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Technical note

Morphological identification of animal hairs: Myths and misconceptions, possibilities and pitfalls

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ABSTRACT

The examination of hair collected from crime scenes is an important and highly informative discipline relevant to many forensic investigations. However, the forensic identification of animal (non-human) hairs requires different skill sets and competencies to those required for human hair comparisons. The aim of this is paper is not only to highlight the intrinsic differences between forensic human hair comparison and forensic animal hair identification, but also discuss the utility and reliability of the two in the context of possibilities and pitfalls. It also addresses and dispels some of the more popular myths and misconceptions surrounding the microscopical examination of animal hairs. Furthermore, future directions of this discipline are explored through the proposal of recommendations for minimum standards for the morphological identification of animal hairs and the significance of the newly developed guidelines by SWGWILD is discussed.

1. Introduction

The morphological identification of animal (non-human) hairs (MIAH) is based on fundamental aspects of microscopy, biology, and zoology. The purpose of MIAH is to categorize the animal source of an unknown hair sample to a particular taxon based on well-defined, genetically based features that are characteristic to that group. The breadth of knowledge required to identify mammalian hairs from all potential taxa is extensive but may be relatively simple in certain contexts, for example identification of mammal hairs as encountered in biological fieldwork, in museum curation, or in the textile industry. In contrast, the forensic examination of hair involves knowing not only the range of expression of mammalian hairs within taxa, but also being aware of other structures that may resemble hairs, such as man-made wig fibers and faux fur fibers, insect seta, and plant tendrils. The forensic context is thus wider and more complicated than a controlled mammalian orientation.

This complexity is compounded because forensic hair examiners typically are examiners of human hair. Unlike MIAH, the human hair practitioner is dealing with hairs from a single species, *Homo sapiens*, and answering a quite different series of questions which may include (but not limited to):

(1) Is it a human hair?
(2) From what area of the body did it originate?
(3) Is there damage, disease or treatment evident in the hair?
(4) Are the hairs suitable for forensic nuclear DNA profiling?
(5) Does the hair contain sufficient information for comparison to a putative human source or sources?
(6) Could the hair have originated from one of those sources?
(7) What is the broad ethic origin of the donor of the hairs? (i.e. Caucasian, Mongoloid or African).

Although questions 1–3 may also be relevant to anthropology, questions 4–7 are purely forensic in nature and address a concept specific to forensic methods, i.e. source attribution. In fact, categorization and source attribution represent the core and enduring questions asked of a forensic investigation: "What is this material?" "Where did it come from?" and "Does it confirm or

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reject associations between people, places, and things involved in criminal activities". The first part, categorization or identification, is common enough among sciences; what sets forensic science apart is its core intention of sourcing where the identified item came from (the victim, suspect, their environments or the scene).

The composition and origins of materials lend themselves to a greater or lesser specificity of sourcing. Hairs, because of their complex matrix and variable expressivity, are limited by their "intra sample variations (which) can be nearly as large as variations between certain samples from different sources. . .the results of a hair comparison (are) far less than certain" [1]. The process of human hair comparison is widely considered as fundamentally 'subjective' in the context that results and conclusions are not quantifiable but based on opinion. This practice is not unique to forensic analyses; it is also relevant in areas of the medical profession such as histology (e.g. identifying cancer cells) and anthropology/paleontology (e.g. identification of human/animal remains on the basis of bone or teeth morphology).

Typically, three conclusions can be drawn from a human hair comparison, given suitable samples:

(1) The questioned hair exhibits the same microscopical characteristics as the known sample and therefore could have come from the person from which the known was taken.
(2) The questioned hair exhibits different microscopical characteristics as the known sample and therefore could not have come from the person from which the known was taken.
(3) The questioned hair exhibits both similarities with, and differences to, the known sample and therefore no conclusion can be drawn as to the source of the questioned sample.

In some instances positive associations deduced from this comparative process have been afforded more probative value than is scientifically warranted resulting in individuals being wrongfully incarcerated [2]. As a consequence, criticism has been leveled at forensic human hair comparison, which may tarnish related or similar disciplines, especially MIAH. However, there is a fundamental difference between comparative examinations between human hairs to infer an association to a particular individual (sourcing) and MIAH, which is an exercise in taxonomy to identify an animal hair to a particular taxon and not to a particular animal. Therefore, criticisms leveled at the former are not relevant to the latter.

