

Morphology of hair of two- and three-toed sloths (Edentata: Bradypodidae)

Daniel E. Wujek and Joan M. Cocuzza

Department of Biology, Central Michigan University, Mt. Pleasant, Michigan 48859, U.S.A.

(Received: November 6, 1985)

Abstract: Micromorphological differences between hairs of the two-toed sloth (*Choloepus hoffmanni*) and of the three-toed sloth (*Bradypus variegatus*) were observed by means of scanning electron microscopy. Hairs of the two-toed sloth had longitudinal grooves which exposed a uniform cortex when viewed in cross section. Hairs of the three-toed sloth have irregular transverse fissures and a cortex that contains scattered fusi. These morphological differences support the placement of the two sloth genera into separate families. Hairs of four other xenarthran species are also illustrated.

Micromorphological structures in the hairs offer definite and unchanging characteristics which are useful for the purposes of identification and illustration of diagnostic characteristics of hairs and the preparation of keys that may be used successfully by other than specialists. Aside from its potential use in taxonomic studies to ascertain mammalian relationships, knowledge of hair structure has direct value in the fur industry, crime solution, and economic vertebrate zoology. While the first three are readily apparent, the latter may require some explanation. To ascertain food habits of carnivorous animals, e.g., hawks, owls, eagles, mountain lions, coyotes, it is necessary to analyze the contents of stomachs, droppings, or pellets. Keratin is not fully digested and frequently provides the only available clues to help identify the meal. Knowledge of hair structure thus facilitates identification of ingested materials and offers a basis for more accurate and complete studies of predation and its effect on prey species.

Additionally, systematic/evolutionary implications of the differences between hairs of *Bradypus* and *Choloepus* may shed light on family placement for these two genera. The present paper attempts to address the family placement and describes hair structure for two- and three-toed sloths using scanning electron microscopy and to complement obser-

vations made by Aiello (1986) on hairs belonging to other Edentata (= Xenarthra). This study is designed also to provide a broad framework of comparative data within which more inclusive studies of individual groups, such as the armadillos and anteaters can be evaluated.

MATERIAL AND METHODS

Hairs of three two-toed (*Choloepus hoffmanni* Peters) and seven three-toed (*Bradypus variegatus* Schinz) sloths were collected on the mainland and Barro Colorado Island, Panama, and in northeast Costa Rica, near the town of Puerto Viejo de Sarapiquí, in January and February, 1984. The hairs were clipped from the animal's nape and either fixed in 2% phosphate buffered glutaraldehyde (pH 7.2) or air-dried and placed into vials for transportation back to the laboratory.

Hairs were prepared in a variety of ways for scanning electron microscopy (SEM). One lot each of fixed and unfixed hairs was air-dried and mounted on aluminum stubs by means of copper adhesive tape. A third lot was post-fixed in 1% buffered osmium tetroxide for 1 hr and dehydrated through an ethanol series. From this lot, one subsample was air-dried and mounted as described above. A second was critical-point dried (CPD) in a Bomar SPC-50; a portion of this subsample was freeze fractured

using liquid nitrogen prior to CPD. Hairs were mounted as the air-dried material. All stubs were coated with 20-30 nm of gold with a Hummer I sputter coater and stored in a desiccator prior to examination with an AMR 1200 SEM.

Additional hairs from related taxa were obtained from specimens at the University of Michigan Museum of Zoology [*Bradypus tridactylus* (UMMZ 46410), *Cyclopes didactylus* (UMMZ 1134751), *Myrmecophaga tridactyla* (UMMZ 103304), *Tamandua tetradactyla* (UMMZ 124688)]. These were prepared as the air-dried material described above.

RESULTS AND DISCUSSION

Observations of the air-dried fixed and unfixed hairs revealed excessive cracking and distortion. Therefore observations from the Panamanian and Costa Rican hairs are from the CPD hairs. Hairs from the museum specimens, while possessing large amounts of particulate material (dust?), did not require CPD.

Hairs of two-toed sloths have a maximum width of 0.16 mm. A series of longitudinal ridges and furrows, 3-9 in number (Fig. 1), run the length of each hair, attenuating near the tip. Imbricate cuticular scales are interrupted by grooves, an observation noted by Hausman (1924) using light microscopy. Freeze-fractured sections of *Choloepus* hair (Fig. 2) also show that the cuticle is not continuous around the shaft. The discontinuous cuticle surrounds a medulla and cortex. Freeze-fractured hairs of *B. variegatus* are not only more complex, but are larger in width (0.4 mm). Beneath the cuticular layer is a cortex with scattered fusi (Fig. 3). These fusi are not continuous chambers extending the entire length of shaft, but are only shallow "air pockets". Development of fusi in other mammalian hair has been described by Hausman (1920). Hollow hairs are present in only a few mammals, including mountain goats, reindeer, gaint pandas, and polar bears, presumably as an aid in heat insulation (Brunner and Coman, 1974).

