ABSTRACT

HAIRBASE™: THE DEVELOPMENT OF AN ONLINE REFERENCE ATLAS OF MAMMALIAN HAIR

The class Mammalia contains approximately 5,400 species that display incredible variation in their pelage characteristics. When attempting to identify an unknown animal based on the morphological characteristics of its hair, the macroscopic and microscopic examination of guard hairs is often used. Species identification from small amounts of hair or single hairs has been the goal of many published atlases. However, many of these atlases do not adequately reflect the range of variation both between and within individual species. HAIRbase™ is an online digital database of bright field and scanning electron microscope images of mammalian hair. In contrast to many other atlases, HAIRbase™ contains images from both primary and secondary guard hairs from three distinct regions on the body from each species represented.

HAIRbase™ is an applicative tool that can aid forensic hair examiners by providing a visual reference that contains diagnostic information regarding traits of the hair shield, subshield, and basal regions, including medullary configurations, cortical characteristics, and cuticular patterns that can be used to generate leads in investigations involving animals.

Michael Vincent Gonzalez
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HAIRBASE™: THE DEVELOPMENT OF AN ONLINE REFERENCE ATLAS OF MAMMALIAN HAIR

by

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INTRODUCTION

Illegal hunting and the fur trade comprise a $4 billion dollar black market industry, second in the world only to the trafficking of narcotics and weapons (1). The identification of trafficked wildlife may rely on accurate diagnosis of hair left behind at a crime scene, as trace evidence found on objects connected to illegal activity, or from body parts that are themselves the trafficked items. Hair may come from a variety of mammalian species (2-4), each of which demonstrates a great deal of morphological variation that can aid in the identification of the animal from which it came (5-7). Therefore, the analysis of mammalian hair morphology is an important tool that wildlife forensic scientists and animal welfare professionals can use to combat these illegal activities (8-10).

Hair morphology has been studied in academic circles for many years (3,5,7,10-14). Hair morphological studies are vital to forensic professionals attempting to make taxonomic designations based upon the identification of hair fiber characteristics entered as evidence or found at a crime scene (3,5,7,10). Although reference materials play an important role in any forensic case that relies on morphological comparison, it is important to remember that comparative studies ultimately rely on the use of a verified hair reference standard collection. One should always compare like to like: that is, to ensure that standard and questioned hairs are comparable in their macroscopic features (e.g., length, diameter, color, banding pattern) and type (e.g., guard hair, secondary, underhair) in the first instance. Then, it is important to compare similar portions of one hair to another (e.g., basal to basal, shield to shield). Animal hair atlases have proven invaluable to forensic professionals by illustrating morphological differences that

can provide a fast and efficient way to eliminate certain species while suggesting others that may require further investigation (3,5,7,10-14).

Over the years, several atlases of hair morphology have been published that provide representative images of the degree of variation among hairs in order to aid in the identification of certain mammalian groups (3,5,7,10-14). These atlases have been of great use to comparative hair morphologists over time. However, current atlases are either limited in their geographical scope (e.g., Europe, Wyoming, Australia) or lacking in the degree of morphological variation that can occur both within and between animals when the animal and/or body part of origin or the country of origin of the evidentiary hair is unknown.

Many laws, including the Endangered Species Act of 1973 (15) and the Marine Mammal Protection Act (16), and trade agreements, such as the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) (17,18) determine which mammals are protected and to what extent these animals are protected. Many published mammalian hair atlases do not take endangered and trafficked animals into account and, so, their utility to the forensic wildlife hair examiner is often limited. Likewise, few of these atlases offer full coverage of the range of variation that may be seen among domestic animals, and which must be taken into consideration during a forensic examination.

Current atlases are further limited by the amount of variation they record across the different body regions of a given individual of a specific species. The class Mammalia is extremely diverse, comprising roughly 5,400 species organized into 29 orders (19). As a result of the level of morphological diversity encountered across all mammalian hairs, guard hairs from the dorsal region of an individual (medially between the shoulder blades) have been the hairs most commonly

referenced (3,5-7,12,13,20). However, a large number of mammals, including furbearers and other endangered species, show variance in pelage characteristics from one body region to another (21,22)(Fig. 1).

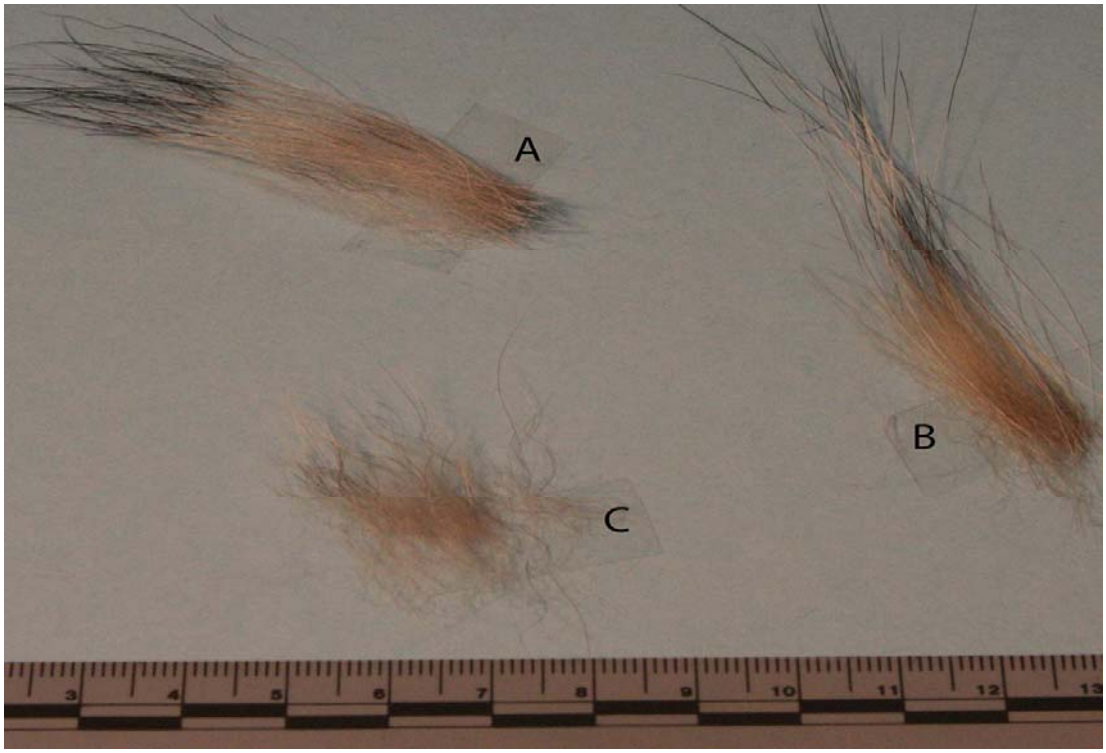

FIG 1: The degree of variation between the grades of hair on *Lycalopex griseus* (Argentinian Grey Fox). Hairs from the back, or dorsum (A), differ from hairs of the tail, or caudal region (B) in length, color pattern, and degree of coarseness. Both of these types of hairs, in turn, differ markedly from the hairs of the belly, or ventrum (C).

A forensic animal hair atlas must also address the variation in diameter or "grades" of hair that may be observed on a particular body region of a given individual. A mammal's coat contains several grades of hair which are separated into two broad categories, underhair and overhair (3,23,24). Underhair mainly functions to insulate the mammal and provide warmth (3,23,24). Underhairs have been found to be morphologically simple, offering few characteristics that can be

used to distinguish species and, so, are of limited value to the forensic examiner (3,10). Overhair, on the other hand, includes the primary and secondary guard hairs, which function to provide protection (5, 9,11,15). True overhairs, *sensu scricto*, are those extra long hairs, found primarily in furbearers scattered sparsely over the body and are generally too large in diameter and undifferentiated to be useful in microscopic identification. These true overhairs are termed GH0 in Teerink's scheme of grading mammalian hairs (Fig. 2A (3)). The overhairs that contain the greatest diagnostic value include the primary guard hairs (GH1) and secondary guard hairs (GH2)(Fig. 2A (3)). Primary and secondary guard hairs are morphologically distinct and are, therefore, of particular interest to forensic hair examiners (3,6,10). The cuticle, cortex, and medulla of primary guard hairs, especially from the dorsum, have distinct characteristics that can be used for identification purposes (6,7,13,14,22,25,26). Secondary guard hairs form gradations between the longer primary guard hairs and the shorter, more dense, finer underhair or fur (3,10). The morphological characteristics of secondary guard hairs are oftentimes more diagnostic than those of primary guard hairs (27). However, despite this fact, secondary guard hairs are not taken into account by most hair atlases.

Lastly, most current atlases are available in textual form only, including CD-ROM versions (12,28), making the representative image collections static by nature. However, the needs of the forensic wildlife hair examiner are closely aligned with the international judicial system (29,30), and change depending on the current standing of endangered species litigation (29,30).

HAIRbase™ is a web-based reference atlas, specifically geared toward the needs of the forensic trace professional. This database attempts to alleviate many of the shortcomings of previous hair morphological references. These

shortcomings include species selection relevant to the forensic examiner, geographic scope, limits in the coverage of variation on a specimen, and the static nature of these primarily textual references. HAIRbase™ attempts to alleviate many of these issues by including broad inclusion of forensically relevant species, a greater geographic coverage, a wider representation of morphological variation among and within individuals of the class Mammalia, and the adaptability that digital media provides. By addressing these problems with existing atlases, HAIRbase™ can become an important applicative tool to trace examiners in multiple scientific disciplines for years to come.

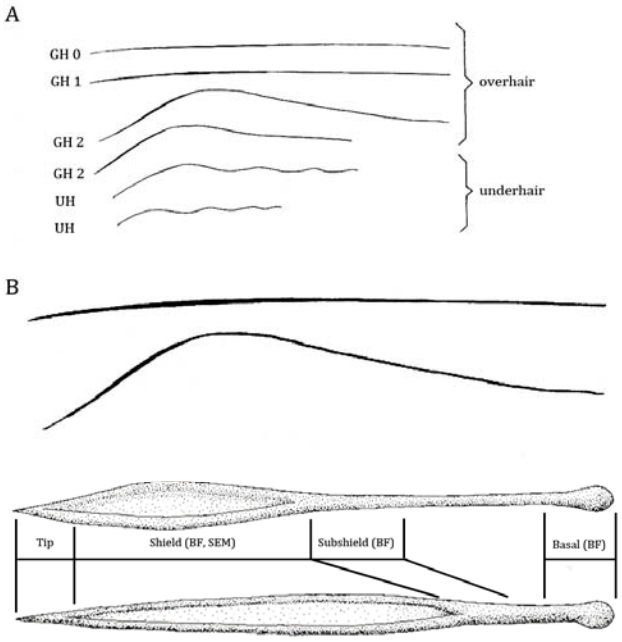

FIG 2: The structure of primary and secondary mammalian guard hairs.
(A) Primary and secondary guard hairs (GH1 and GH2, respectively) are morphologically distinct, so they are of particular interest to forensic hair examiners. (B) The types of primary and secondary guard hairs that were chosen for inclusion in HAIRbase™ (top) and the morphological regions – namely the shield, subshield, and basal – of each hair that for which images were taken for inclusion in the database (bottom) are illustrated. This figure was adapted and redrawn from Moore, *et al.*, 1974 (5) and Teerink, 1991 (3).

LITERATURE REVIEW

The morphology and structure of mammalian hair has been studied for many years (3,5,7,10-14). The information and literature regarding the development, structure and function of hair can fill many volumes and the information, in its entirety, cannot be covered here. However, the use of certain characteristics and structures of mammalian hair for identification purposes is a relatively novel idea (22). The search for identifying characteristics of mammalian hair began in earnest in the early 1920's and has continued to the present day (9, 31-33). From this beginning, a number of proposed techniques and reference atlases that attempt to increase the reliability of this comparative science have been produced (3,5,6-7,10,34). Although, the techniques applied are different due to technological advances in microscopy for example, many of the basic tenets of comparative hair morphology for identification purposes remains the same.

With recent litigation regarding the protection of mammalian species (29-30), the protection and conservation of these animals has come to the forefront in recent years. Often, in a wildlife forensic context, examiners are not required to make identifications down to an individual animal but instead are expected to make a taxonomic designation at the species level. Due to the variation of the hair morphology in the class Mammalia, this is often difficult. However, the search and classification of these identifying characteristics has proven instrumental in the prosecution of crimes against animals and still remains a valuable tool in the forensic examiner's arsenal (3,5,7,10,34).

Hair Physiology

The hair follicle is truly a remarkable structure, complete with muscles (the *arrectores pilorum*), a rich blood supply, nerve endings (making hair a valuable

vehicle for sensory response and tactile sensation), and a number of glands that perform duties ranging from waterproofing to hair cycle regulation (24,35-37). It is an organ – developed *in utero* as an invagination of the epidermis – in which division, differentiation, and migration of cells occur (24,36).

Different processes in the hair follicle give rise to the growth of the hair fiber (36-37). This activity results from the hardening of the contents of the medullary, cuticular and cortical cells of the hair shaft (24,36). The hair fiber is the major component of the hair follicle. A hair is characterized as a long thin cylinder of keratinized cells, which contains three cellular components (36-37).

The life cycle of hair is a dynamic, continuous process composed of three phases: anagen, catagen and telogen (37). The hair cycle is a pattern of growth, regression, and loss of the hair fiber (24,37). This process of hair cycling enables animals to adapt to drastic changes in environmental conditions (i.e., changing seasons). The first phase of the hair cycle, known as the anagen phase, is characterized by a period of high metabolic and mitotic activity, which initiates the growth of the hair fiber (36-37). The next phase of the hair cycle is the catagen phase, during which the follicle undergoes gradual and orderly morphological and functional changes as it enters its regression phase (24,37). The hair then ceases to grow, where it usually stays in a suspended state for about 2 to 3 weeks (36-37). The final stage of the hair cycle is the telogen phase, also known as the mature stable state of hair growth. The telogen phase can last up to 4 months and the hairs found in this phase have a very short follicle (24,37). Hairs found in this phase are most often shed and this phase is only finished when a new anagen phase is commenced (24,37). These telogen hairs are most often found at crime scenes and are commonly used in criminal investigations (24).

