# MICROSCOPIC ANALYSIS OF FEATHER AND HAIR FRAGMENTS ASSOCIATED WITH HUMAN MUMMIFIED REMAINS FROM KAGAMIL ISLAND, ALASKA

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## INTRODUCTION

Human mummified remains of 34 different infant and adult individuals from Kagamil Island, Alaska, are accessioned in the Department of Anthropology, National Museum of Natural History, Smithsonian Institution. Kagamil Island is one of the small islands in the Island of Four Mountains group of the Aleutian Islands, Alaska and is well known for the mummy caves located on the southwest coast of the island. The Kagamil mummy holdings at the Smithsonian represent one of the largest, best documented and preserved collections of this type. Although these specimens are stored in ideal conditions, many small feather and hair fragments have become loose or disassociated from the actual mummies over the years. This preliminary investigation of fragmentary fiber material retrieved from these artifacts is the first attempt to identify bird and mammal species associated with the mummified remains of the Kagamil Island, Alaska collection and is part of the ongoing research connected with these artifacts. All specimens included in this study were collected by Henderson (Dall 1874) and Hrdlička from 1936 to 1938 (Hrdlička 1945) and are attributed to the Aleutian Island site at Kagamil.

The identification of birds from microscopic feather evidence has been used in systematic studies of birds (Chandler 1916; Dove 1997, 2000); in ecological studies of prey remains (Day 1966); in the identification of birds that collide with aircraft (Brom 1991; Dove 2000); and in the identification of anthropological artifacts (Dove 1998; Rogers et al. 2002). It has been shown that certain groups of birds may have diagnostic suites of microscopic characters in the plumulaceous (downy) feather barbs (Figure 1) which aid in the identification of orders, families and even species of birds (Chandler 1916; Dove 1997, 2000; Brom 1991; Reaney et al. 1978; Robertson et al. 1984).

Several thorough studies published by Hausman (1920a, 1920b, 1920c, 1924, 1930) paved the way for a vast array of research on the attributes of mammalian hair. Some studies examined the commercial aspects of hair produced by the domestic breeding of fur bearing mammals (Appleyard 1978) while other studies have focused on hair iden-

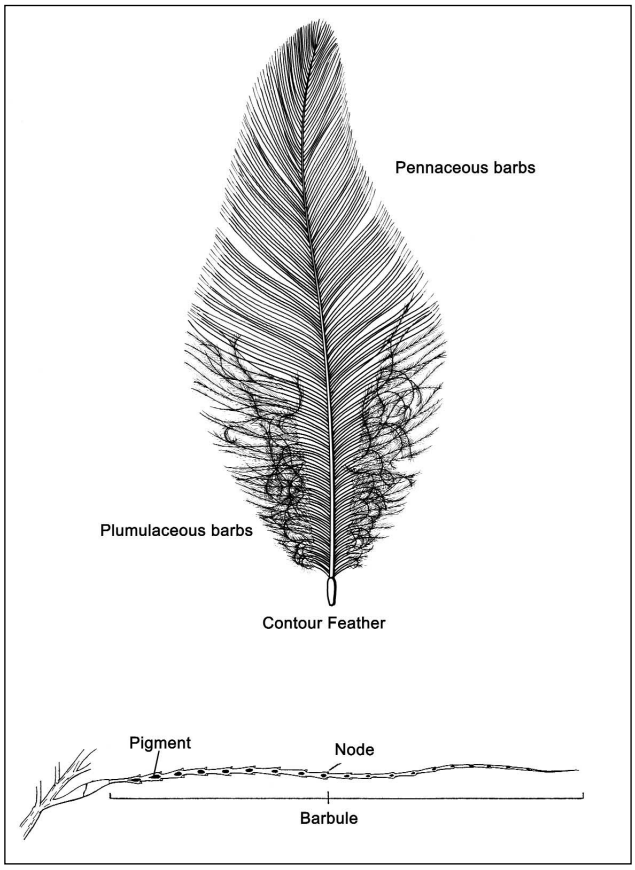


*Figure 1. Topography of a contour feather showing plumulaceous barbs, which are subdivided into barbules (below), that have diagnostic microscopic characteristics for identification.*

tification of stomach or scat contents (Day 1966; Cypher et al. 1994); hair tubing studies (Lindemayer et al. 1999); and wildlife remains from aircraft strikes (Dove and Peurach 2001). Identification keys based mainly on dorsal guard hair characteristics are available for many geographical regions and can be used to distinguish between samples of different mammal groups (Brunner and Coman 1974; Mayer 1952; Moore et al. 1974).