This paper is primarily aimed at raising awareness levels of what can go wrong for inexperienced, unwary or inadequately trained practitioners attempting to microscopically identify animal hair. The paper also discusses the future of MIAH in the context of accreditation of the discipline and its practitioners.

2. Morphological identification of animal hairs

All mammalian hair is composed of the protein keratin. Mammalian hairs are all similar in their chemical composition and major structural features but they do differ to a greater or lesser extent in morphology at varying taxonomic levels. Mammalian hair consists of three layers: an outermost cuticle, an inner cortex, and a central core or medulla as illustrated in Fig. 1. Mammalian hairs bear morphological features characteristic for a particular taxon that may be phylogenetic in origin or functionally derived, these are:

(1) the configuration of cells in the medullae of guard hairs,
(2) cuticle scale patterns,
(3) transverse cross-sectional shapes.

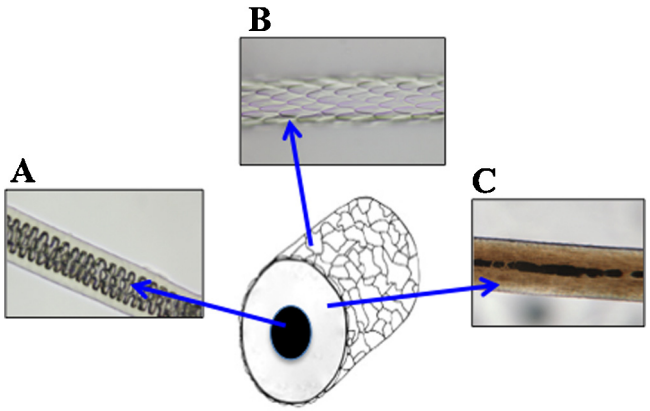

Fig. 1. Generic diagram of a mammalian hair shaft (centre) which consists of three major components the central core or medulla (A), cuticle (B) and cortex with pigment granules (C) (No scale bar, illustrative purposes only).

Additionally, mammals exhibit somatic variation in hair morphology that must be taken into consideration for taxonomic identification. Whilst the examination of animal hairs takes into consideration gross morphological features such as color (banded or uniform), length and general profile, these are not, in general, taxon specific. However, these features may assist in excluding animals from a particular taxon as sources of the hair in question if a number of taxa share similar microscopical morphological characteristics.

3. Myths and misconceptions

Several popular myths and misconceptions exist regarding MIAH that demonstrate 'a little knowledge is a dangerous thing' when exercised without any competence in MIAH.

*3.1. Myth: Cat (*Felis catus*) and dog (*Canis familiaris*) hairs can be reliably identified solely on root shapes*

Hairs from cats and dogs are undoubtedly the most commonly encountered animal hairs in forensic (crimes against the person) examinations. There are a number of forensic publications that state that the identification of these two species may be effected solely on the basis of their root shapes [3,4]. It is generally accepted in the scientific community that hairs from these two species can be distinguished, and identified, on the basis of the shape of their hair roots, i.e. dog hairs exhibit spade-shaped roots, and cat roots are fibrillated (Fig. 2). However, both of these root shapes can occur in both species [5] and other species. In order to effect an accurate identification, and one that withstands scientific scrutiny, the examiner must consider details of the medulla and scale pattern throughout the length of guard hairs in order to distinguish between each of these species—not solely the root shapes. Furthermore, the examiner must query the aggregate morphological characteristics in order to consider what other animals might exhibit similar features in all aspects, i.e. medulla pattern, cuticle pattern, and in some instances, cross-sectional shapes.

Some early work by Peabody et al. [6] indicated that medullary index (i.e. the ratio of the medulla diameter to the hair diameter) could be used as a basis for discriminating domestic cat (*Felis catus*) hairs from dog (*Canis familiaris*) hairs. Although this work was original and important, we believe that it is of limited forensic value. Identifications were effected by comparing data derived from reference hairs of unknown body origin with questioned hairs of unknown body origin. We believe a more scientifically valid approach would have been to produce different data sets derived from hairs from known body areas, for comparison with data