Macroscopic Variation of Hair

The evaluation of a questioned guard hair begins with a macroscopic evaluation. Macroscopic characteristics that are particularly important to note are color, banding pattern, length, and form of the hair fiber in question (3,5,7,10). The form of the hair refers to its overall shape. Hair can vary in both shape and structure; however, there are regions on each hair fiber that are generally recognized. The basal portion of the hair contains the root end, usually comprising about one-fifth of the hair shaft (5,7,10). The subshield is characterized as the area immediately below the shield region (if present) and comprises the middle portion of the hair shaft (5). The shield region is a widened, flattened area located at various positions on the more distal portion of the hair shaft (5). Hair may show extreme variation along the length of the hair shaft, making the representation of each region important to illustrate the variation that can be seen on a given species.

Hair diameter determines the various grades of hair and includes, in decreasing diameter: vibrissae, bristle hairs, overhairs, guard hairs, and underhairs (3,10). The ability to recognize the different grades of hair is an invaluable skill, which can only be developed by repeated exposure, such as that commonly experienced by the forensic trace evidence examiner.

Vibrissae, which are commonly referred to as whiskers or tactile hairs, are large, stiff hairs that function primarily as sensory organs (10). Vibrissae are thick hairs that do not lend themselves to readily to transmitted light microscopy and, so, are seldom studied. Indeed, like coarse overhairs, vibrissae may not exhibit traits that facilitate their identification at lower taxonomic levels. Also, vibrissae are relatively few in number on a given carcass, and they are not frequently left behind at the scene of a crime.

Bristle hairs are rather stiff, rigid hairs that are specialized in some mammals (10), such as the domestic pig. Bristle hairs are generally consistent in diameter along the length of the hair shaft (10). The medullae of these hairs are generally very thin to absent. Bristle hairs commonly exhibit frayed tips.

Most mammalian pelages show the presence of coarse overhairs, which are sparsely scattered across the coat of the specimen (3,10). These overhairs are noticeably longer than the guard hairs (10). These hairs, like vibrissae and bristle hairs, have little microscopic value at lower taxonomic levels. As a result, course overhairs were not chosen for inclusion in HAIRbase™.

Guard hairs are the next largest hairs in size, and these hairs comprise a large proportion of the pelage of most mammals (3,5,7,10-14). Guard hairs are of traditional importance in hair identification, because they have been seen to display the most diagnostically relevant features (3,5, 7-8, 10-14). It is also important to note that there are a variety of sizes or grades of guard hairs that also require recognition, separation, and separate scientific analysis.

Finally, underhairs are shorter and finer than guard hairs, and they commonly have an undulating appearance (3,5,10). Underhairs remain fairly consistent in diameter along the lengths of their shafts. Underhairs can be similar in structure and function among many mammalian taxa, so they may be of only limited diagnostic use to the forensic trace evidence examiner seeking identification below the taxonomic level of family.

It is important to note that, on most furbearing animals, a continuous gradation of hair fibers exists from one hair "type" to another which often makes the separation of the different hair types difficult on these animals (10). However, the ability to effectively separate the different grades of hair from one another can aid in the successful identification of a given animal.

Microscopic Variation of Hair

Many microscopic morphological features of hair have been used to identify the type of animal from which the hair originated (5,10-14). As mentioned above, hair cells differentiate into three layers – the cuticle, medulla, and cortex – and each layer has a distinct function that contributes to the morphology of the hair fiber (24). Identification of the patterns of these differentiated cells often form the basis of forensic hair identification in both humans and non-humans (14,23-24).

The outermost layer of hair, known as the cuticle, is composed of flattened scale cells (scales that overlap) which surround the hair completely, offering protection to the more delicate cortex (3). Cuticle cells grow over one another in an overlapping fashion from the hair's root to its tip (3,7,38-40). The cells that comprise the hair's cuticle overlap to form recognizable patterns that are indicative of certain mammalian orders and families (7,38-40). In some rare cases, these scales may be pigmented, as seen in some bats (10). Along most of the hair fiber, scales are flattened against the body of the hair; however, towards the basal region, these scales may be more apparent under bright field microscopy (5).

The cortex is composed of spindle-shaped cells that measure approximately 80-100 μM long by 5-10 μM wide (24). The chemical bonds found within the cortex contribute to the overall strength of the hair, while the cortical pigments are responsible for giving hair its color (10,24). Under the light microscope, the individual cells of the cortex are not visible. Rather, they appear as a hyaline mass without much detail. For this reason, the cortex is limited to pigment characteristics that may be useful for identification purposes (3,5,7,10).

The medulla appears as a central column of cells that runs medially through the hair shaft (6,9,10,23,32). A medullary structure is not always found within

mammalian hair. However, when it is present, it can be classified in a number of ways (3,7,10). The primary purpose for the medulla is presently unknown, but common hypotheses include increasing the thermal insulating properties of hair, forming a channel for waste removal, and maintaining the diameter of the hair (24). The cellular composition and diameter of the medulla varies widely across the class Mammalia (10-11) and, therefore, may be used to help identify a questioned animal hair.

Hair morphology remains an important facet of forensic analysis, especially regarding the prosecution of crimes against wildlife (3,5-6). Morphology is simply the study of shape and structure, and this is helpful in a forensic context, because the identification of morphological characteristics can be used to make taxonomic determinations. The identification of trafficked materials often relies on the accurate morphological analysis of hair fibers found at a crime scene, confiscated at customs, or found on objects that are connected with illegal activity. The proper and accurate diagnosis of these hair fibers relies on many morphological features that, together, may make a taxonomic identification possible (5,7,10).

Reference materials play a vital role in the analytical process regarding the evaluation of unknown hair samples. The organization, classification scheme, and dichotomous keys devised for reliable identification of unknown animal hairs differs from reference to reference (3,5-7,10). These differences in the ways that morphological structures are described often make it difficult to use these references to their fullest. The biggest benefit of reference atlases to the forensic trace evidence examiner is in the range of morphological variation that the given atlas is able to display. Although no hair atlas or database will ever be complete, shortcomings can certainly be addressed and improved to the benefit of the forensic trace evidence examiner and the profession as a whole.

Hair Atlases and Classification Schemes

Researchers have long recognized the benefit of hair morphology references evidenced by the number currently available in circulation (3,5,7,10,22,23). These references are primarily textual, and they attempt to offer adequate coverage of the morphological variation seen within the class Mammalia. They are often organized using a geographical scope, cataloguing the species of a particular state or region of a country. This substantially narrows the number of species that need to be addressed and helps to make the construction of dichotomous keys much simpler. However, many times, especially in a forensic context, the origin of a particular ("questioned") hair fiber is not known. The application of forensic unknowns to geographically-based references limits their utility.

In order to illustrate the limited utility of geographically-based references, let's look at four atlases of mammalian hair identification (3,5,7,10). The identification schemes of each of these texts differ markedly, not only in the methodologies employed, but also in the naming designations of the morphological structures under view. The texts also differ in geographic region covered, number of images displayed, and opinion regarding the diagnostic relevance of certain methods. In fact, the successful identification of an unknown animal hair cannot be applied to any one specific methodology, but must rely on the aggregation of many characteristics including a thorough macroscopic and microscopic evaluation. No one specific method is superior to another. Rather, all characteristics that can be gathered are beneficial in order to make a reliable taxonomic determination based on the morphological characteristics of a given animal hair.

Nicholas Petraco and Thomas Kubic (7) offer an identification scheme for unknown mammalian hair. The classification scheme begins with the analysis of cuticle scale casts to view the cuticle scale pattern of the basal portion of the animal hair in question (7) (Fig. 3). Then, classification of the cellular composition of the medulla is completed (7). These two observations are reported by the author to be an adequate means of separation for common animal hair encountered by professional hair examiners. Although this identification process may prove satisfactory for a small subset of mammals, when applied to the entirety of the class Mammalia, it cannot designate lower taxonomic levels. A taxonomic designation cannot be based solely on two analytical methods in order for a reliable identification to be made.

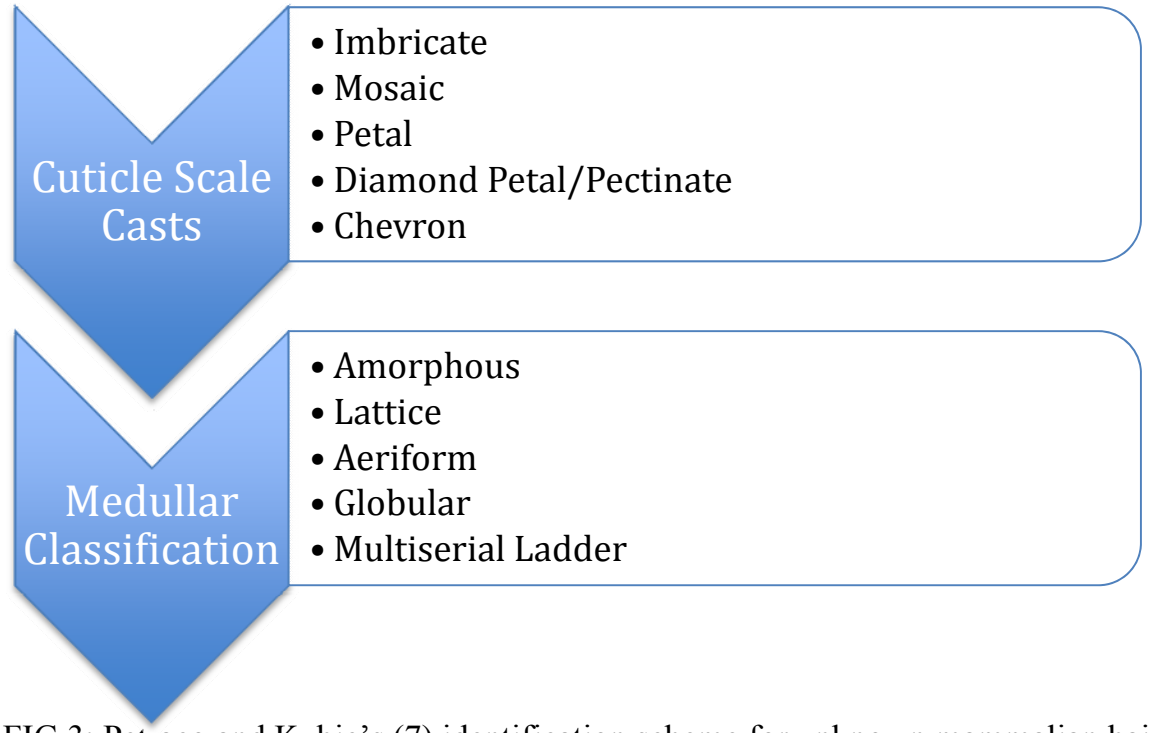

FIG 3: Petraco and Kubic's (7) identification scheme for unknown mammalian hair. This identification scheme requires classification of the cuticular pattern followed by the medullar classification in order to make an identification of an unknown mammalian hair.

Brunner and Coleman (10) offer a different approach to the identification of the hair of a number of mammal species. Whereas Petraco and Kubic (7) relied on the analysis of the cuticular pattern as a launching point for further investigation (7), Brunner downplays the importance of such a technique saying, “scale patterns can very often be ignored in the identification process and are generally only used to confirm identifications made on the basis of other criteria”(10). Brunner speculates that the transverse cross-sectional shape of the hair fiber should be the first identifying feature, followed by medullary cellular analysis and designation (10). The naming designations of the cuticle and medulla, while similar, have some differences between the two atlases as well (see Figs. 3 and 4). By viewing these two very different identification schemes, one may begin to appreciate the difficulty of animal hair identification. The difficulty of animal hair identification relies on the premise that the naming and designation of certain morphological structures of hair are subjective, or contingent on the analysis of the individual trace evidence examiner. The identification of individual structures can differ from examiner to examiner, which can often compound the problem of forensic identification of animal hair fibers.

The final two atlases have no discernable scheme for identification. Rather, they advocate the importance of an aggregation of characteristics for the proper identification of an unknown hair fiber. Teerink (3) and Moore and co-authors (5) have written atlases that differ markedly in regional scope, but approach hair analysis in much the same way. These two atlases realize the importance of the macroscopic examination of unknown hair fibers and attempt to separate species initially using this criterion. Petraco and Brunner have different opinions regarding the efficacy of certain analytical tests to identify hair. Petraco is a proponent of cuticle scale casts as an initial means of separation of unknown animal hairs, while

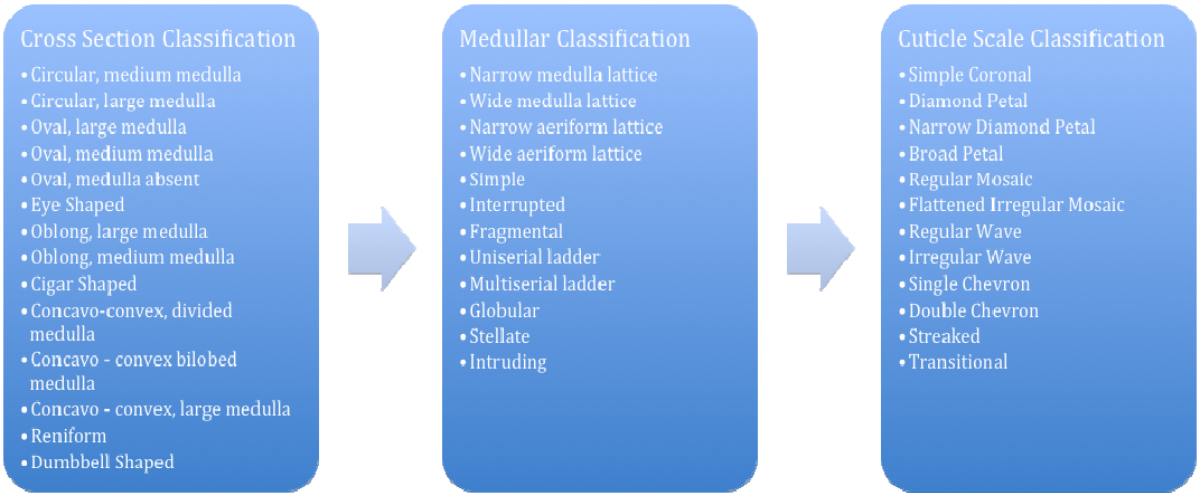

FIG 4: Brunner and Coleman's (10) identification scheme for unknown mammalian hair. This identification scheme requires cross-sectional classification, then medullar classification, and finally cuticle scale classification in order to identify an unknown mammalian hair.

Brunner relies on the transverse cross-sectional shape of said animal hairs (7,10). Neither Teerink nor Moore and co-workers comment on the importance of any particular test or structural feature but, instead, they rely upon the aggregation of multiple characteristics including macroscopic observation, cuticular pattern classification, and medullar classification (3,5). In addition, Teerink investigates the cross-sectional shape of the hair fiber (3) (Fig. 5).