## METHODS

A total of 54 feather and 46 hair samples were examined from 34 different catalogued mummies (infant and adult) in the collections of the Smithsonian Institution, Department of Anthropology (Table 1). Due to the fragile nature of these objects, many loose pieces or partial feather and hair fragments were detached from the artifacts and available for microscopic examination, thus the analysis did not involve any form of destructive and/or invasive procedures.

Typically, the mummified bodies are wrapped in a combination of bird skins, marine mammal fur and grass mattings. In a few cases, the bundles have been further cushioned by adding grass and seaweed. Although there is no direct evidence at this time, computed tomography reveals that bodies may be wrapped in a combination of several layers of feathers and fur (Figure 2). Sometimes, the inner-most layer consists of an inverted bird skin, which on some infants has been applied as a head-gear. Because of the non-invasive demands on the artifacts in this study, none of the bird or mammal skins originating on the internal part of the bundle could be identified. However, CT scanning suggests that it might be very likely that the internal bird and mammal skins are similar to the skins facing the external surfaces and responsible for the loose feather and hair fragments used for the present analysis.

Minute samples of feather and hair were mounted on labeled glass microslides and prepared following the methods described in Laybourne and Dove (1994) and Dove (1998) with the exception that samples were not washed due to the small amount of material available for study. Microslides were examined with Reichert Diastar and Zeiss compound comparison light microscopes at 100 – 400X. Photomicrographs were taken with a Polaroid DMC Ie digital camera. Microslides were labeled with the Department of Anthropology catalogue number and are stored with the Kagamil mummy collection at the Smithsonian Institution. The Kagamil feather and hair samples were compared with a large reference collection of microslides (Smithsonian Institution, Division of Birds and Division of Mammals) made from known species that occur throughout the Aleutian Islands.

In this study, feather identification was conducted mainly by microscopic examination of the downy barbs found associated with the Kagamil specimens. Downy feather barbs are located at the

*Table 1 (opposite page). List of birds and mammals identified from fragments associated with mummies from Kagamil Island, Alaska catalogued in the Department of Anthropology, Smithsonian Institution. In cases where more than one sample was examined for a specific item, samples are numbered 1 to 6. Parentheses indicate lowest possible level of taxonomic identification, with genus and species in italics.*

