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Ancient hairs: need for morphological analysis of prehistoric and extant Mammals

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Abstract

Hair keratin can stand vagaries of nature and may be well preserved in fossilized hairs found in ice, amber, mummies, scats (or coprolites) of carnivores, bird pellets etc. Ancient hairs are also found in archeological investigations in form of artifacts made by animal hairs like paint brushes, apparel, cordages etc. Analysis of ancient hairs can be useful for study of cuticle patterns, medulla, pigments, isotope ratios etc. Mitochondrial DNA or hair keratin protein or amino acids can be extracted for studying phylogenetic relationship between extinct and extant members. This mini-review presents some examples of fossil hairs found and analyzed so far and points towards the importance of study of ancient hairs. Study of hair morphology and or molecular analysis can help in identification of mammals that lived at the time when the artifacts from hairs were made and used by the prehistoric man. Comparisons of fossil hairs with the present populations may help us understand the biodiversity that prevailed in the regions in the past. Further, such comparisons may possibly throw some light on molecular and or morphological modifications due to the environmental or geographical change that lead to adaptations or alterations in demography or extinction of the species. To the best of our knowledge, morphological analysis has not been done in many samples of fossil hairs and hairs from paint brushes, apparel etc. that were used by ancient civilizations.

Key words

Ancient, Cuticle scale, Environment, Evolution, Fossil, Hair, Mammal, Medulla, Museum.

Introduction

Hair analysis based on morphological features like cuticle scale patterns, medulla and pigment or molecular analysis of DNA and protein, trace elements, chemicals etc. can help in pursuing studies of extinct organisms, dietary habits, evolution, ancient gene functions, forensic toxicology studies, etc. (Bergfield, 2007; Bianucci *et al.,* 2008; Wolinsky, 2010; Thompson *et al.* 2013). Morphological analysis of mammalian hairs may help in species identification, understanding evolutionary effects including adaptive alterations due to climate changes in many species or origin of hairs (review by Novacek, 1997; Chernova, 2006; Gilbert *et al.,* 2004, 2007; Bergfield, 2007; Bianucci *et al.,* 2008; Wolinsky, 2010). Mitochondrial DNA analysis from ancient hair is also possible for genetic characterization and phylogenetic studies (Gilbert *et al.,* 2004, 2007; Wolinsky, 2010; Clack *et al.* 2012). However, weathering of hair should be considered while analyzing the morphological features (Chang *et al.,* 2005). This review presents some of the studies on fossil hair and highlights the importance of comparisons with extant species and analysis of ancient hairs not studied so far.

Ancient hairs

The significance of study of structure, isotope ratio and trace element analyses of historic and extant human and

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animal hairs and the difficulties in studies of archeological hair samples is reviewed by Thompson *et al.* (2013). Scanning electron microscopic (SEM), atomic force microscopy and infrared spectroscopy analysis of human hairs from precolumbian natural mummies of the Dirección de Antropología Física del Instituto de Antropología e Historia (INAH) collection (Mexico city) and comparison with extant samples has been done (Mansilla *et al.* 2011). Though reports of fossilized or preserved hairs in amber, coprolites or frozen remains of animals, or impressions of hairs are rare (Poinar, 1988; Poinar & Columbus, 1992; Meng & Wyss, 1997; Ji *et al.,* 2002; Meng *et al.,* 2006; Gilbert *et al.,* 2007; Clack *et al.* 2012), study of these samples have revealed some interesting findings. For example, examination of coprolite aged about 200,000 yrs., indicates that humans were eaten by brown hyena (*Parahyaena brunnea*) (Backwell *et al.,* 2009), though not known whether humans were hunted or their corpse were consumed. Furthermore, ancient hair analysis has established association of Neolithic man and red deer. Fox-fur as arm band found on the body establishes association of fox with Lindow Man or Lindow II (British Museum Collection Online: Lindow Man/Lindow II). Indications of dogs being used as sledge dogs have been revealed from comparisons of extant and fossil dog hairs of Chukotka (Russia) (Chernova *et al*., 2016).

Hair and identification

Some studies on ancient hairs have helped in identification of genus, order or species of class Mammalia. For example, human hair strands have been identified in Miocene amber. Coprolites and regurgitalites containing hairs or impressions of hairs from late Paleocene Nomogen Formations at Mongolia are possibly from multituberculate *Lambdopsalis bulla*, an unidentifiable mammal (possibly rodent Eurymylid), *Palaeostylops iturus* and *Tribosphenomys minutus* (Meng & Wyss, 1997). However, in some cases even though the hair characteristics were clear, it could not be confirmed whether the hairs belonged to Solenodontid insectivores or other insectivores or rodents (Peñalvera & Grimaldi, 2006). Many hair samples cannot be identified due to bacterial degradation (Meng & Wyss, 1997). In some hairs, scale patterns are not distinct enough to discriminate between mammalian species though are helpful in discriminating filament from that of mammalian hair (Vullo *et al.,* 2010). SEM studies shows similarity of hair cuticle, cortical structure in hairs from matted wool ("wads"), the woolly rhinoceros (rhino) *Coelodonta antiquitatis* and woolly mammoth *Mammuthus primigenius*. However, medulla structure is specific for species. Further, similarity of rhino hair structure with vibrissae of predatory small mammals is reported (Chernova *et al.* 2015a & b). Extant and fossil dog hairs of Chukotka (Russia) analysis helped in identification of species (Chernova *et al*., 2016).