By analyzing this small subset of reference literature, differences in classification schemes (e.g., medullary types, cuticlular scale types) and naming designations that often – as well as the importance that Brunner and Petraco place on certain analytical techniques for the purposes of hair identification – can begin to be appreciated (3,5,7,10). Therefore, it is a number of characteristics rather than a schema that involves only one or two characteristics that will ultimately lead to the successful identification of an unknown animal hair. No analytical technique is

more important than the next, and all techniques should be used in tandem to make a successful taxonomic designation based on the morphological characteristics of an unknown mammalian hair.

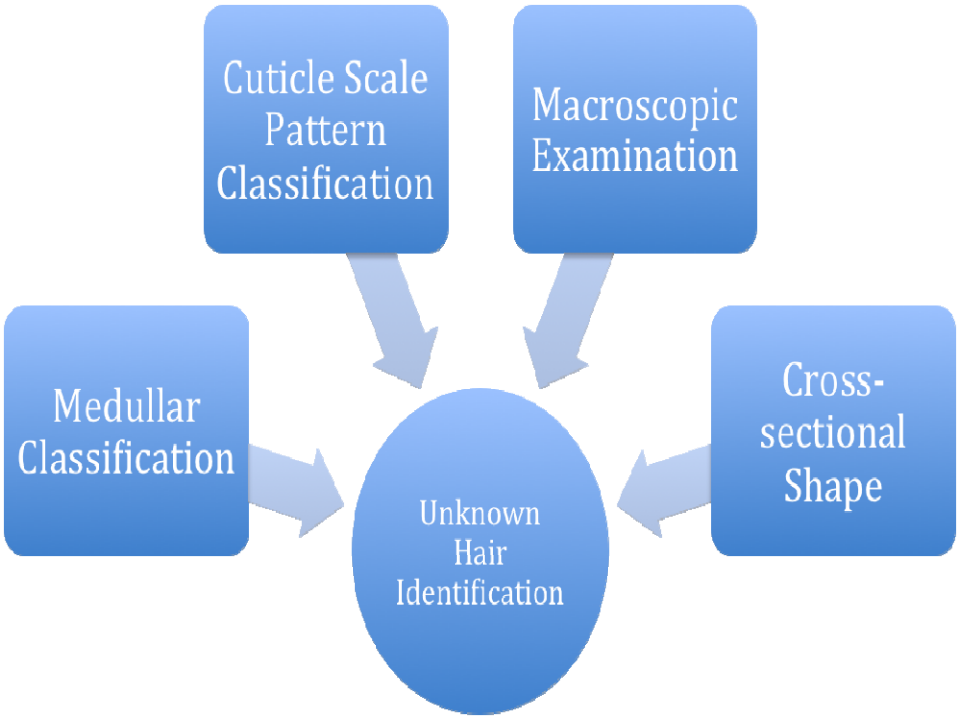

FIG 5: Teerink's (3) identification scheme for unknown mammalian hair.
The identification of an unknown mammalian hair requires the aggregation of all characteristics (see Appendix F for Classification types that are possible).

MATERIALS AND METHODS

Sample Collection

Animal specimens were obtained from the collections at the U.S. Fish and Wildlife National Forensic Laboratory in Ashland, Oregon, and the Biology Department at the California State University, Fresno, representing 133 species from 19 families representing 2 orders of the class Mammalia. Of these, 46 species are either endangered or protected (Appendix A).

Hair was collected from each specimen by either plucking it or cutting it as close to its base as possible with a razor blade. Hair was collected from three body regions: 1) the dorsal region, between the shoulder blades; 2) the ventral region, on the midline between the forelimb and the hind limb; and 3) at the tip of the tail (Fig. 6). For animals that did not have prominent tails (e.g. the chimpanzee, *Pan troglodytes*), hair was collected from the sacral region of the specimen. These three body areas were chosen, because they provided the greatest level of variation within a given individual while being manageable for a large number of species. Animals that exhibited sudden or marked differences in appearance over their entire bodies (e.g. the Okapi, *Okapi johnstoni*) were sampled in the additional body regions: back of thigh, forehead, top of foot, and vibrissae. Approximately 20-25 hairs were collected from each body region of each individual, for a total collection of approximately 60-75 hairs from each animal. The collected hair from each body region was then placed in a separate sterile biohazard plastic specimen bag (Fisherbrand, Part # 01-800-00). The plastic specimen bag was sealed and labeled with the following information: genus, species, common name, area on the body from which the hair was collected (i.e. dorsal, ventral, tip of tail, back of thigh, forehead, top of foot, or vibrissae), and sample provenance (if known).

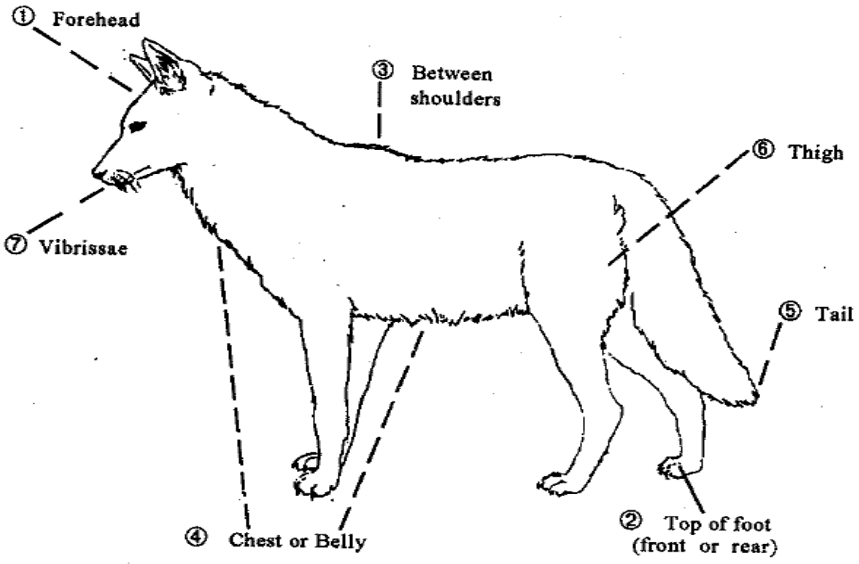

FIG 6: Hair regions collected: Hair was plucked with tweezers from the dorsal region (3), ventral region (4) and tip of tail region (5) of each specimen.

Loose Hair Storage

The collected hair samples were organized and stored in the Human Identification Laboratory for future use. The plastic specimen bags of collected hair from the selected regions on each specimen were placed in standard sheet protectors with a backer card displaying the common and scientific name. These species "packets" (including plastic specimen bags containing hair from the separately collected body regions and provenance information) (Fig. 7B, 7C) were then organized into individual three-ring binders (Fig. 7A). The three-ring binders were divided by the taxonomic order (e.g., Carnivora, Artiodactyla, etc.). The individual species belonging to that particular order were further arranged alphabetically by family (Mustelidae, Procyonidae, etc.). The representatives within each family were sorted alphabetically by genus. This organizational system was used to facilitate fast and efficient navigation through the loose hair collection.

FIG 7: Loose hair storage and organization: A. represents an overall image of the three-ring binder dividing the collected species. B. Picture of the large Ziploc bag with labels. C. Small plastic bag for individual region on each specimen.

Preparation of Hair for Microscopical Examination

Preparation of Hair for Bright Field Microscopy

Hair from each body region was removed from its collection bag and graded as to whether it was a primary guard hair (GH1), secondary guard hair (GH2), or underfur (UH). Figure 2A displays the scheme used to distinguish

primary from secondary guard hairs. Approximately 3-5 primary and secondary guard hairs were selected from each collection bag. Several hairs of each type were then plated onto their own glass microscope slides (Fisher Scientific) using Flotexx® mounting medium (Lerner Cytology/Histology Reagents, Thermo Scientific - Model 137702). Flotexx® was chosen because it has a refractive index (R.I.=1.52; 41) that is close to that of hair (R.I.=1.55; 3,7). Using mounting media with a refractive index that is close to that of the mounted object allows the examiner to obtain images that are free from shadow and contrast, which could otherwise mask the internal morphological characteristics of the hair in question (3,7). Each hair was oriented so that the basal region of the hair fiber corresponded with the left of the microscope slide. This served as an aid to the photographer to properly orient the hair under the microscope. Each hair on each slide was examined, and hairs were selected and photographed in a manner that documented microscopic fields that contained the most representative morphological characteristics for the particular hair type and section under view.

Preparation of Hair for Scanning Electron Microscopy

Hair from the dorsal region was removed from its collection bag and graded as to whether it was a primary guard hair (GH1), secondary guard hair (GH2), or underhair (UH). Approximately five to ten primary guard hairs were removed to a sterile petri dish and dried in a desiccator for a period of 1-2 days. Scanning electron microscope mounts were then prepared using a sterile razor blade to excise a section of the hair's shield region. The hair fiber was adhered to a metal specimen mount (Ted Pella, Inc. Redding, CA) with double stick carbon tape (Ted Pella, Inc. Redding, CA). The specimen and mount were then sputter-coated with gold at 6 mA voltage for 25 s. This procedure was performed once at 0 degrees

(specimen laying flat) and once at an angle of 45 degrees. Once the sputter-coating process was complete, the hair samples were viewed and photographed in a manner that documented microscopic fields that contained the most representative cuticular characteristics for the particular specimen and hair type under view.

Microscopy Slide and Stub Storage

Scanning Electron Microscope

Specimen Mount Storage

The gold-coated specimen mounts for Scanning Electron Microscopy were stored inside a desiccator in labeled cases (Ted Pella Inc.) for future use and reference.

Bright Field Microscopy Slide Storage

Individual storage boxes (Fisher Scientific) were used for long-term storage of the bright field whole mount specimens. Boxes were separated by taxonomic order. Within the boxes, slides were organized alphabetically by genus. A legend was included with each slide storage box which provided information regarding genus, species, and individual body region corresponding to the numbered slot that the microscope slide occupies (see Fig. 8).

Digital Image Acquisition

An Olympus BX45 transmitted light microscope coupled with a Q-imaging Retiga 2000R Camera was used to acquire digital images of the basal, sub-shield and shield portions of each hair specimen at 400 X magnification (Fig. 2C). Hair fibers too large for adequate viewing at 400 X magnification (e.g. the wild boar, *Sus scrofa*) were photographed at 200 X magnification. If variation was visualized along the shaft of the hair specimen, such as a marked increase or decrease in

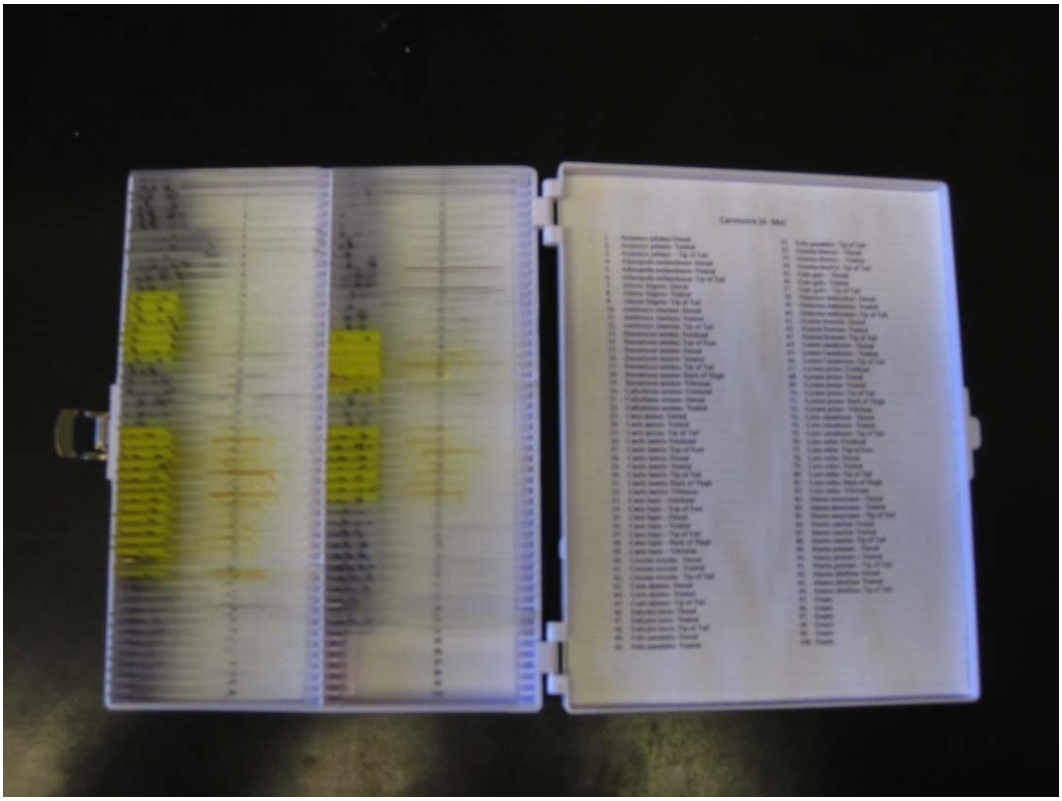

FIG 8: Bright field microscopy slide storage. Microscope slides with whole mount specimens are on the left with a comprehensive listing of the slides on the right.

diameter, medullary configuration change, or a change of the pigment color or density, then additional digital images were taken in order to record these variations.

A Hitachi S-3500N Scanning Electron Microscope was used to obtain images of the cuticlar scale pattern of select specimens at 700 and 1,500 X magnification. The select specimens that were chosen represented the 21 families of the class Mammalia (1 representative from each family) that compose this database. This was done to show the wide variation regarding the cuticle pattern across family. Cuticle patterns were not recorded on a genus or species level, because, although differing characteristics may be observed, gross characteristics remain similar below the family taxonomic level (26).

A macroscopic and microscopic evaluation was conducted for each specimen. The classification scheme used, including cuticle scale descriptions, medullary configurations, and biological hair regions, was obtained from Moore and co-workers (5). The macroscopic characteristics recorded included hair color, form, and banding. Hair color was classified according to a Munsell color chart (42). Form refers to the overall look of the hair including shape and how that shape changes from the root to the tip. Banding patterns are an important classification in distinguishing mammals. Color banding is a band of color on a hair that is sharply separated from adjacent areas of different colors above and below the band (5,13,43). While many hairs are un-banded, the presence of banding is noteworthy, because this macroscopic feature can be used to distinguish certain taxa from others (5,13,34,43).