| USNM Catalogue # | Bird Identification | Mammal Identification |
|---|---|---|
| 17475 | 1. eider (Anatidae) | 1. fox (*Alopex* or *Vulpes*) |
| | 2. auklet (Alcidae) | 2. bear (*Ursus*) |
| | | 3. otter (*Enhydra* or *Lontra*) |
| 17480 | 1. puffin (*Fratercula*) | 1. earless seal (Phocidae) |
| | 2. alcid (Alcidae) | 2. eared seal or walrus (Otariidae) |
| 17481 | 1. puffin (*Fratercula*) | No mammals |
| 17482 | 1. Common Raven (*Corvus corax*) | 1. otter (*Enhydra* or *Lontra*) |
| 17483 | 1. alcid (Alcidae) | 1. otter (*Enhydra* or *Lontra*) |
| | | 2. cf. caribou (*Rangifer*); earless seal (Phocidae) |
| | | 3. bear (*Ursus*) |
| 377698 | 1. alcid (Alcidae) | No mammals |
| 377699 | 1. puffin (*Fratercula*) | No mammals |
| 377832 | 1. eider (Anatidae) | No mammals |
| 377899 | No birds | 1. earless seal (Phocidae) |
| 386376 | 1. puffin (*Fratercula*) | 1. eared seal or walrus (Otariidae) |
| | 2. auklet (Alcidae) | 2. otter (*Enhydra* or *Lontra*) |
| 386378 | 1. puffin (*Fratercula*) | 1. otter (*Enhydra* or *Lontra*) |
| 386379 | No birds | 1. otter (*Enhydra* or *Lontra*) |
| 386380 | 1. alcid (Alcidae) | 1. earless seal (Phocidae) |
| | 2. kittiwake (*Larus*) | 2. fox (*Alopex* or *Vulpes*) |
| 386381 | No birds | 1. otter (*Enhydra* or *Lontra*) |
| | | 2. bear (*Ursus*) |
| | | 3. earless seal (Phocidae) |
| 386382 | 1. Pelagic Cormorant (*Phalacrocorax pelagicus*) | No mammals |
| 386383 | 1. Pelagic Cormorant (*Phalacrocorax pelagicus*) | 1. earless seal (Phocidae) |
| | 2. auklet (Alcidae) | |
| | 3. Parakeet Auklet (*Aethia psittacula*) | |
| 386384 | 1. Least Auklet (*Aethia pusilla*) | 1. fox (*Alopex* or *Vulpes*) |
| | 2. auklet (Alcidae) | 2. fox (*Alopex* or *Vulpes*) |
| | 3. cormorant (*Phalacrocorax*) | 3. bear (*Ursus*) |
| | 4. auklet (Alcidae) | |
| 386385 | 1. Least Auklet (*Aethia pusilla*) | No mammals |
| 386386 | 1. goose (Anatidae) | 1. eared seal or walrus (Otariidae) |
| | 2. gull (Laridae) | 2. eared seal or walrus (Otariidae) |
| | 3. goose (Anatidae) | |
| 386387 | 1. eider (Anatidae) | 1. earless seal (Phocidae) |
| | 2. auklet (Alcidae) | 2. Unidentified hair |
| 386388 | 1. auklet (Alcidae) | 1. earless seal (Phocidae) |
| | 2. auklet (Alcidae) | 2. eared seal or walrus (Otariidae) |
| | | 3. eared seal or walrus (Otariidae) |
| 386389 | 1. auklet (Alcidae) | 1. otter (*Enhydra* or *Lontra*) |
| 386390 | 1. puffin (*Fratercula*) | No mammals |
| | 2. Common Raven (*Corvus corax*) | |
| 386391 | 1. goose (Anatidae) | 1. eared seal or walrus (Otariidae) |
| | 2. auklet (Alcidae) | 2. fox (*Alopex* or *Vulpes*) |
| 386392 | 1. Common Raven (*Corvus corax*) | 1. eared seal or walrus (Otariidae) |
| | 2. Canada goose (*Branta canadensis*) | 2. bear (*Ursus*) |
| | 3. gull (*Larus*); Murre (*Uria*) | |
| 386393 | 1. gull (*Larus*) | 1. bear (*Ursus*) |
| | 2. gull (*Larus*), possibly Herring Gull | 2. earless seal (Phocidae) |
| | 3. gull (*Larus*) | 3. otter *(Enhydra or Lontra)* |
| | 4. plover or sandpiper (Charadriidae or Scolopacidae) | 4. earless seal (Phocidae) |
| | | 5. earless seal (Phocidae) |
| | | 6. earless seal (Phocidae) |
| 386394 | 1. Tufted Puffin (*Fratercula cirrhata*) | 1. earless seal (Phocidae) |
| | 13 individual beaks | |
| 386395 | 1. puffin (*Fratercula*) | 1. earless seal or walrus (Phocidae or Otariidae) |
| 386396 | 1. goose (Anatidae) | 1. otter (*Enhydra* or *Lontra*) |
| | 2. alcid (Aldicae) | 2. cf. caribou (*Rangifer*) |
| 386397 | 1. Common Eider (*Somateria mollissima*) | No mammals |
| | 2. Ancient Murrelet (*Synthliboramphus antiquus*) | |
| 386398 | 1. Least Auklet (*Aethia pusilla*) | No mammals |
| 386399 | 1. puffin (*Fratercula*) | No mammals |
| | 2. auklet (Alcidae) | |
| 386400 | 1. Common Raven (*Corvus corax*) | 1. earless seal (Phocidae) |
| 386377 | 1. puffin (*Fratercula*) | No Mammals |