Changes in morphology

Fossil hair morphology studies reveal adaptive changes due to climate change. Evidence of adaptations to harsh environmental conditions is seen in analysis of extant and fossil dog hairs of Chukotka (Russia) (Chernova *et al*., 2016). Comparative study on hairs from ancient frozen bison and extant species shows change in cuticle thickness and hair medulla for better insulation but the morphology of hairs has not significantly changed during the course of evolution (Chernova & Kirillova, 2013; Kirillova *et al.,* 2013). Similar findings are also reported in study on fossilized hairs from *Equus* species (*E. lenensis*, *E.* conf. *lenensis*, and *E. caballus*) and modern horses (*E. caballus*) (Spasskaya *et al.,* 2012). Further, these studies also indicate close relationship between ancient and modern respective species (Spasskaya *et al.,* 2012; Chernova & Kirillova, 2013; Kirillova *et al.,* 2013); specifying that possibly order or family specific features are retained despite some modifications due to environmental changes. On the other hand, no significant differences are found in fossilized hairs (found in amber from the Font-de-Benon quarry at Archingeay-Les Nouillers in Charente-Maritime (southwestern France) and the hairs from extant species. Similarly, cave lion *Panthera spelaea* Goldfuss, 1810 fossil hairs and *Panthera leo* hairs do not differ in morphological features (Kirillova *et al*., 2014). Therefore, in some mammals there are no noticeable adaptive or evolutionary changes in hair morphology (Vullo *et al.,* 2010). Moreover, morphological similarity may exist due to similar habitats and climatic conditions but there may be genetic differences as seen in comparative morphological and protein analysis on hairs from Holocene "Yukagir Horse" (*Equus spp*.), Lena and modern Yakutian horses (Chernova *et al*., 2015c). Thus, alterations or lack of modifications in hair morphology for adaptations for insulation are species specific.

Animal association and dispersal

Hair analysis can also help in establishing interspecies animal/plant associations. Study on fossil hair in Dominican amber indicates that it may have belonged to a carnivore that possibly had association with female spikelet of the grass genus *Pharus* (Gramineae: Bambusoideae: Phareae). This association was possibly for dispersal during late Eocene (Poinar & Columbus, 1992). Study based on ectoparasites (Listrophorid and Staphylinoidea fur mites) found with fossil hair indicate that the hair belonged to rodent. Thus, this study not only establishes association of rodents and ectoparasites but also shows faunal distribution and proposes dispersal model of fauna in West Indies besides model for its biogeography (Poinar, 1988). Mammoth hair and admixture of fur matt from rhinoceros and bison (from Russia), contained remains of terrestrial and aquatic plants, insects, crustaceans including cladoceran subgenus *Daphnia* (*Ctenodaphnia*) and other Arctic branchiopod crustaceans, birds and mammals. Presence of these organisms in hair matt helped in deciphering Paleoenvironment, shift in the environmental conditions and landscapes during the formation of thermokarst (Kirillova *et al.*, 2015, 2016).

Evolution

Study of ancient hair can also assist in establishing origin of hair in mammals. One of the earliest known eutherian mammal (*Eomaia scansoria*) fossil found in China has an impression of halo of fur surrounding the skeleton. Carbonized filaments and impressions of hairs (both guard hairs and underhairs) round the body are preserved but are thin on the tail (Ji *et al.,* 2002). Hair impressions in Mesozoic mammalian fossils have also been recorded (Meng *et al.,* 2006) and fossil remains or impressions of hairs including guard hairs establish origin of fur before origin of tooth crown (Zhou *et al.,* 2013). However, no morphological features with reference to cuticle types are described though it is not clear whether these impressions were clear enough to study morphology. Hybridization between breeds and with wolves was revealed by analysis of hairs from extant and fossil dogs of Chukotka (Russia) (Chernova *et al*., 2016).

Uninvestigated treasure trove

There are few findings of ancient hair samples or impressions but many remain uninvestigated regarding morphological studies and comparisons with extant species. Morphological analysis of frozen fossil of woolly rhinoceros (*Coelodonta antiquitatis* Blum., 1799) (Chernova *et al*., 2015a & b) found on the bank of the Lower Kolyma River, near the village of Cherskii of the Nizhnekolymskii District of Yakutia (Boeskorov *et al.,* 2009, 2011) remained uninvestigated till 2015. Many museums across the world treasure many artifacts made from hairs. For example, The British Museum, The Petrie Museum and The Nicholson Museum have garments from Helen Spring Australia made with cow and human hairs; hooded cloak (made from wool and goat hair) worn by Maghrib of North Africa, hunting helmet (decorated with sea-lion whiskers) from Alaska, North America, wig of human hair made from sheep's wool, vegetable fibers, and human hair from Thebes, Egypt, paint brushes with hair bristles from China and Japan etc.; Iceman's bear-fur cap, leggings made from goat hide with deer skin laces, outer part of shoes made from deerskin etc. It is not clear whether these hair samples belonging to different animals were identified on basis of hair cuticles, medulla and pigment. Further, no comparisons of these hairs have possible been done with the extant species. To the best of our knowledge, hair morphology studies based on cuticle scale patterns, medulla and pigmentations have not been done in many hairs obtained from prehistoric times. Though isotopic analysis or atomic force microscopy of hair samples may be better especially for archeological samples (Mansilla *et al.* 2011, reviewed in Thompson *et al.* 2013); it may not always be easily accessible for all investigators interested in studies on hairs from ancient and living animals. Therefore, in such cases, light microscopy studies may also be useful at least in those samples which are well preserved.

Conclusion

From the perusal of literature it is evident that there is a lacuna in study on morphology of many ancient hair samples. It would be interesting to undertake these studies in order to gain insight into prehistoric mammalian fauna that prevailed in the region where samples are found. This may also help in understanding the inter- and intra-species relationships that could have existed in past and make an attempt at correlating those to present day population dynamics. It may also assist in understanding the prevailing conditions that could have caused extinction of some of the mammalian species. Further, such studies may help in developing models that may help in protecting the environment and the flora-fauna relationship after learning lessons from the past.

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