Microscopic observations, such as medullary, corticullar, and cuticular characteristics, were then recorded according to a classification system adapted from Moore and co-workers (5). Medullary characteristics included a description and classification of the medulla type displayed. The shape of the cuticle scales and configuration is also described. Cortex characteristics such as pigment aggregation and color of pigment is also included in the evaluation. The classifications recorded and the classification system employed has been adapted from Moore and co-workers. Measurements of the medulla diameter, shaft diameter, and medullary index of the primary dorsal guard were carried out using Caseworks 2 software (Mideo Systems) after proper calibration with a scale micrometer (Fisher Scientific).

Photo Manipulation

Adobe Photoshop version CS4 (Adobe Systems Incorporated) was used to prepare images for final publication. The image was cropped, placed on a uniform background, and the image properties (contrast, brightness, and color) were adjusted so that the internal characteristics of the hair could be best visualized in two dimensions.

A photo template was created in Adobe Photoshop to optimize the process of image manipulation and final publication (see Fig. 9).

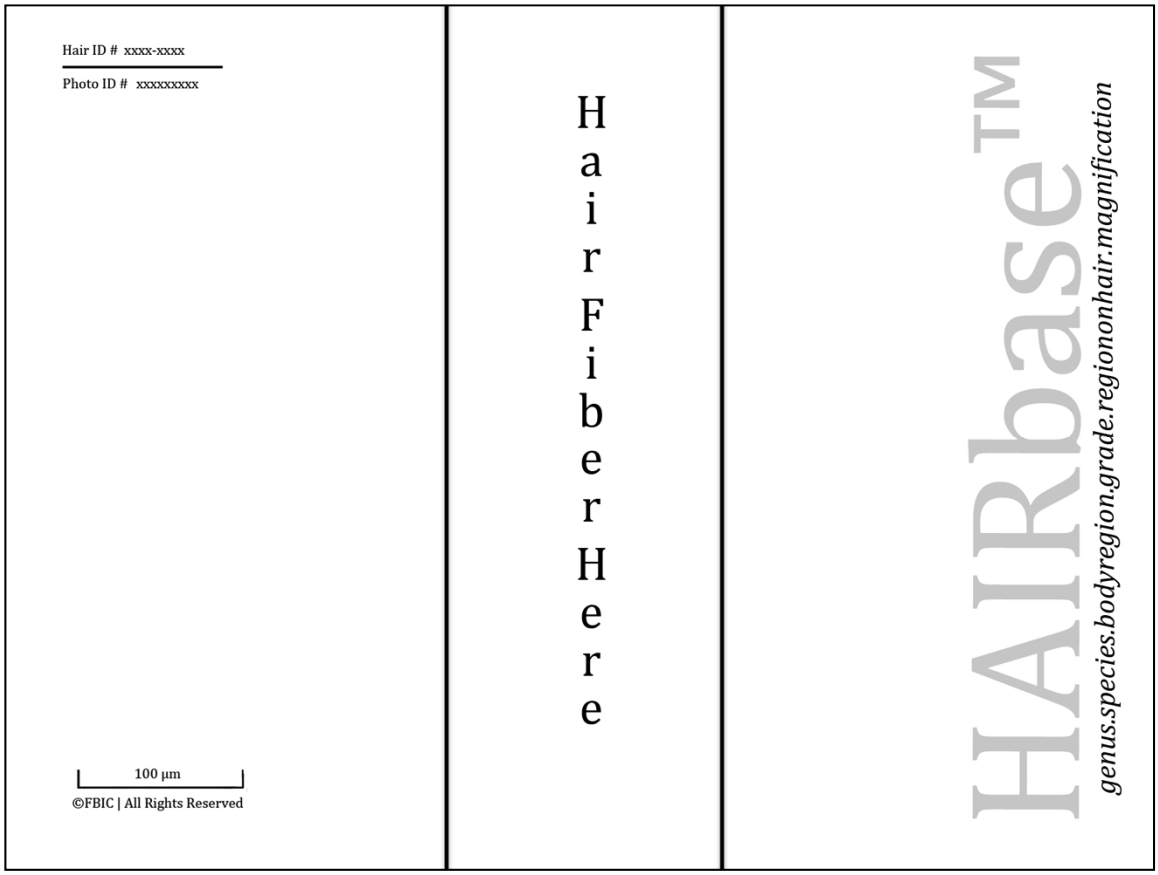

FIG 9: HAIRbase™ image template. The template was designed to aid in the consistent processing of multiple images of mammalian hair. Identifying numbers are in the upper left corner, scale for reference in the bottom left, and the file name of the specimen on the right side of the template.

Development of an Internet-based User Interface

A user interface was created with iWeb ’09 version 2.0.4, a template-based website creation tool (Apple, Inc.), that allows the publishing of website content quickly and easily. The site is organized around a phylogenetic tree (44), which allows for easy navigation to each of the 16 orders of the class Mammalia that will be represented in the dataset. Individual order pages contain a list of species within that order that are contained within the database. Species pages display information regarding each individual specimen, including pelage observations, geographic distribution, and descriptions and measurements of dorsal guard hairs, photo-documentation of each hair specimen. Species pages generally reflect the variation present in a single individual. The images are separated into single albums displaying basal, sub-shield, and shield images of the primary and secondary guard hair from each of the particular areas on the specimen collected.

The main infrastructure of the HAIRbase™ website has been constructed using the “Darkroom” template in iWeb ’09. Explanation for the creation of several types of webpages, including layout, formatting, and design features for the creation of order, species, image, and subspecies/breeds webpages using iWeb ’09 (see Appendix B).

RESULTS AND DISCUSSION

Development of HAIRbase™

Rationale for Species Selection

This work describes the creation of a database of primary and secondary guard hair images of domesticated, endangered, and non-protected mammals from around the world, which has been compiled largely through the use of bright field and scanning electron microscopy. HAIRbase™, as the database is known, covers variation across the class Mammalia by including a variety of mammals not previously seen in any atlas, including multiple regions on each specimen, multiple grades of hair, and multiple images of each hair. The dataset currently includes approximately 1,700 bright field microscopic images and 25 scanning electron microscopic images, with updates to be added frequently. HAIRbase™ is freely available on the Internet, allowing universal access and easy navigation through the collection. The implementation and the launching of HAIRbase™ on the Internet provides forensic investigators and researchers alike with a valuable resource for morphological comparison and animal identification. Contributions of additional or novel images from researchers may also be uploaded, with provenance data, making the collection interactive and expansive.

HAIRbase™ was developed to include a representative collection of 133 species, which were chosen because of their significance to illegal wildlife trade (e.g., tiger, *Panthera tigris*; Tibetan antelope, *Pantholops hodgsonii*) or to facilitate legal trade in the fur industry (e.g., American mink, *Mustela vison*; American beaver, *Castor canadensis*). Many specimens were chosen as sole representatives of the family or genus in which they reside. The selected species come from the orders Artiodactyla and Carnivora, which comprise the majority of

the cases seen in forensic wildlife casework (45). Many of the selected species are listed as endangered or protected and are exceedingly rare in the wild, including 47 species that are protected under The Endangered Species Act of 1974 (see Appendix A,(15)) from the Artiodactyla and Carnivora orders of the class Mammalia.

The current geographic focus for the mammals of HAIRbase™ is the mammals of North America, with select non-North American species that are seen in illegal trapping and poaching crimes, since the majority of forensic casework currently handled by the U.S. Fish and Wildlife Service involves furbearers and "trophy" animals. Additionally, of the 1,900 protected species of the class Mammalia, roughly 1,320 are native to North America (46). By having a North American focus, HAIRbase™ allows the inclusion of the greatest number of protected species while remaining centered on those species that seem to be most relevant to the greatest number of potential user groups. Several groups of mammals that are not endangered or trafficked are also included in HAIRbase™ as well.

Although the database is arranged by species (the lowest taxonomic unit typically used in all organizational schemes of hair atlases), a comment is warranted here on the actual likelihood of making an identification to the species level based on hair microscopy. Claims of species-level identification are commonly attributed to microscopic hair identification (e.g., 47), but the reality is that genus- or family-level identifications are more likely (48). Forensic wildlife morphologist Bonnie C. Yates explains that hair is a conservative tissue and, therefore, differences in the structure of the hair do not typically change among congeners unless the function has changed evolutionarily (personal communication). These functional changes are usually seen at higher taxonomic

levels (i.e., genus or family). Therefore, identification at the genus or family level may be the best that can be attained with present scientific certainty.

Rationale for Classification of Morphological Characteristics

Many classification schemes exist regarding the morphological structures of mammalian hair. The classification scheme employed by HAIRbase™ was presented by Thomas Moore and co-authors in 1974 (5). The classification schemes of the cellular organization of the medulla and cuticle can be seen in Figures 10 and 11, respectively. Individual hair fibers were classified using this scheme to correlate to the U.S. Fish and Wildlife Service that have also adopted this classification scheme for the use in wildlife forensic casework.

Rationale for Presentation of Micrographs

Hair from the dorsal region of mammals has been studied and characterized for use in atlases and other academic references for many years (3,5,7,10-14,26). However, often an animal will display extreme variability on different areas of its body (21-22). To account for this variation, three areas on each specimen were collected and analyzed and have been included in HAIRbase™. These areas are the dorsal, ventral, and tail regions of the specimen. While other areas on the body can certainly be collected and displayed, these three regions were found to be the most variable between species, and so were chosen to represent the range of hair variation of the given mammals.

Mammals have multiple grades of hair ranging from the long and coarse overhairs to the short and dense underhair or fur fibers (3,5,26). The transition of these grades of hair from one to another is more or less gradual; however, four grades of hair have been found to be distinguishable from one another (3).

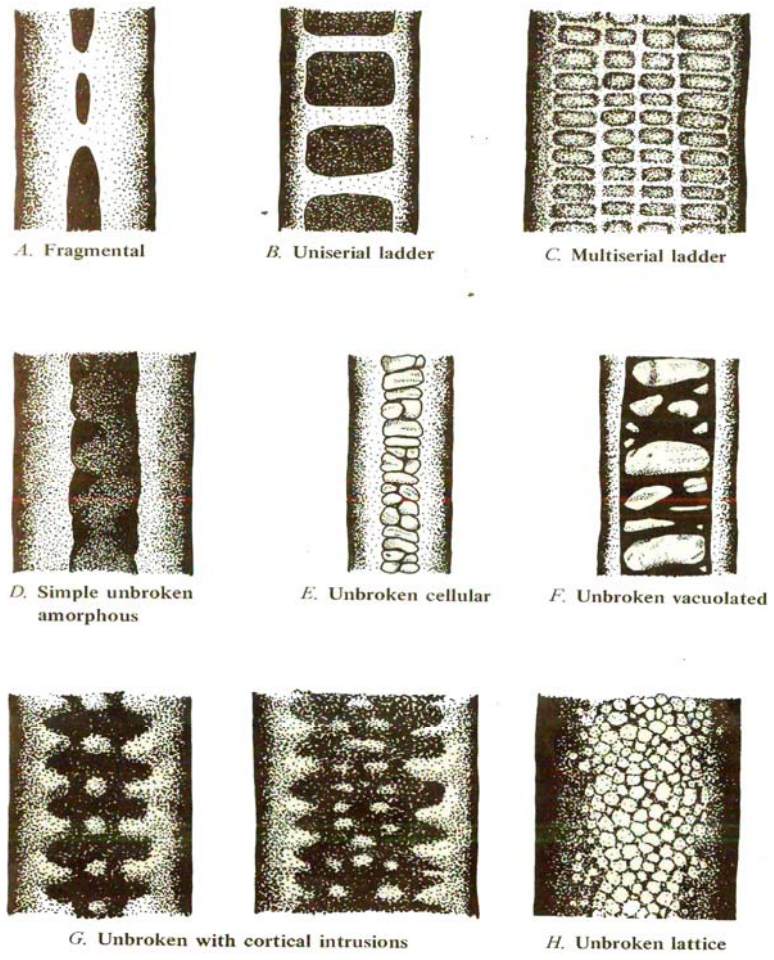

FIG 10: Cellular classifications of the mammalian medulla. Reproduced with permission of author. Moore *et al*. 1974 (5). This figure shows medullary classifications that can be seen in a mammalian hair fiber.

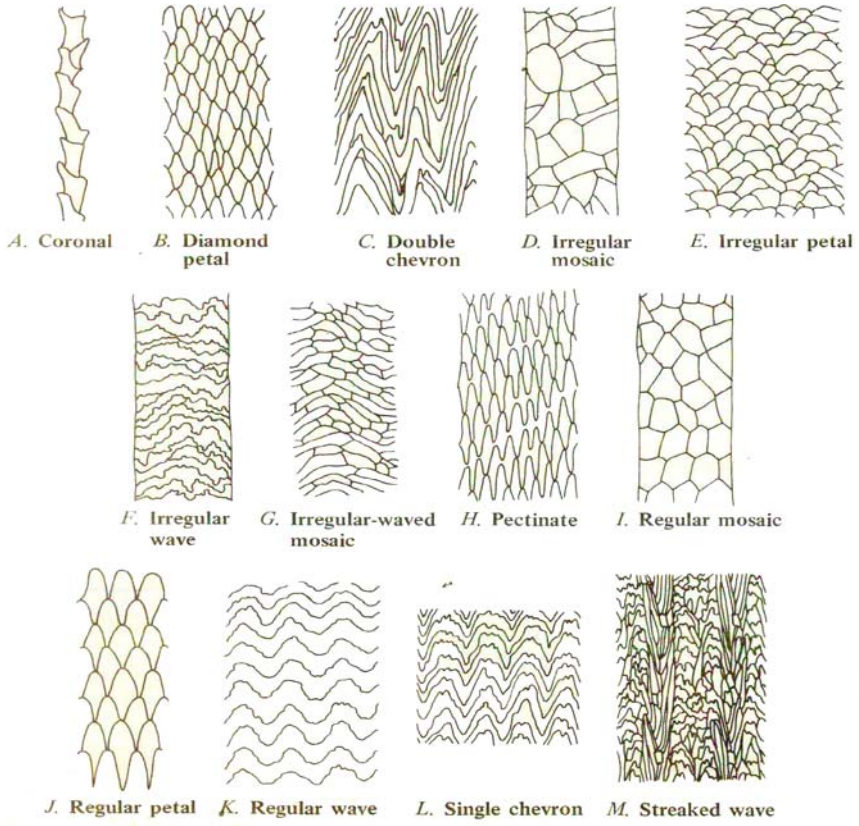

FIG 11: Cuticular pattern classifications of mammalian hair. Reproduced with permission of author. Moore *et al*. 1974 (5). This figure shows cuticular classifications that can be seen in a mammalian hair fiber.