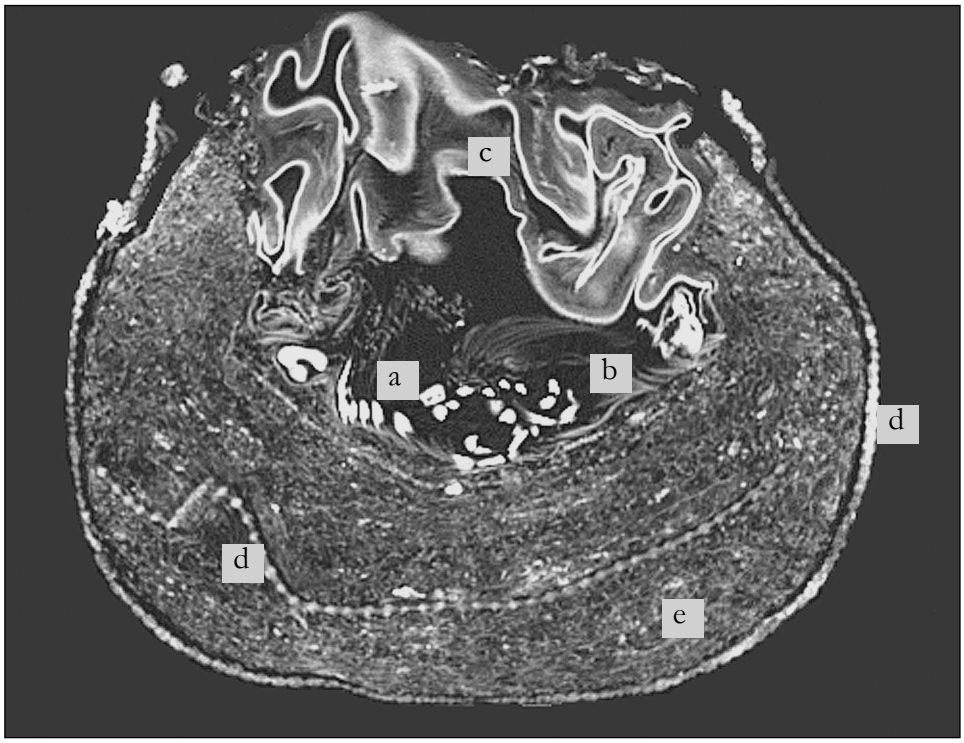


*Figure 2. CT scan of USNM-386389. Infant mummified body from Kagamil Island. Body (a) is protected by layers of bird skin (b), mammal fur (c), grass mattings (d), and seaweed (e).*

base of most contour feathers (or grow in between feather tracts) and function to provide insulation. The variation in the microscopic feather characters of the downy barbules (which branch from downy barbs) such as node shape, node distribution, pigment patterns and length of downy barbules (Figure 1) were used in this study to aid in the identification of bird species.

Mammal identifications were based on microscopic hair characters such as presence or absence and configuration of the medulla, overall hair length, shape, color, and external scale patterns (Figure 3). Hair terminology is based on Brunner and Coman (1974).

Because it was impossible to remove whole feathers, bird carcasses, or mammal skins from the mummy specimens in this study, microscopic identifications could not be corroborated in the usual way by matching whole or partial fragments to museum specimens. Therefore, the identification results of this study are preliminary until more detailed sampling is permitted.

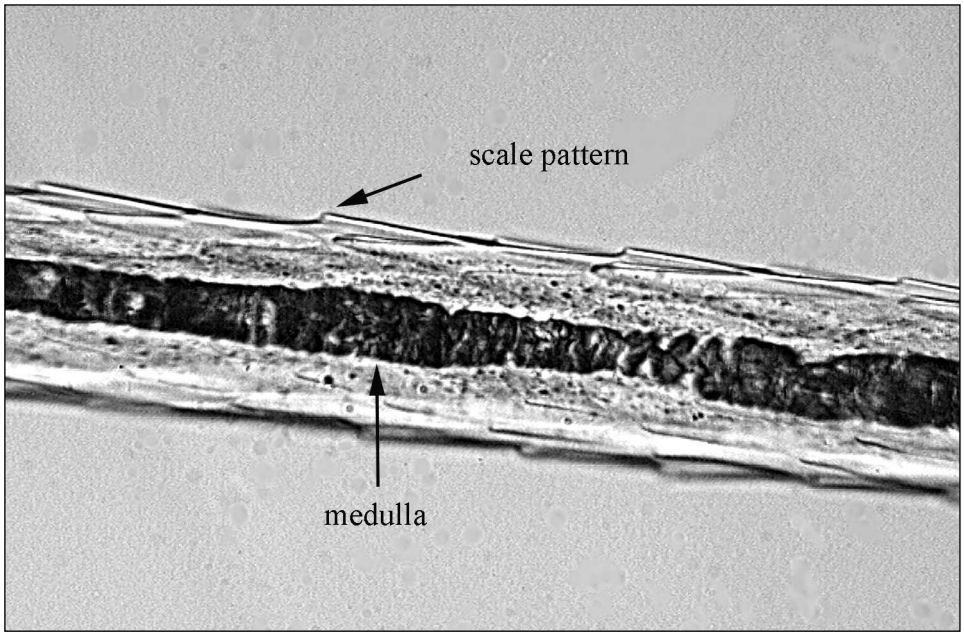


*Figure 3 Topography of a hair showing some characters used for microscopic analysis. Sea Otter (Enhydra lutris)*