Even when the cortex and cuticle separate in *Bradypus*, the medulla remains intact giving continuity to the hair (Fig. 4). Here algal colonization, a normal feature of the pelage (Wujek and Timpano, 1987), also can be observed. Distinct coronal cuticular scales are evident on hairs lacking algal epiphytes and these hairs

best exhibit the transverse fissures (Fig. 5). Hair of both *Bradypus* species (Figs. 5, 6) closely resemble: those of anteaters which were first illustrated by Hausman (1924) from light microscopy, and recently illustrated by SEM (Aiello, 1986) and this paper (Figs. 7-9). Externally, no differences could be observed between hairs of *B. variegatus* and *B. tridactylus*. Internally, however, fusi were not observed in hairs of *B. tridactylus*, but these may have been destroyed over time due to specimen handling, and might be present in newly collected hairs. The systematics of living species of sloths, which date from the time of Linnaeus, have received uneven treatment from a number of investigators (see recent review by Wetzell and Avila-Pires, 1980). Our data supports Wetzell and Avila-Pires' placement of *Bradypus* in the Bradypodidae and *Choloepus* in the Choloepidae where it is more closely related to the Megalonychidae, the ground sloths. Two species of algae are frequently cited (Thompson, 1972) as occurring on sloth hair, *Trichophilus* and *Cyanoderma*. Wujek and Timpano (1987) have recently shown that *Cyanoderma* is synonymous with *Pleurocapsa* and created a new genus (*Rufusia*) for this red alga and transferred two other previously described taxa to two coccoid green genera. In addition to observing these taxa, we have observed for the first time on sloth hair the subaerophile, *Navicula contenta* fo. *biceps* Arnott (Fig. 10).

RESUMEN

Los pelos del perezoso de dos dedos, *Choloepus hoffmanni*, tienen estrías longitudinales y una corteza uniforme (vista en corte transversal). Los pelos del perezoso de tres dedos, *Bradypus variegatus*, tienen fisuras transversales irregulares y una corteza con "fusi" diseminados. Las diferencias macromorfológicas apoyan la separación de ambos géneros en familias diferentes.

ACKNOWLEDGMENTS

D.E.W. thanks Bonifacio de León for assistance in the field and G.G. Montgomery for making laboratory and field arrangements in Panamá. This study was supported by grants from the Smithsonian Tropical Research Institute and Central Michigan University's Research