Underhair is much thinner and appears to have a wavy appearance (3,10, 26). Underhair remains relatively consistent in structure and function across the class Mammalia with few exceptions (3,10). Underhair was not chosen for inclusion in HAIRbase™, because this grade of hair is diagnostically unremarkable in isolation. Among overhairs, the primary guard hair is coarser, sometimes with a thickening in the distal region of the hair, known as the shield, and a thinner proximal region, known as the sub-shield and basal regions (3,5,7,10). The primary and secondary guard hairs were chosen for representation in HAIRbase™ because they display a number of characteristics that can be used for identification purposes (3,24).

In addition to the variation of hair grades on each mammal, hairs can often display different characteristics depending on the linear position along the length of the hair being viewed (3,24,26). The three segments chosen for image capture – the basal, sub-shield, and shield regions of the hair – cover the widest range of variation along each hair shaft. The basal region of the hair is directly adjacent to the root. The sub-shield region is found on the shaft of the hair fiber. The shield is the area on the hair shaft that shows a marked increase in diameter. These areas were also chosen for inclusion in HAIRbase™ because they allow the viewing of a greater amount of characteristics and forensically are the areas that tend to be useful in hair comparisons (3,5,10).

Rationale for Website Presentation

The HAIRbase™ website is the graphical user interface (GUI), which was designed to accommodate professionals with a thorough knowledge of hair classification and identification. The website is formed around a cladogram of the class Mammalia with links to the individual order webpages. A navigation bar

allows easy navigation to the “Welcome,” “Home,” “About,” “Browse,” “FBIC,” “NFWFL,” and “Contact” webpages. The “Home” webpage displays the central cladogram previously described. The “About” webpage describes the materials and methods that were used in the construction of HAIRbase™. The “Browse” page offers an additional way to browse the collection. This is done through a listing of the mammalian orders comprising the dataset with the number of species representatives that currently represent that particular order of mammal. The “FBIC” and “NFWFL” are links to the home pages of the Forensic Biotechnology Institute of California and the National Fish and Wildlife Forensic Laboratory, respectively. These two agencies collaborated to create HAIRbase™. The “Contact” link directs the user to contact information that will allow the contribution of verified hair samples to HAIRbase™. The individual order webpages contain information of the order as a whole (e.g., # of species, genera, and families included) and any identifying hair characteristics that are commonly used to separate the hair of animals of that particular order. The individual representatives of each of the orders are further separated to the family taxonomic level (e.g., Canidae, Felidae, etc.). This facilitates the easy navigation through the collection of species. Also, it has been found that closely related species exhibit similar morphological characteristics regarding their hair fibers (3,5,10).

The organization and layout of the species page can be seen in its final form in Appendix C. The information included on these webpages was determined to be helpful for the successful determination of the origin of an unknown mammalian hair. An overall species image is included in the upper left corner of the page, adequately displaying the pelage and macroscopic appearance of the animal being viewed. Below the species image is a distribution map, displaying the geographical range of the given species as adapted from the IUCN Red List (49-

50). A link to a page presenting the scanning electron microscope images of an example of cuticular scalation at the familial level is included below the species distribution map. The right side of the webpage is dedicated to textual information including scientific classification of the animal (e.g., order, family, genus, species, etc.), conservation status, congeners to consider, pelage observations, and dorsal guard hair measurement and description. Conservation status refers to information regarding legal protection of the particular animal. The congeners of each species were also included, because the hair of closely related species is morphologically similar. This informs the viewer that these related mammals should be referred to in addition to the species illustrated for possible morphological similarity. Pelage observations refer to the macroscopic appearance of the animal (e.g., fur color variation, hair form, etc.). The dorsal guard hair measurement and description includes microscopic characterization of the guard hair depicted in the images. The measurements deemed appropriate for inclusion were:

1. Overall Length Measurement (in millimeters)
2. Shaft Diameter (in micrometers)
3. Medullary Index value (a proportion: medulla width/shaft width) (7)

The images were organized into albums by body region, displaying images of 3 morphological regions on each hair (basal, subshield, and shield). If these body regions were not available, another body region was chosen to display the morphological variation within the specimen. The individual images were organized into columns, with the primary guard hair images on the left and secondary guard hair images on the right. The basal, subshield, and shield regions were organized so that the user can easily view the morphological characteristics of the different regions of the hair shaft, as well as perform a cross comparison between the primary and secondary guard hairs. Provenance information, total

magnification, and any notes that may be of particular interest to the viewer or explanatory in nature (e.g., presence of clearing in the medulla) were included with the images. With the layout described above, the combination of ease of use and the information that the site contains will serve as a valuable applicative tool to professional trace evidence examiners.

User Guidelines

The arena of endangered species law and trade statutes are constantly changing and being updated (51). Since HAIRbase™ will remain "active" on the Internet, with more specimens, information, and images constantly being added, the information given about the conservation status for each species can change along with these regulations. The importance of a reliable online reference that can adapt to the changing needs of its user groups ensures that HAIRbase™ will remain a relevant reference for forensic professionals.

Almost as integral as the information contained within the database is the proper utilization of such a tool. The effective use of HAIRbase™, while begun from a perspective of wildlife forensic trace evidence analysis, remains similar in application across multiple disciplines dealing with hair identification. HAIRbase™ is intended to show variability and subtleties of animal hair structure and function. It is not intended as a replacement for microscopical comparison of actual animal hairs. Morphology, as a comparative science, ultimately relies on the use of a reference standard, that is, an actual hair from an identified source. The images collected in this database should not, nor were they meant to, be used alone or exclusively for an identification. The user is encouraged to always compare actual hair standards from known specimens for direct comparisons, whether microscopically or macroscopically.

The importance of reliable hair standards for hair identification is unquestioned. However, references and atlases play a large role in prompting further investigation of certain species and specimens. Atlases can also function as a type of initial screening process before preparing whole mounts of specimens and comparing to actual standards from a reference collection. HAIRbase™ is specifically geared to the forensic community, and is set apart because it approaches the study of hair morphology by stressing the concept of variation.

Hair is commonly seen in forensic casework and analyzed in a standardized manner reliant on comparison with a prepared reference sample. However, before this microscopical comparison can take place, the forensic analyst must generate investigative leads by eliminating certain species and considering ones that show similarities to the unknown sample. HAIRbase™ has been designed and constructed to be a launching point for further investigation, with the atlas implemented as a type of screening tool to eliminate unlikely species and further investigate similar candidates. Through the implementation of HAIRbase™, the time and resources required for the initiation of a hair examination are dramatically reduced.

Future Research

A great strength of HAIRbase™, and of dissemination on the Internet in general, is the ease of integration of new information and new techniques. The initial design and infrastructure of HAIRbase™ has been described here. However, because the website remains live on the Internet, there are multiple scientific avenues that can and should be pursued to ensure the professional use and application of HAIRbase™.

Internet dissemination allows the inclusion and analysis of more species within the class Mammalia quickly and easily. Containing approximately 5,400 species, the class Mammalia is extremely large and equally diverse. This thesis has described the analysis of 133 such mammals belonging to the Artiodactyla and Carnivora orders. However, there are other orders that remain undone and are forensically relevant. One forensically relevant order that requires classification and analysis is Primates. The development of a domestic section will also aid forensic examiners to aid in civil litigations. The inclusion of these species will further aid forensic professionals by giving them a reference for the variation occurring in non-human primates (i.e., monkeys and apes) and domestic species (i.e., dog, cats, sheep, etc.).

Owing to the overall coverage of variation among and within species, more body regions on each specimen can be collected and analyzed. More images of each hair fiber can be included in the dataset, as well as different grades of hair (other than primary and secondary guard hairs) on the same specimen. The cuticle scale pattern images can be expanded to the genera or species level. Currently, cuticle scale SEM images were taken at the family taxonomic level. Also, more images of the cuticle scale pattern can be captured.

New techniques can certainly be applied to the hair fibers under study. These techniques include taking transverse and longitudinal cross-sections of the hair fibers. The viewing of transverse cross-sections allows the analysis of the cross-sectional shape of the hair, which can be used to separate certain species (10). Longitudinal cross-sections permits “clearing” of the medulla, by allowing the infiltration of mounting media into the medullar cells and driving out the trapped air. This technique gives a clear view of the cellular composition of the medulla and can aid in hair identification by allowing the easy viewing of

morphological characteristics that may be obscured by dense pigment, or air in the medulla (24).

This discussion has been concerned with the morphological features of the hair of these selected mammals. However, there is no reason why HAIRbase™ cannot expand into the genetic realm. That is why HAIRbase™ is infinitely expandable. With multiple scientific avenues to consider, HAIRbase™ can truly become a valuable resource for forensic trace examiners and beyond.

SUMMARY

HAIRbase™ is a flexible online atlas of hair morphology, specifically geared to the needs of the wildlife forensic community, that attempts to address the deficiencies of past atlases by providing information on the characteristics of a given species as a whole while, at the same time, providing enough coverage of a given individual to adequately represent the amount of variation in the grades of hair that are generally encountered over an individual's entire body. HAIRbase™ currently includes 133 species chosen to represent the variation in the Artiodactyla and Carnivora orders within the class Mammalia, and for many species will include two grades of hair from three regions on the body of each individual, as well as three positional images from each hair. The user interface of HAIRbase™ is designed to allow easy navigation through the collection. Individual species' web pages display information regarding the specimen including observations of pelage, geographic distribution, and dorsal guard hair description and measurement, as well as the images captured for that particular specimen. The images are separated into individual albums displaying basal, sub-shield, and shield images of the primary and secondary guard hair from each of the particular areas on the specimen collected. The great strength of this database is the capability to add more specimens, allowing the database to grow and further accommodate the needs of the forensic trace examiner, as well as other professionals in scientific disciplines that employ morphology in the identification of trace material.

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APPENDICES

APPENDIX A: SPECIES INCLUDED IN HAIRBASE™

Order	Family	Genus	Species	Common Animal Name	Conservation Status
Artiodactyla	Antilocapridae	*Antilocapra*	*americana*	Pronghorn Antelope	least
	Bovidae	*Aepyceros*	*melampus*	Impala	least
		Alcelaphus	*buselaphus*	Kongoni Hartebeest	least
		Antidorcas	*marsupialis*	Springbuck	least
		Bison	***bison***	**Bison**	**near threatened**
		Bos	***grunniens***	**Yak**	**vulnerable**
			Javanicus	**Java Banteng**	**endangered**
			primigenius	**Cow**	**extinct in the wild**
			taurus	Domesticated Cow	domestic
		Bubalis	***mindorensis***	**Tamaraw**	**critically endangered**
		Budorcas	***taxicolor***	**Sichuan Takin**	**vulnerable**
		Capra	***caucasian***	**West caucasian Tahr**	**endangered**
			hircus	Goat	domestic
			ibex	Alpine Ibex	least
		Capricornus	***sumatraensis***	**Mainland Serow**	**near threatened**
		Cephalophus	***zebra***	**Zebra Duiker**	**vulnerable**
		Cervus	*elaphus*	Red Deer	least
		Connochaetes	*taurinus*	Bridled gnu-wildebeest	least

		Gazella	***rufifrons***	**Red-fronted Gazelle**	**vulnerable**
		Hippotragus	*equinus*	Roan Antelope	least
			niger	Sable Antelope	least
		Kobus	*ellipsiprymnus*	Waterbuck	least
		Litocranius	***walleri***	**Gerenuk**	**near threatened**
		Mardoqua	*sp*	Dik Dik	least
		Muntiacus	*reevesi*	Chinese Muntjac	least
		Naemorhedus	***goral***	**Himalayan Goral**	**near threatened**
		Nanger	*granti*	Grant's Gazelle	least
		Nilgitragus	***hylocrius***	**Nilgiri Tahr**	**endangered**
		Oreamnos	*americanus*	Mountain Goat	least
		Oreotragus	*oreotragus*	Klipspringer	least
		Oryx	***beisa***	**Beisa Oryx**	**near threatened**
			gazella	Gemsbok	least
		Ovibus	*moschatus*	Muskox	least
		Ovis	***ammon***	**Mountain Sheep**	**near threatened**
			canadensis	Mountain Big Horn Sheep	least
			dalli	White Sheep	least
			dalli	Dall Sheep	least
			domestica	Lincoln Cross Sheep	domestic
			ammon polii	**Marco Polo Sheep**	**near threatened**
		Pantholops	***hodgsonii***	**Tibetan Antelope**	**endangered**
		Philantomba	*monticola*	Blue Duiker	least
		Pseudois	*nayaur*	Chinese Bharal	least
		Raphicerus	*campestris*	Steinbuck	least
		Redunca	*redunca*	Bohor Reedbuck	least

		Rupicapra	*rupicapra*	Chamois	least
		Saiga	***tatarica***	**Saiga Antelope**	**critically endangered**
		Sylvicapra	*grimmia*	Crowned Duiker	least
		Taurotragus	*derbianus*	Giant Eland	least
		Tragelaphus	*strepsiceros*	Greater Kudu	least
		Tragelaphus	*anagasii*	Lowland Nyala	least
	Camelidae	*Alces*	*alces*	Moose	least
		Axis	***porcinus***	**Hog Deer**	**endangered**
		Camelus	*taur*	Dromedary Camel	domestic
		Capriolus	*capriolus*	Roe Deer	least
	Cervidae	*Cervus*	*nippon*	Sika Deer	least
			canadensis	Elk	least
		Dama	*dama*	Fallow Deer	least
		Elaphurus	***davidianus***	**Pere David's Deer**	**extinct in the wild**
		Lama	*glama*	Llama	domestic
			guanicoe	Guanaco	least
		Moschus	***mosciferus***	**Siberian Musk Deer**	**vulnerable**
		Muntiacus	*reevesi*	Reeve's Muntjac	least
		Odocoileus	*hemionus*	Mule Deer	least
			virginianus	White-tailed Deer	least
		Rangifer	*articus*	Barren Ground Carribou	least
			tarandus	Caribou	least
		Vicugna	*vicugna*	Vicugna	least
	Giraffidae	*Giraffa*	*camelopardalis*	Giraffe	least
		Okapi	***johnstonii***	**Okapi**	**near threatened**
	Suidae	*Sus*	*domestica*	Pig	domestic