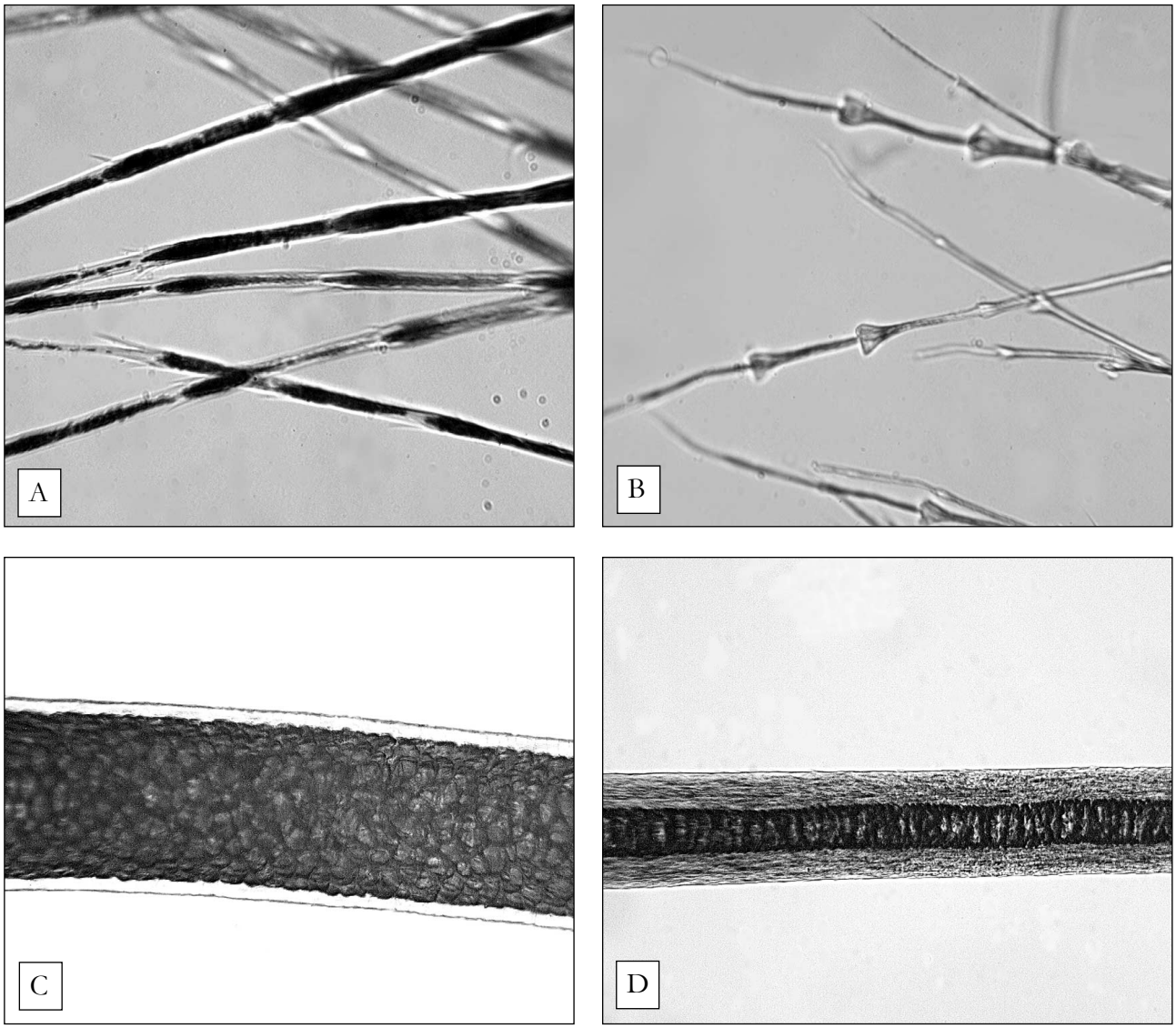


*Figure 4. Photomicrographs showing typical microscopic characters of (A) auklet (Alcidae), (B) eider (Anatidae), (C) deer (Cervidae), and (D) otter (Mustelidae).*

## RESULTS

### Bird Identifications

In this preliminary study, more than a dozen different species of birds representing four different avian orders (Charadriiformes, Anseriformes, Pelecaniformes, Passeriformes) were identified from the downy feather fragments associated with the Kagamil mummies (Table 1). Table 2 shows that the majority of the bird species were from the avian orders Charadriiformes (auks, gulls and shorebirds) or Anseriformes (ducks, geese and swans). The Common Raven (*Corvus corax*) was the only songbird (Passeriformes) identified in this study. Forty-one of the feather samples could only be identified to a general "group" of birds (e.g. auklet) because of insufficiently available feather material. One item (#386394) contained 13 individual distal upper beaks of Tufted Puffin (*Fratercula cirrhata*).