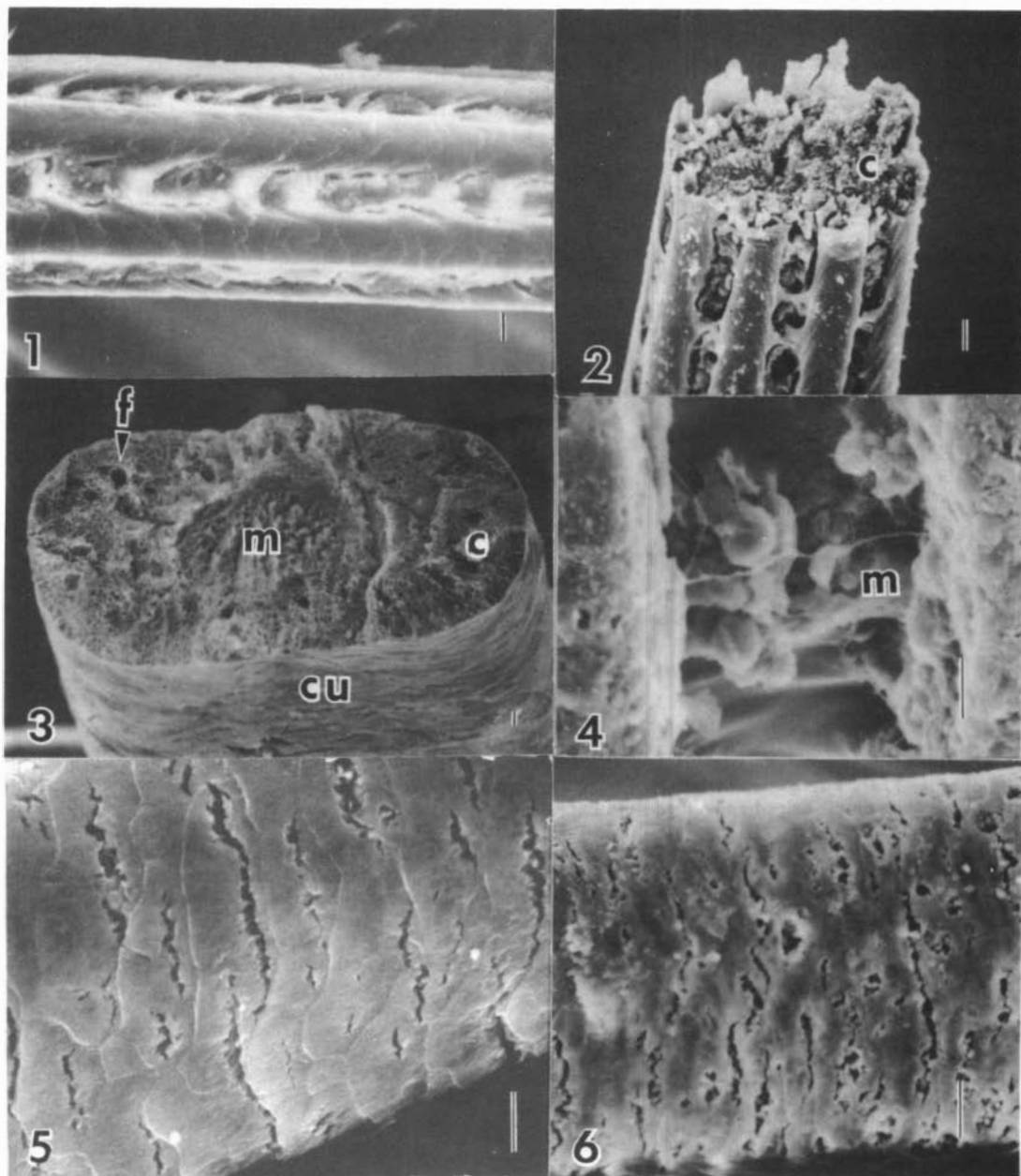
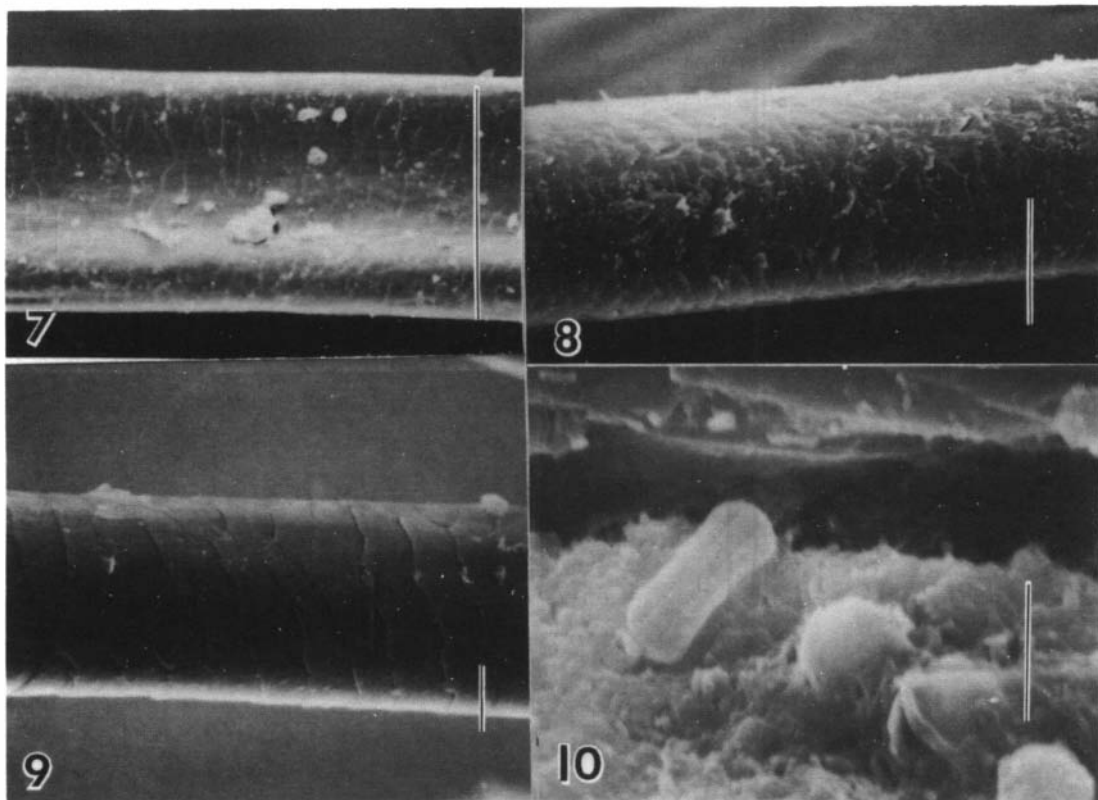


Fig. 1. *Choloepus hoffmanni* hair showing ridges and furrows. Fig. 2. Freeze-fracture section of *C. hoffmanni* hair. Fig. 3. Fusi (f) present in the cortex (C) of a freeze-fractured *Bradypus variegatus* hair. Fig. 4. Intact medulla (M) of a *B. variegatus* hair with associated unknown green coccoid algae. Fig. 5. Cuticular scales of a *B. variegatus* hair. Fig. 6. *B. tridactyla* hair. Key to labelling: C = cortex, Cu = cuticle, F = fusi, M = medulla. Bar = 10 μ m.

Professor Program and Research and Creative Endeavors Committee. Appreciation for the use of the Organization for Tropical Studies facilities at Finca La Selva, Costa Rica, is acknowledged. We also thank R. Lowe, E. Stoermer, and K. Camburn for assistance in identifying the diatom. Hairs from UMMZ were provided by P. Meyers and G. Schuett.

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Hairs of: Fig. 7. *Myrmecophaga tridactyla*. Fig. 8 *Tamandua tetradactyla*. Fig. 9. *Cyclopes didactylus*. Fig. 10. *Navicula contenta* on the hair of a two-toed sloth Bar = 10 μ m.

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