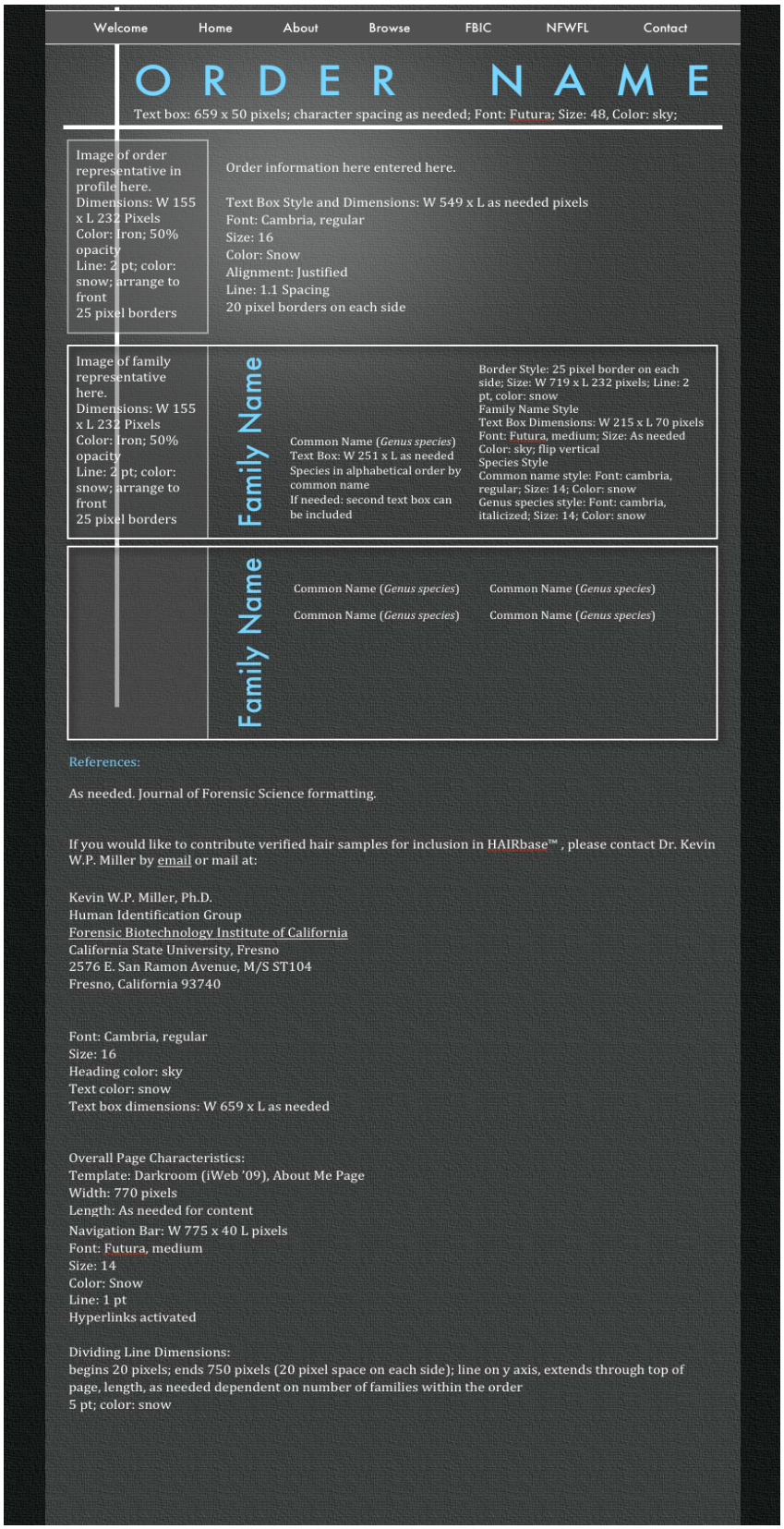
			scrofa	Wild Boar	least
	Tayassuidae	*Pecari*	*tajacu*	Collared Peccarry	least
	Tragulidae	*Tragulus*	*jovanicus*	Lesser Mouse Deer	least
Carnivora	**Ailuridae**	***Ailurus***	***fulgens***	**Red Panda**	**vulnerable**
	Canidae	*Canis*	*aureus*	Golden Jackal	least
			latrans	Coyote	least
			lupus	Grey Wolf	least
			lupus domesticus	Dog	domestic
		Cuon	***alpinus***	**Dhole**	**endangered**
		Lycaon	***pictus***	**African Wild Dog**	**endangered**
		Nyctereutes	*procyonoides*	Raccoon Dog	least
		Urocyon	*cinereoargenteus*	Grey Fox	least
		Vulpes	*vulpes*	Red Fox	least
	Felidae	***Acinonyx***	***jubatus***	**Cheetah**	**vulnerable**
		Felis	*catus*	Cat	domestic
			domestica	Domesticated Cat	domestic
		Leopardus	*pardalis*	Ocelot	least
		Linx	*canadensis*	Lynx	least
		Lynx	*rufus*	Bobcat	least
		Neofelis	***nebulosa***	**Clouded Leopard**	**vulnerable**
		Panthera	***leo***	**Lion**	**vulnerable**
			Onca	**Jaguar**	**near threatened**
			pardus	**Leopard**	**near threatened**
			tigris	**Tiger**	**vulnerable**
			tigris sumatrae	**Sumatran Tiger**	**critically endangered**
			tigris tigris	**Bengal Tiger**	**endangered**

		Prionailurus	*bengalensis*	Leopard Cat	least
		Puma	*concolor*	Puma	least
			yaguarundi	Jaguarundi	least
		Uncia	***uncia***	**Snow Leopard**	**endangered**
	Herpestidae	*Suricata*	*suricata*	African Meerkat	least
	Hyaenidae	*Crocuta*	*crocuta*	Spotted Hyaena	least
		Hyaena	***brunnea***	**Brown Hyaena**	**near threatened**
	Mephitidae	*Mephitis*	*mephitis*	Striped Skunk	least
		Spilogale	*putorius*	Eastern Spotted Skunk	least
	Mustelidae	***Aonyx***	***cinerea***	**Oriental Small-clawed Otter**	**vulnerable**
		Enhydra	***lutris***	**Sea Otter**	**endangered**
		Gulo	*gulo*	Wolverine	least
		Lontra	*canadensis*	North American River Otter	least
		Martes	*caurina*	American Marten	least
			zibellina	Sable	least
		Mustela	*erminea*	Ermine	least
			frenata	Long-tailed Weasel	least
			nigripes	**Black-footed Ferret**	**endangered**
			putorius	Ferret	domestic
			siberica	Siberian Mink	least
			vison	American Mink	least
		Taxidea	*taxus*	American Badger	least
		Martes	*pennanti*	Fisher	least
	Otariidae	***Calorhinus***	***ursinus***	**Northern Fur Seal**	**vulnerable**
		Zalophus	*californicus*	Sea Lion	least
	Phocidae	*Phoca*	*vitulina*	Harbor Seal	least

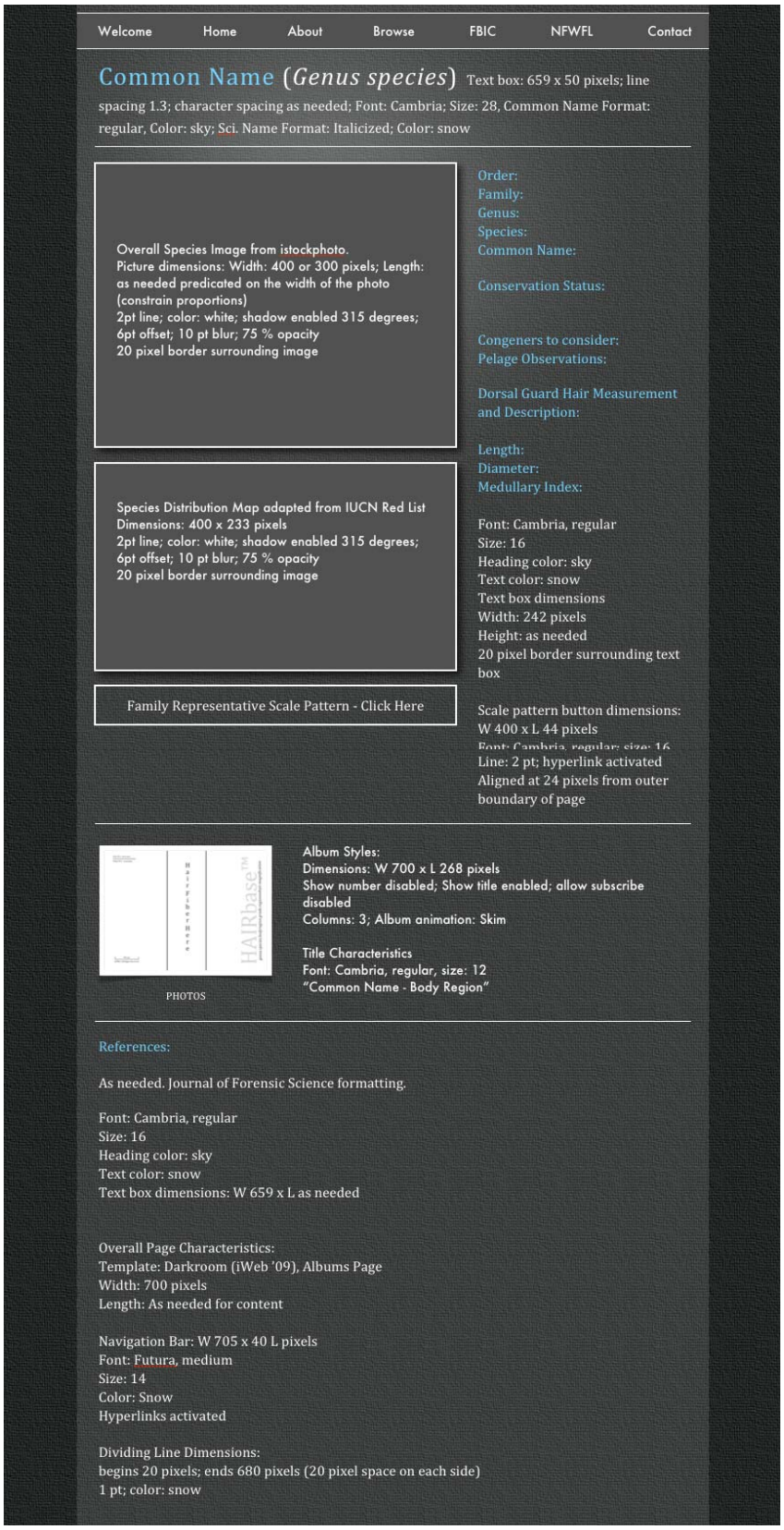
	Procyonidae	*Bassariscus*	*astutus*	Ringtail Cat	least
		Nasua	*narica*	White-nosed Coati	least
		Procyon	*lotor*	Raccoon	least
		Potos	*flavus*	Kinkajou	least
	Ursidae	***Ailuropoda***	***melanoleuca***	**Giant Panda**	**endangered**
		Genetta	*thierryi*	Genet Cat	least
		Ursus	*arctos*	Brown Bear	least
		Helarctos	***malayanus***	**Malayan Sunbear**	**vulnerable**
		Melursus	***ursinus***	**Sloth Bear**	**vulnerable**
		Tremarctos	***ornatus***	**Sloth Bear**	**vulnerable**
		Ursus	*americanus*	Black Bear	least
			thibetanus	**Asiatic Black Bear**	**vulnerable**
			maritimus	**Polar Bear**	**vulnerable**
			arctos horribilis	**Grizzly Bear**	**vulnerable**

Bolded species are currently protected under the Endangered Species act of 1974.