Auklets (a sub-group of six species of birds within the family Alcididae) composed the majority of the avian identifications in this study. According to del Hoyo et al. (1996), all six species of auklets (Least, Crested, Parakeet, Whiskered, Cassin's, Rhinoceros) occur throughout the Aleutian Islands. The downy feather microstructure characteristics of these six auklets are similar to each other and do not vary enough to confidently assign specific identifications based on microscopic analysis alone. However, the microscopic feather structures of the auklets do

*Table 2. Percentages of birds and mammals represented in the Kagamil mummy samples.*

| Birds: | |
|---|---|
| Order | |
| Charadriiformes (auks, gulls, and shorebirds) | 63 |
| Anseriformes (ducks, geese, swans) | 21 |
| Pelecaniformes (pelecans, cormorants) | 11 |
| Passeriformes (song birds) | 05 |
| Total (percent) | 100 |
| **Mammals:** | |
| Family | |
| Phocidae (earless seals) | 30 |
| Mustelidae (weasels, otters) | 20 |
| Otariidae (eared seals, walrus) | 20 |
| Ursidae (bears) | 13 |
| Canidae (dogs) | 11 |
| Cervidae (deer) | 04 |
| Phocidae or Otariidae (seal) | 02 |
| Total (percent) | 100 |

differ from other genera within the family Alcidae (auks) by having oblong-shaped, heavily pigmented nodes with long prongs (Figure 4).

A female Common Eider (*Somateria mollissima*) was identified on item #386397 based on one whole feather that was attached to the outside of the mummy bundle. Eiders typically can be differentiated microscopically from other species within Anseriformes (ducks, geese, swans) by the heavy stippling of pigment throughout the barbule (Figure 4). Anseriformes also have diagnostic, triangular-shaped nodes that are located on the distal portion of the barbule. Sekora (1973) lists three species of eider (Common, King and Steller's) as occurring throughout the Aleutians and reports the Common Eider as a known breeder in the chain. Three other samples in this study contained eider feathers that could not be identified to the species level.

The Common Raven (*Corvus corax*) was found in four separate samples and represents the only passerine species identified in this study. Ravens are known in Native American cultures of the Northwest as being the creator of earth, moon, sun, and stars, as well as being regarded as tricksters and cheaters (Borman and Heinrich 1999). Jochelson (1933) reported that beaks of ravens were used as hunting amulets by the Aleuts. The few taxonomic identifications of birds to species level in this study were based on microscopic examination in combination with some other diagnostic character observed on the whole feathers attached to the bundles.

**Mammal Identifications**

The majority of the mammals identified from the Kagamil mummy remains were carnivores (Order Carnivora) and include (in order of abundance): earless seals (Family: Phocidae), otters (Genera: *Lontra* or *Enhydra*), eared seals (Family: Otariidae), Bear (Genus: *Ursus*), and fox (Genera: *Alopex* or *Vulpes*). Only two samples contained deer (Family: Cervidae, possibly caribou). Over 71% of the samples identified were from aquatic or semi-aquatic mammals (Table 2) and were found in 14 samples.

Earless seals (Phocidae) often have hair shafts that are broken distally, resulting in hairs that are typically short, wide, and completely lacking a medulla when compared to other carnivores (Mayer 1952). Hairs of eared seals or walrus (Otariidae) were identified from eight samples and share many characteristics with those of the earless seals (Phocidae) with the exception that the overhairs and guard hairs of otariid seals have medullas whereas

