external morphology of these hairs, types of scales that form the external shaft and their chemical composition, are examples of the evolutionary responses of the animals to their environments.







MATERIALS AND METHOD

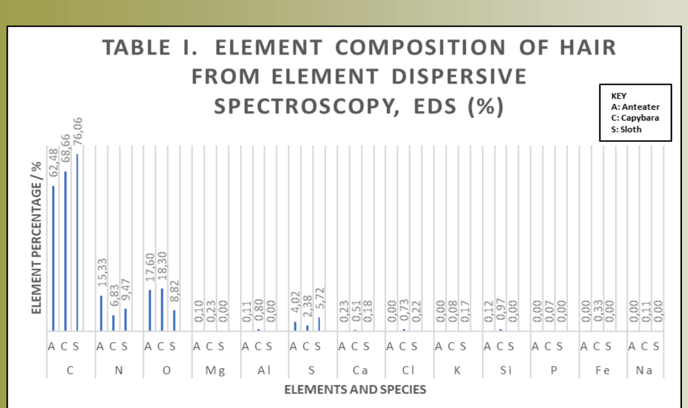
◊ The hair samples were from animals in Loro Parque, a zoological park in Tenerife, Spain. Hairs from the dorsal area between the scapulae of the three species were cut approximately 2 cm distal from the epidermis. All animals were used to handling by their keepers and all humane safeguards were observed. The samples were stored in sealed containers without sterilisation so that chemical composition was unaltered until further processing. Light microscope (LM) slides were prepared by clipping a small section of the hair and adding two drops of distilled water onto the slide before placing the cover slip for direct visualisation of the gross appearance of the hair shafts. A HARRIS PHILLIP © microscope was used with a BMS eyepiece & C-mount camera ©.

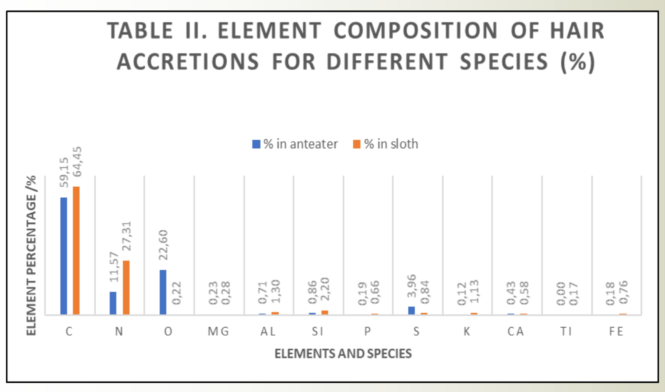
◊ SEM samples were cut and placed on an aluminium stub of 3 cm diameter by means of double-sided adhesive carbon tape. The hairs were handled with gloves and tweezers to avoid contamination. The samples were sputtercoated with silver atoms to a depth of 15nm (Quorum Q150R ES Plus©).

◊ They were then examined using a ZEISS EVO 15© SEM with an acceleration voltage of 20 kV. High resolution photomicrographs were taken for morphological examination. External characteristics of the shaft of the dorsal guard hair were observed, such as the cuticular scale patterns, presence of grooves, shape and width. The elemental composition for each hair was obtained by EDS using the Oxford XMaxN© detector incorporated in the SEM. Graphs were compiled from the data for later interpretation.

RESULTS AND DISCUSSION

- We found fundamental differences in the type of scale, presence of furrows and hair size, as well as in the chemical composition of the hairs. In Figure 1, the sloth´s hair shows an agglomeration of 8 to 10 fibres (23 nm average) in a cylindrical shape that tend to fuse towards the tip of the hair. The scales are cuticular in shape and accumulated soil can be seen in the grooves.
- The hair of the capybara, as seen in Figure 2, presented a different structure, with the presence of two adjacent fibres joined by a groove without the presence of accumulation of soil, and with a diameter of 423 nm. The type of scale is a flattened mosaic with irregular edges and the presence of electrically charged particles in the soil accumulated within the scales is striking, visible as white encrustations.
- In Figure 3, the hair of the giant anteater is seen presenting two fibres with a wider and shallow groove, with accumulation of soil and a diameter of 221 nm. The scales are flattened with irregular edges. The cross-section appearance of the hair is that of a dumb-bell.
- In Table I we can observe the EDS analysis of the composition of the elements showed a difference between the percentages found in the hair and in the soil of the different animals. The most abundant elements in the hair of the three species were carbon (76.06% in the sloth), followed by nitrogen (15.33% in the anteater), oxygen (18.30% in the capybara) and sulphur (5.72% in the sloth). In TABLE II, we can observe that the most abundant elements in the soil impregnated in the sloth and anteater hair grooves were carbon (64.45% in the sloth), nitrogen (27.31% in the sloth), oxygen (22.60% in the anteater) and sulphur (3.96% in the anteater). Other elements such as magnesium, calcium, potassium, silica, iron and titanium were found as traces.