APPENDIX B: WEBPAGE TEMPLATES



Order webpage template



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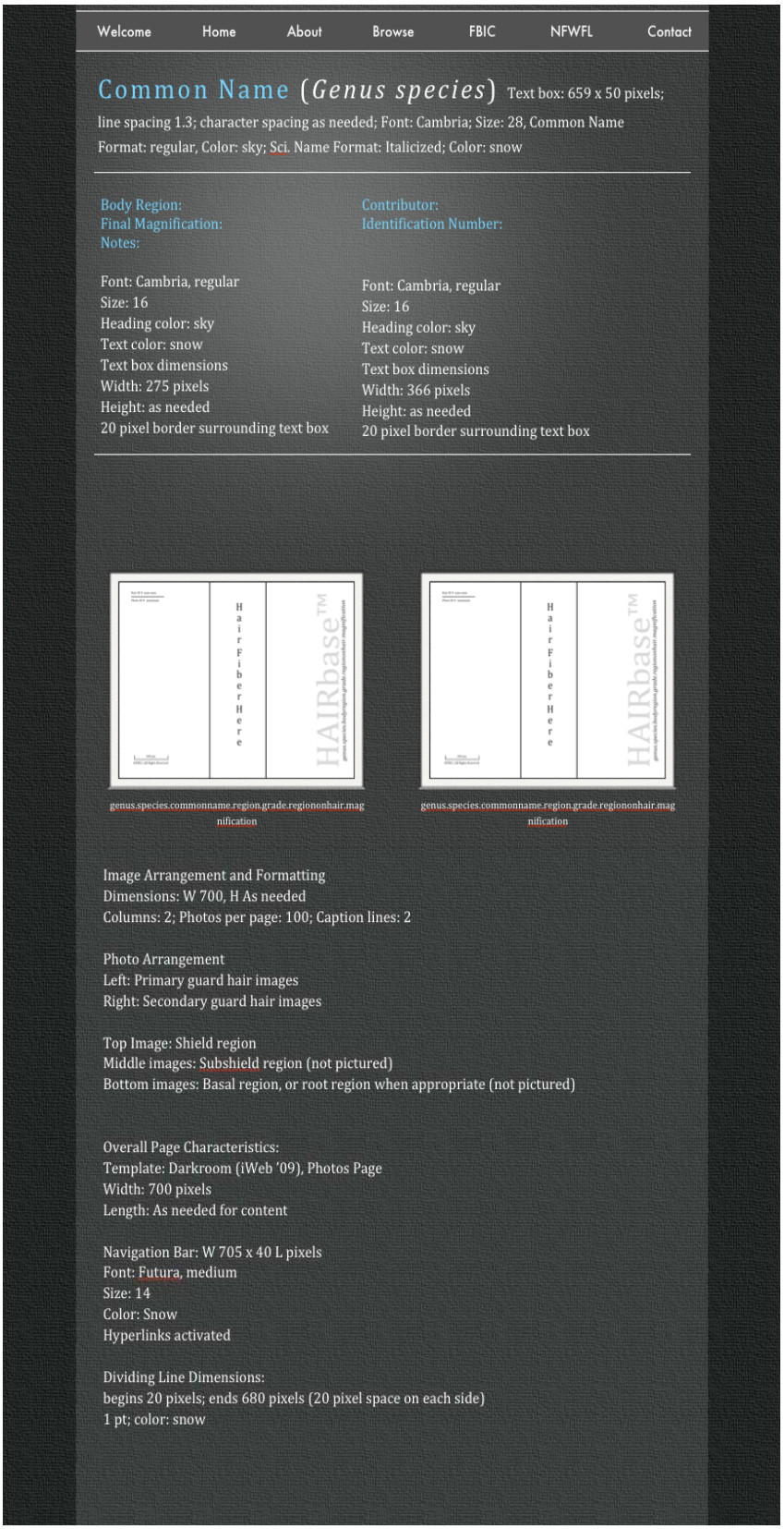
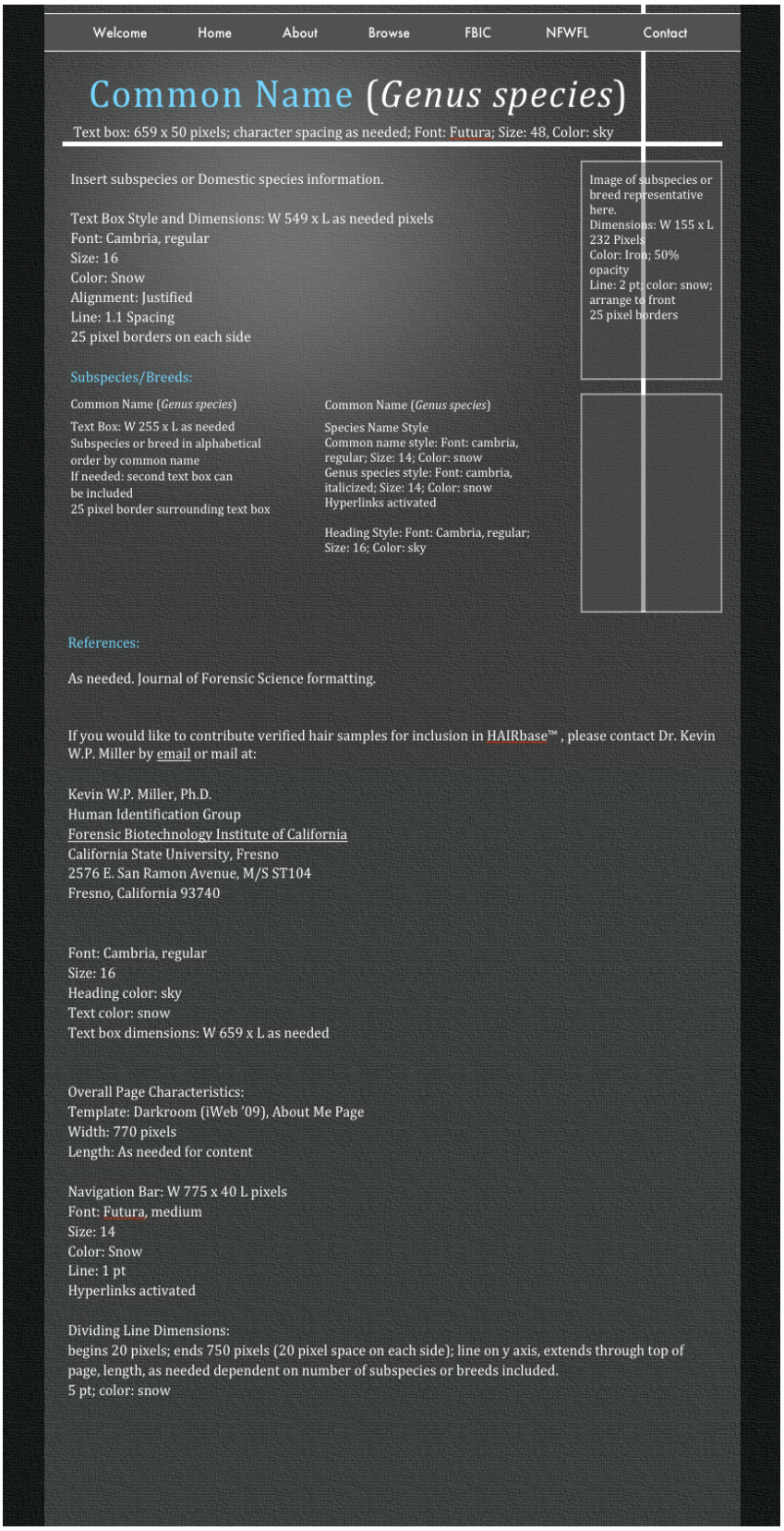


Album webpage template



Subspecies/Breed webpage template

APPENDIX C: HAIRBASE™ IDENTIFICATION NUMBERS AND CONGENERS

Order	Common Name	Identification Number	Congeners
Artiodactyla	Pronghorn Antelope	BA516	None
	Addax	NFWFL Coll.	None
	Impala	NFWFL Coll.	None
	Kongoni Hartebeest	CSU BGC 01	*caama, lichtensteinii*
	Springbok	CSU BGC 02	None
	American Bison	NFWFL Coll.	*bonasus*
	Yak	NFWFL Coll.	*frontalis, javanicus, sauveli, taurus*
	Java Banteng	NFWFL Coll.	*frontalis, grunniens, sauveli, taurus*
	Domestic Cow	NFWFL Coll.	*frontalis, grunniens, javanicus, sauveli*
	Tamaraw	NFWFL Coll.	*bubalis, depressicornis, quarlesi*
	Sichuan Takin	NFWFL Coll.	None
	West Caucasian Tur	NFWFL Coll.	*falconeri, hircus, ibex, nubiana, pyrenaica, sibirica, walie*
	Goat	NFWFL Coll.	*caucasica, falconeri, ibex, nubiana, pyrenaica, sibirica, walie*
	Alpine Ibex	NFWFL Coll.	*caucasica, falconeri, hircus, nubiana, pyrenaica, sibirica, walie*
	Mainland Serow	NFWFL Coll.	*crispus, milneedwardsii, rubidus, swinhoei, thar*
	Zebra Duiker	NFWFL Coll.	*adersi, brookei, callipygus, dorsalis, jentinki, leucogaster, natalensis, niger, nigrifrons, ogilbyi, rufilatus, silvicultor, spadix, weynsi*
	Blue Wildebeest	CSU BGC 04	*gnou*
	Red-fronted Gazelle	CSU BGC 06	*rufina, thomsonii*
	Nilgiri Tahr	NFWFL Coll.	*jayakari, jemlahicus*

	Roan Antelope	NFWFL Coll.	*leucophaeus, niger*
	Sable Antelope	NFWFL Coll.	*equinus, leucophaeus*
	Waterbuck	CSU BGC 07	*kob, leche, megaceros, vardonii*
	Gerenuk	CSU BGC 08	None
	Dik Dik	CSU BGC 09	*guentheri, kirkii, piacentinii, saltiana*
	Himalayan Goral	NFWFL Coll.	*baileyi, caudatus, griseus*
	Grant's Gazelle	CSU BGC 10	*dama, soemmerringii*
	Mountain Goat	NFWFL Coll.	None
	Klipspringer	CSU BGC 11	None
	Beisa Oryx	CSU BGC 12	*dammah, gazella, leucoryx*
	Gemsbok	NFWFL Coll.	*beisa, dammah, leucoryx*
	Muskox	NFWFL Coll.	None
	Argali	NFWFL Coll.	*aries, canadensis, dalli, nivicola*
	Marco Polo Sheep	NFWFL Coll.	*aries, canadensis, dalli, nivicola*
	Lincolnshire Cross Sheep	mam 612	*ammon, canadensis, dalli, nivicola*
	Mountain Big Horn Sheep	NFWFL Coll.	*ammon, aries, dalli, nivicola*
	Dall's Sheep	NFWFL Coll.	*ammon, aries, canadensis, nivicola*
	Chiru	NFWFL Coll.	None
	Blue Duiker	NFWFL Coll.	*maxwellii*
	Chinese Bharal	NFWFL Coll.	*schaeferi*
	Steenbok	CSU BGC 14	*melanotis, sharpei*
	Bohor Reedbuck	CSU BGC 15	*arundinum, fulvorufula*
	Chamois	NFWFL Coll.	*pyrenaica*
	Saiga Antelope	NFWFL Coll.	*borealis*

	Common Duiker	NFWFL Coll.	None
	Cape Buffalo	CSU BGC 16	None
	Giant Eland	NFWFL Coll.	*oryx*
	Lowland Nyala	NFWFL Coll.	*buxtoni, eurycerus, imberbis, scriptus, spekii, strepsiceros*
	Greater Kudu	CSU BGC 17	*angasii, buxtoni, eurycerus, imberbis, scriptus, spekii*
	Dromedary Camel	NFWFL Coll.	*bactrianus, dromedarius*
	Llama	NFWFL Coll.	None
	Guanaco	NFWFL Coll.	None
	Vicugna	NFWFL Coll.	None
	Moose	NFWFL Coll.	*americanus*
	Hog Deer	NFWFL Coll.	*axis, calamianensis, kuhlii*
	Roe Deer	NFWFL Coll.	*pygargus*
	Elk	CSU BGC 03	*elaphus, nippon*
	Red Deer	NFWFL Coll.	*nippon*
	Sika Deer	NFWFL Coll.	*elaphus*
	Fallow Deer	N1304	None
	Pere David's Deer	NFWFL Coll.	None
	Siberian Musk Deer	39637	*anhuiensis, berezovskii, chrysogaster, cupreus, fuscus, leucogaster*
	Indian Muntjac	NFWFL Coll.	*atherodes, crinifrons, feae, gongshanensis, puhoatensis, putaoensis, reevesi, rooseveltorum, truongsonensis, vuquangensis*
	Reeve's Muntjac	NFWFL Coll.	*atherodes, crinifrons, feae, gongshanensis, muntjak, puhoatensis, putaoensis, rooseveltorum, truongsonensis, vuquangensis*
	Mule Deer	mam 214	*virginianus*
	White-tailed Deer	NFWFL Coll.	*hemionus*
	Caribou	NFWFL Coll.	None

	Giraffe	NFWFL Coll.	None
	Okapi	35928	None
	Pig	NFWFL Coll.	*ahoenobarbus, barbatus, bucculentus, cebifrons, celebensis, oliveri, philippensis, salvanius, verrucosus*
	Wild Boar	mam 1718	*ahoenobarbus, barbatus, bucculentus, cebifrons, celebensis, oliveri, philippensis, salvanius, verrucosus*
	Collared Peccary	NFWFL Coll.	None
	Lesser Mouse Deer	NFWFL Coll.	*kanchil, napu, nigricans, versicolor, williamsoni*
Carnivora	Red Panda	NFWFL Coll.	None
	Golden Jackal	NFWFL Coll.	*adustus, latrans, lupus, mesomelas, simensis*
	Dog	NFWFL Coll.	*adustus, aureus, latrans, lupus, mesomelas, simensis*
	Coyote	N1115	*adustus, aureus, lupus, mesomelas, simensis*
	Grey Wolf	N1081	*adustus, aureus, latrans, mesomelas, simensis*
	Dhole	501049	None
	African Wild Dog	NFWFL Coll.	None
	Raccoon Dog	NFWFL Coll.	None
	Grey Fox	CSU 1506	*littoralis*
	Red Fox	N1087	*lagopus, macrotis, pallida, bengalensis, cana, chama, corsac, ferrilata, rueppelii, velox, zerda*
	Cheetah	NFWFL Coll.	None
	Domestic Cat	NFWFL Coll.	*bieti, catus, chaus, manul, margarita, nigripes, silvestris*
	Ocelot	NFWFL Coll.	*braccatus, colocolo, geoffroyi, guigna, jacobitius, pajeros, tigrinus, wiedii*
	Lynx	N1245	*lynx, pardinus, rufus*
	Bobcat	CSU 1705	*canadensis, lynx, pardinus*
	Clouded Leopard	NFWFL Coll.	None
	Lion	NFWFL Coll.	*onca, pardus, tigris*

	Jaguar	NFWFL Coll.	*leo, pardus, tigris*
	Leopard	NFWFL Coll.	*leo, onca, tigris*
	Sumatran Tiger	MO 608344	*leo, onca, pardus*
	Bengal Tiger	591444	*leo onca, pardus*
	Leopard Cat	NFWFL Coll.	*iriomotensis, planiceps, rubiginosus, viverrinus*
	Puma	N1240	*yagouaroundi*
	Jaguarundi	NFWFL Coll.	*concolor*
	Snow Leopard	NFWFL Coll.	None
	African Meerkat	35944	None
	Spotted Hyena	NFWFL Coll.	None
	Brown Hyena	789503, 1449	*hyaena*
	Striped Skunk	NFWFL Coll.	*macroura*
	Eastern Spotted Skunk	NFWFL Coll.	*aquaticus, angustifrons, gracilis, pygmaea*
	Oriental small clawed otter	NFWFL Coll.	*capensis*
	Sea Otter	NFWFL Coll.	None
	Wolverine	NFWFL Coll.	None
	North American Otter	mam 075	*felina, longicaudis, provocax*
	American Marten	NFWFL Coll.	*americana, flavigula, foina, gwatkinsii, martes, melampus, pennanti, zibellina*
	Fisher	NFWFL Coll.	*americana, flavigula, foina, gwatkinsii, martes, melampus, zibellina*
	Sable	NFWFL Coll.	*americana, flavigula, foina, gwatkinsii, martes, melampus, pennanti*
	Ermine	CSU 69	*eversmanii, africana, altaica, felipei, frenata, itatsi, kathiah,*

			lutreola, lutreolina, nigripes, nivalis, nudipes, putorius, sibirica, strigidorsa, subpalmata
	Long-tailed Weasel	CSU 74	*erminea, eversmanii, africana, altaica, felipei, itatsi, kathiah, lutreola, lutreolina, nigripes, nivalis, nudipes, putorius, sibirica, strigidorsa, subpalmata*
	Black-footed Ferret	NFWFL Coll.	*erminea, eversmanii, africana, altaica, felipei, frenata, itatsi, kathiah, lutreola, lutreolina, nivalis, nudipes, putorius, sibirica, strigidorsa, subpalmata*
	Ferret	NFWFL Coll.	*erminea, eversmanii, africana, altaica, felipei, frenata, itatsi, kathiah, lutreola, lutreolina, nigripes, nivalis, nudipes, sibirica, strigidorsa, subpalmata*
	Siberian Mink	NFWFL Coll.	*erminea, eversmanii, africana, altaica, felipei, frenata, itatsi, kathiah, lutreola, lutreolina, nigripes, nivalis, nudipes, strigidorsa, subpalmata*
	American Mink	CSU 2818	*macrodon*
	American Badger	NFWFL Coll.	None
	Northern Fur Seal	NFWFL Coll.	None
	Sea Lion	NFWFL Coll.	*japonicus, wollebaeki*
	Harbor Seal	NFWFL Coll.	*largha*
	Ringtail Cat	NFWFL Coll.	*sumichrasti*
	White-nosed Coati	NFWFL Coll.	*nasua*
	Kinkajou	mam 1343	None
	Raccoon	CSU 1508	*cancrivorus, pygmaeus*
	Giant Panda	NFWFL Coll.	None
	Malayan Sunbear	NFWFL Coll.	None
	Sloth Bear	NFWFL Coll.	None
	Spectacled Bear	NFWFL Coll.	None