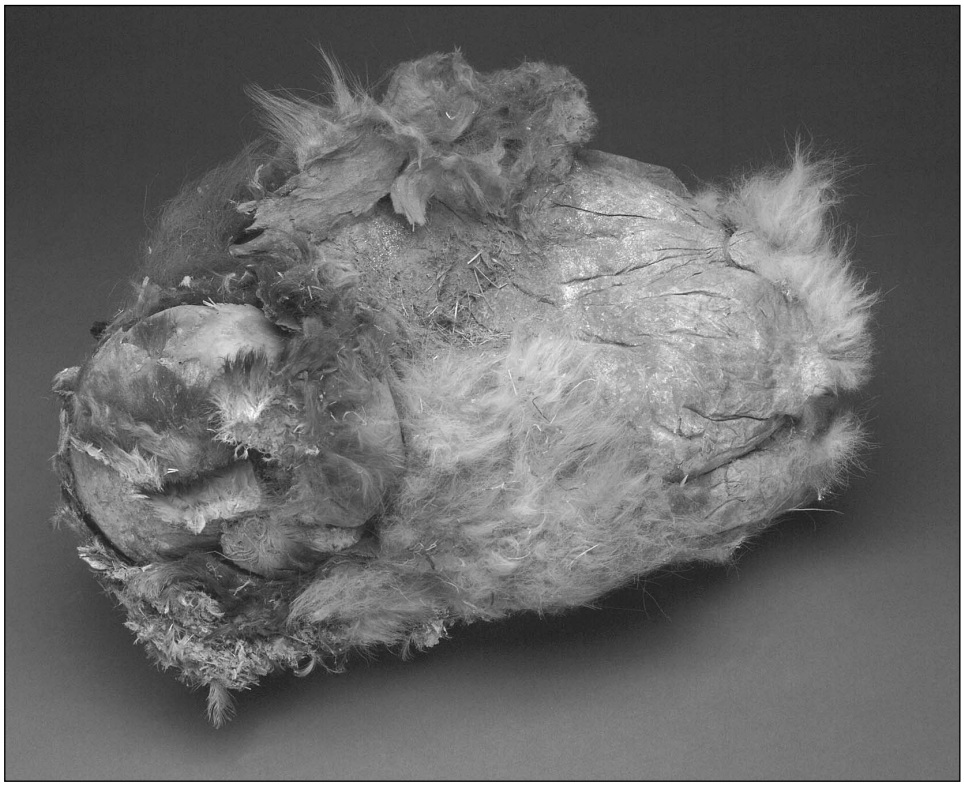

*Figure 5. Kagamil infant mummy (USNM-386384) covered in bird and mammal skins. Photo by Center for Scientific Imaging and Photography. National Museum of Natural History, Smithsonian Institution.*

phocid hairs do not (Yochem and Stewart 2002). Attempts were not made to distinguish between piniped genera until more detailed sampling can be done.

Otter (Mustelidae) was identified from 10 samples comprising 20% of the mummies examined in this study, but species designation between sea otter (*Enhydra* ) and river otter (*Lontra* ) could not be determined. Mustelid hairs always have a petal shaped scale pattern on the underhairs as well as on the base of overhairs and guard hairs. Some carnivores may also show this basal scale pattern, but it is not as extensive as in mustelids. In addition, the overhairs of mustelids widen distally into a broad shield that is not as pronounced in other carnivores (Teerink 1991). Other terrestrial members of the family Mustelidae also share these characteristics with otters, but the hair shaft is longer and wider in the otter.

The identification of bear (*Ursus*) from six samples was based primarily on the length (138 mm longest hair) and the microscopic character of a simple, amorphous medulla (less than ½ diameter for the entire hair shaft). Microslides of the samples were compared with the reference collection or published literature for mammals (native and non-native species) that might have hair of this length such as human (*Homo*), musk ox (*Ovibos*), bison (*Bison* ), cow (*Bos*), and horse (*Equus*). All were found to possess different characteristics of the medulla when examined with light microscopy. The identification to species level is problematic because most of the hairs with bear-like characteristics in this study possessed a distinctive orange coating. It is reported that the Aleuts used ochre dye as well as their own blood to dye components for amulets or simple decorations (Jochelson 1933).

Fox (*Alopex* or *Vulpes*) were found in five samples and were distinguished from other closely related canids and members of the family Mustelidae based on hair length as well as characteristics of the medulla and external scale pattern. Guard hairs of wild species of dog that were reviewed in the microslide reference collection were found to have wider medulla (more than ½ the diameter of the hair shaft) and had much darker pigment than was found in these samples. The length of the hair eliminates all terrestrial mustelids from that region except wolverine (*Gulo*), and the Kagamil samples lacked the narrow basal region followed by a wide shield near the tip found on most mustelids (Moore et al. 1974). However, the Kagamil samples did posses the basal petal scales seen in some carnivores as well as mustelids. The hair shaft of the wolverine has a much greater diameter than that of the fox. Further, identification of fox was problematic for reasons similar to the bear identifications. These hair samples were always found to be bright orange and showed evidence of orange-colored debris adhering to the outside of the hair shaft.

*Figure 6. Harbor Seal (Phoca vitulina) on Ship Rock Island between Umnak and Unalaska islands. Identification: by James Mead, Marine Mammal Program, Smithsonian Institution. Photo by Bruno Frohlich.*

The possible identification of caribou (*Rangifer tarandus*) from two samples was based on geographic distribution of the species and the microscopic observation of the unbroken lattice medulla, a character found in members of the family Cervidae as well as in other artiodactyls. Caribou is the only cervid species native to the Aleutian Islands (Hall 1981). This species was also introduced on Seward Peninsula between 1892 and 1902 (Dau et al. 2000). Figure 4 shows examples of typical microscopic characters observed in cervid (deer) and otter hair.

## DISCUSSION

The identification of birds and mammals from fragmentary evidence in this study was difficult due to the minute samples available for study, the inaccessibility of the bird and mammal specimens within the bundles (Figure 5), and the non-invasive restrictions on the artifacts. Therefore, exact species identifications could not be made on the associated birds and mammals for the majority of these mummies. Additionally, it was impossible to determine if cross contamination of fragments occurred over time or during storage and transport. However, the large number of samples analyzed in this study does confirm that certain types of birds and mammals were preferred in the burial rituals of the Kagamil mummies by the Aleuts.