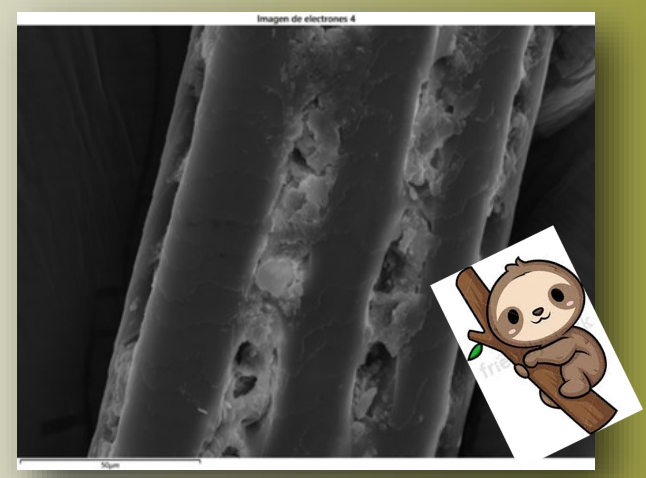


Fig. 1. Sloth hair central

Fig 2. Capybara hair

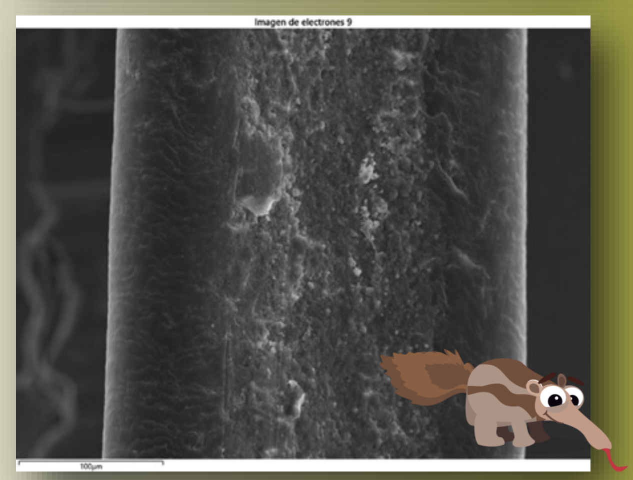


Fig. 3. Giant Anteater

WHAT COULD THE OBSERVED DIFFERENCES MEAN?

⇒ The presence in the sloth of the furrows that merge towards the tip of the hair, together with the accumulation of soil, seem to have effects on the absorption and condensation of water vapour from the environment, increasing the possibility of regulating the effects of temperature and humidity around the animal's skin. Given that this species has a very slow metabolism compared to other mammals, the effects asume greater importance. Furthermore, sloths can camouflage themselves using green algae that grow on the soil accumulated in the grooves. Other scientists mention the prevalence of sulphur, potassium, calcium and magnesium in samples taken, which is consistent with the results of our research.

⇒ The semi-aquatic capybara, having different ecological strategies from the sloth, shows differences in the configuration of the scales, more typical of mammals with stiff, bristle-like hair. The large size of the hairs of the capybara seems to be related to their low density which, together with the ability of the scales to accumulate soil (with inorganic elements such as iron, silicates, sodium and aluminum, corroborated in our study), helps protect this animal from the strong rays of the sun on the tropical plains.

⇒ The giant anteater has dorsal hairs with a medium span between the sloth and the capybara, probably due to their high density on the animal. The shape of the hair shows characteristics of bristle-like hair, more similar to the capybara. The presence of soil in the groove between the two fibres in lesser quantity than that found in the sloth may mean less thermoregulatory importance for the animal, being mainly terrestrial and more active in nature. However, the presence of elements found such as silica, aluminum and calcium can have defensive effects against ants and termites, essential items in the giant anteater's diet.

⇒ To conclude, there are substantial differences in morphology and some differences in element composition of the shaft of the cover hairs between the two-toed sloth, capybara and giant anteater. Thus, it is inferred that different hair morphology and extent of earth accretions are adaptations to different environments. The close proximity in a controlled environment of the study animals precludes any clear conclusion about differences in element composition of the hairs and earth accretions between the three study species. However, the potentially high value of this technique for making comparative studies in the wild is demonstrated.

ACKNOWLEDGEMENTS

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