### BIRDS

The group of birds most often identified in this study was Charadriiformes (auks, gulls, shorebirds). This is not unusual considering that vast numbers of auks and gulls occur and breed throughout the Aleutian Islands. Sowls et al. (1973) estimated breeding colonies of kittiwakes in Alaska to be nearly 2 million and Sekora (1973) estimated more than 1,000 breeding puffins and 285,000 breeding Common and Thick-billed Murres on Kagamil Island alone. An inventory of 3,985 bird bones from middens discovered at Nikolski, a village that lies only 42 km east of Kagamil, listed shearwaters and fulmars (Procellariformes) as representing 40% of the birds found in the village debris followed by puffins and auklets representing 32%, and ducks, cormorants, albatross and others representing 28% (Laughlin 1980). Birds and eggs probably comprised about 20% of the early Aleutian diet and puffins were used for food and clothing (Laughlin 1980).

The practice of inverting whole bird skins over the heads of infants is apparent throughout the Kagamil mummies in this collection. The purpose of this practice is unknown but Laughlin (1980) explains that the early Aleutians used puffin skins to make full-length parkas that were reversible. The feathers were often worn on the inside during cold weather and on the outside during social occasions (Laughlin 1980). Geese and ducks (especially eiders) are known for the warm insulation that is provided

by the down feathers and were used with some frequency in these Kagamil burials. The breeding and wintering ranges of Common Eiders (Goudie et al. 2000) would have made them easily obtainable during all seasons of the year.

It is not surprising that the Aleuts used the birds that lived in the area to construct clothing for the burial garments of the mummies. The bird groups identified in this study are mainly consistent with what would have been expected to be available for use in the everyday lives of the people. It is interesting to note, however, that certain birds were not found in this study. Waterproof parkas made by some Aleuts had white feathers from the Bald Eagle, and hawks and owls were used in the dismemberment practices of making mummies and for ceremonial and magical purposes (Laughlin 1980). Jochelson (1933) describes a practice of using the reddish down of the Rosy Finch (*Leucosticte tephrocotis*) to ornament birdskin parkas and as amulets to attract whales. None of these species were found in this preliminary study.

## MAMMALS

Mammal identifications were complicated for the same reasons listed for bird identifications. Additionally, the different types of hair (e.g. underhair, guard hair) on the same animal exhibit a great deal of variation. Many of the characters on the guard hair can only be used with assurance when it is known where the unknown samples have been taken from the body of the mammal. Other variables such as the age of the animal or the season when the hair was collected may cause variation in the characteristics of the hair.

The preference for using earless seals during burial practices may be based on the importance of this animal as a component of their hunting practices as well as a central part of the diet. Laughlin (1980) reported that one-third of the diet of the Aleuts was found to consist of the meat of marine mammals. The livelihood and cultural practices of the Aleuts were influenced greatly by sea otter (*Enhydra lutris*), especially after contact with Russians with whom the pelts were prized (Jochelson 1933; Laughlin 1980), although the meat was not historically a component of their diet. Laughlin (1980) retold an Aleut account that the meat of otters reportedly tastes like mud, but Jochelson (1933) recanted a report by George Steller that the meat of sea otter is better than that of seals and that suckling otter meat tastes much like lamb. Laughlin (1980) reported that in pre-Russian times the Aleuts rarely hunted otters because they believed them to be akin to humans and even used otter bodies as reference material for autopsies on their dead. When they did hunt otter, considerable effort was taken to appease the good will of the 'person' of the otter.

Because the mummified burial remains of the adult and infants from Kagamil Island are preserved in very good condition, it is possible to study these artifacts in greater detail and gain more information about the types of birds and mammals and the significance of these animals to the rituals of the people of this area. However, more liberal sampling techniques are desired to obtain better material for study of the bird and mammal species used in these artifacts. Whole feathers, bird carcasses, and large portions of mammal skins are partially visible on some of these artifacts, but the feathers and hairs are dirty or stained and need to be properly cleaned to regain natural colors for better identification characteristics. It is possible to make more positive species identifications of the birds and mammals used on these mummies, but more detailed analysis can only be performed using controlled sampling techniques and side by side whole specimen comparisons to unknown samples.

## ACKNOWLEDGEMENTS

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*This page: Cormorants, Anangula Island. Next page: Gull (Anangula Island), young bald eagle (Camel Cove, Adak Island); Red-faced cormorants (Anangula Island); murres and other shorebirds (Ship Rock Island); humpback whale from Bering Sea north of Unalaska; harbor seal (Attu Island); and fox (Adak Island). Photos by Bruno Frohlich.*