	American Black Bear	N1125	*arctos, maritimus, thibetanus*
	Brown Bear	NFWFL Coll.	*americanus, maritimus, thibetanus*
	Grizzly Bear	CSU BGC 18	*americanus, arctos, maritimus, thibetanus*
	Polar Bear	NFWFL Coll.	*americanus, arctos, thibetanus*
	Asiatic Black Bear	NFWFL Coll.	*americanus, arctos, maritimus*
	Genet Cat	NFWFL Coll.	*abyssinica, angolensis, bourloni, cristata, genetta, johnstoni, maculata, pardina, piscivora, poensis, servalina, tigrina, victoriae*

APPENDIX D: HAIRBASE™ SPECIES COLLECTION AND STORAGE CHECKLIST

Order	Common Name	Backer Page	Small Labels	Large Labels	Dorsal Collected and Stored	Ventral Collected and Stored	Tip of Tail Collected and Stored	Other Regions Collected and Stored
Artiodactyla	Pronghorn Antelope	06/15/10	06/21/10	07/12/10	06/30/10	06/30/10	None Available	Forehead
	Addax	06/14/10	02/08/10	07/12/10	06/30/10	06/30/10	06/30/10	None
	Impala	06/14/10	02/08/10	07/12/10	06/30/10	06/30/10	None Available	Forehead
	Kongoni Hartebeest	06/18/10	06/21/10	07/12/10	06/21/10	06/21/10	None Available	Forehead
	Springbok	06/18/10	06/21/10	07/12/10	06/21/10	06/21/10	None Available	Forehead
	American Bison	06/14/10	02/08/10	07/12/10	06/30/10	06/30/10	06/30/10	None
	Yak	06/14/10	02/08/10	07/12/10	06/30/10	06/30/10	06/30/10	None
	Java Banteng	06/14/10	02/08/10	02/08/10	06/28/10	06/28/10	06/28/10	Forehead, Top of Foot, back of thigh, vibrissae
	Domestic Cow	06/14/10	03/15/10	07/12/10	06/30/10	06/30/10	06/30/10	None
	Tamaraw	06/15/10	02/09/10	07/12/10	06/30/10	06/30/10	None Available	Forehead
	Sichuan Takin	06/15/10	02/09/10	02/09/10	06/28/10	06/28/10	06/28/10	Forehead, Top of Foot, back of thigh, vibrissae
	West Caucasian Tur	06/15/10	02/09/10	07/12/10	06/30/10	06/30/10	06/30/10	None
	Goat	06/15/10	02/09/10	07/12/10	07/01/10	07/01/10	07/01/10	None
	Alpine Ibex	06/15/10	02/08/10	07/12/10	06/30/10	06/30/10	06/30/10	None
	Mainland Serow	06/15/10	02/08/10	07/12/10	06/30/10	06/30/10	None Available	Forehead
	Zebra Duiker	06/07/10	02/09/10	02/09/10	06/28/10	06/28/10	06/28/10	Forehead, Top of Foot, back of thigh, vibrissae
	Blue Wildebeest	06/18/10	06/21/10	07/12/10	06/21/10	06/21/10	None Available	Forehead
	Red-fronted	06/18/10	06/21/10	07/12/10	06/21/10	06/21/10	None Available	Forehead

	Gazelle							
	Nilgiri Tahr	06/07/10	02/09/10	07/12/10	07/01/10	07/01/10	07/01/10	None
	Roan Antelope	06/07/10	07/15/10	07/12/10	06/30/10	06/30/10	06/30/10	Forehead, Back of Thigh
	Sable Antelope	06/07/10	06/30/10	07/12/10	06/30/10	06/30/10	06/30/10	None
	Waterbuck	06/18/10	06/21/10	07/12/10	06/21/10	06/21/10	None Available	Forehead
	Gerenuk	06/18/10	06/21/10	07/12/10	06/21/10	06/21/10	None Available	Forehead
	Dik Dik	06/18/10	06/21/10	07/12/10	06/21/10	06/21/10	None Available	Forehead
	Himalayan Goral	06/18/10	02/09/10	07/12/10	06/30/10	06/30/10	06/30/10	None
	Grant's Gazelle	06/18/10	06/21/10	07/12/10	06/21/10	06/21/10	None Available	Forehead
	Mountain Goat	06/18/10	02/09/10	07/12/10	07/01/10	07/01/10	07/01/10	None
	Klipspringer	06/18/10	06/21/10	07/12/10	06/21/10	06/21/10	None Available	Forehead
	Beisa Oryx	06/18/10	06/21/10	07/12/10	06/21/10	06/21/10	None Available	Forehead
	Gemsbok	06/18/10	02/09/10	07/12/10	07/01/10	07/01/10	07/01/10	None
	Muskox	06/18/10	02/09/10	07/12/10	07/01/10	07/01/10	07/01/10	None
	Argali	06/07/10	02/09/10	07/12/10	07/01/10	None Available	None Available	Top of Foot
	Marco Polo Sheep	06/18/10	02/09/10	07/12/10	07/01/10	07/01/10	07/01/10	None
	Lincolnshire Cross Sheep	06/07/10	02/09/10	02/09/10	06/28/10	06/28/10	06/28/10	Forehead, Top of foot, Back of Thigh, Vibrissae
	Mountain Big Horn Sheep	06/07/10	02/09/10	07/12/10	07/01/10	07/01/10	07/01/10	None
	Dall's Sheep	06/18/10	02/09/10	07/15/10	07/01/10	07/01/10	07/01/10	None
	Chiru	06/18/10	02/09/10	07/15/10	07/01/10	07/01/10	None Available	Forehead
	Blue Duiker	06/18/10	02/10/10	07/15/10	07/01/10	07/01/10	07/01/10	None

	Chinese Bharal	06/18/10	02/10/10	07/15/10	07/01/10	07/01/10	07/01/10	None
	Steenbok	06/18/10	06/21/10	07/15/10	06/21/10	06/21/10	None Available	Forehead
	Bohor Reedbuck	06/18/10	06/21/10	07/15/10	06/21/10	06/21/10	None Available	Forehead
	Chamois	06/07/10	02/10/10	07/15/10	07/01/10	07/01/10	None Available	Forehead
	Saiga Antelope	06/07/10	02/10/10	06/30/10	06/26/10	06/26/10	06/26/10	None
	Common Duiker	06/07/10	02/10/10	07/15/10	07/01/10	07/01/10	07/01/10	None
	Cape Buffalo	06/18/10	08/03/10	07/15/10	06/21/10	06/21/10	None Available	Forehead
	Giant Eland	06/07/10	02/10/10	02/10/10	06/28/10	06/28/10	06/28/10	Forehead, Top of Foot, back of thigh, vibrissae
	Lowland Nyala	06/07/10	02/10/10	02/10/10	06/28/10	06/28/10	06/28/10	Top of foot, Back of Thigh, Forehead
	Greater Kudu	06/18/10	06/21/10	07/15/10	06/21/10	06/21/10	None Available	Forehead
	Dromedary Camel	06/08/10	02/10/10	07/15/10	06/30/10	06/30/10	06/30/10	None
	Llama	06/08/10	02/10/10	07/15/10	06/30/10	06/30/10	06/30/10	None
	Guanaco	06/08/10	02/10/10	07/15/10	06/30/10	06/30/10	06/30/10	None
	Vicugna	06/08/10	02/10/10	07/15/10	07/01/10	07/01/10	07/01/10	None
	Moose	06/08/10	06/21/10	07/15/10	06/30/10	None Available	06/30/10	Forehead
	Hog Deer	06/08/10	02/10/10	07/15/10	06/30/10	06/30/10	06/30/10	None
	Roe Deer	06/08/10	02/10/10	02/10/10	06/28/10	06/28/10	06/28/10	Forehead, Top of Foot, back of thigh, vibrissae
	Elk	06/18/10	06/21/10	07/15/10	06/21/10	06/21/10	None Available	Forehead
	Red Deer	06/15/10	02/10/10	07/15/10	06/30/10	06/30/10	06/30/10	None
	Sika Deer	06/15/10	02/10/10	07/15/10	06/30/10	06/30/10	06/30/10	None
	Fallow Deer	06/15/10	09/04/10	07/15/10	06/30/10	06/30/10	None Available	Forehead, Vibrissae
	Pere David's	06/15/10	02/10/10	02/10/10	06/28/10	06/28/10	06/28/10	Forehead, Top of Foot,

	Deer							back of thigh, vibrissae
	Siberian Musk Deer	06/15/10	02/10/10	07/15/10	07/01/10	06/30/10	06/30/10	None
	Indian Muntjac	06/15/10	02/11/10	06/26/10	06/26/10	06/26/10	06/26/10	Forehead, Top of Foot, back of thigh, vibrissae
	Reeve's Muntjac	06/15/10	02/11/10	02/11/10	06/28/10	06/28/10	06/28/10	Forehead, Top of Foot, back of thigh, vibrissae
	Mule Deer	06/15/10	02/11/10	07/15/10	07/01/10	07/01/10	07/01/10	None
	White-tailed Deer	06/15/10	02/11/10	07/15/10	06/26/10	06/26/10	06/26/10	None
	Caribou	06/11/10	02/11/10	06/30/10	06/26/10	06/26/10	06/26/10	None
	Giraffe	06/15/10	06/21/10	07/15/10	06/30/10	06/30/10	06/30/10	None
	Okapi	06/15/10	02/11/10	07/15/10	07/01/10	07/01/10	07/01/10	Back of Thigh, Forehead
	Pig	06/15/10	02/11/10	02/11/10	07/01/10	07/01/10	07/01/10	None
	Wild Boar	06/15/10	02/11/10	07/15/10	07/01/10	07/01/10	07/01/10	None
	Collared Peccary	06/15/10	02/11/10	07/15/10	07/01/10	07/01/10	07/01/10	Unspecified
	Lesser Mouse Deer	06/11/10	02/11/10	07/15/10	07/01/10	07/01/10	07/01/10	None
Carnivora	Red Panda	06/11/10	02/11/10	06/30/10	06/23/10	06/23/10	06/23/10	None
	Golden Jackal	06/11/10	02/11/10	06/30/10	06/23/10	06/23/10	06/23/10	None
	Dog	06/11/10	02/11/10	02/11/10	07/01/10	07/01/10	07/01/10	None
	Coyote	06/09/10	02/11/10	02/11/10	06/28/10	06/28/10	06/28/10	Forehead, Top of foot, Back of Thigh, Vibrissae
	Grey Wolf	06/11/10	02/11/10	02/11/10	06/28/10	06/28/10	06/28/10	Forehead, Top of foot, Back of Thigh, Vibrissae
	Dhole	06/09/10	02/11/10	06/30/10	07/15/10	06/28/10	06/28/10	None

	African Wild Dog	06/09/10	02/12/10	02/12/10	06/28/10	06/28/10	06/28/10	Forehead, Top of foot, Back of Thigh, Vibrissae
	Raccoon Dog	06/09/10	02/12/10	06/30/10	06/23/10	06/23/10	06/23/10	None
	Grey Fox	06/15/10	12/03/10	12/03/10	06/23/10	06/23/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh
	Red Fox	06/09/10	02/12/10	02/12/10	06/23/10	06/23/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh
	Cheetah	06/11/10	09/04/10	06/30/10	06/23/10	06/23/10	06/23/10	None
	Domestic Cat	06/11/10	02/12/10	02/12/10	07/01/10	07/01/10	07/01/10	None
	Ocelot	06/11/10	02/12/10	06/30/10	06/23/10	06/23/10	06/23/10	None
	Lynx	06/11/10	02/12/10	06/30/10	06/23/10	06/23/10	06/23/10	None
	Bobcat	06/15/10	02/12/10	02/12/10	06/28/10	06/28/10	06/28/10	Forehead, Top of Foot, back of thigh, vibrissae
	Clouded Leopard	06/11/10	02/12/10	06/30/10	06/23/10	06/23/10	06/23/10	None
	Lion	06/18/10	09/04/10	06/30/10	06/23/10	06/23/10	06/23/10	None
	Jaguar	06/18/10	02/12/10	06/30/10	06/23/10	06/23/10	06/23/10	None
	Leopard	06/18/10	09/04/10	06/30/10	06/23/10	06/23/10	06/23/10	None
	Sumatran Tiger	06/18/10	02/12/10	06/30/10	06/23/10	06/23/10	06/23/10	None
	Bengal Tiger	06/15/10	02/12/10	06/30/10	06/23/10	06/23/10	06/23/10	None
	Leopard Cat	06/15/10	02/12/10	06/30/10	06/23/10	06/23/10	None Available	Forehead
	Puma	06/15/10	02/12/10	06/30/10	06/23/10	06/23/10	06/23/10	None
	Jaguarundi	06/15/10	02/12/10	02/12/10	06/28/10	06/28/10	06/28/10	Forehead, Top of Foot, back of thigh, vibrissae
	Snow Leopard	06/11/10	02/15/10	06/30/10	06/23/10	06/23/10	06/23/10	None
	African	06/11/10	02/15/10	07/15/10	None Available	06/23/10	06/23/10	Forehead

	Meerkat							
	Spotted Hyena	06/11/10	02/15/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	Brown Hyena	06/18/10	02/15/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	Striped Skunk	06/18/10	02/15/10	06/23/10	06/23/10	06/23/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh
	Eastern Spotted Skunk	06/11/10	02/15/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	Oriental small clawed otter	06/11/10	02/15/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	Sea Otter	06/09/10	02/15/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	Wolverine	06/09/10	02/15/10	07/15/10	06/28/10	06/28/10	06/28/10	None
	North American Otter	06/09/10	02/15/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	American Marten	06/09/10	02/15/10	06/23/10	06/23/10	06/23/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh
	Fisher	06/15/10	02/15/10	06/23/10	06/23/10	06/23/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh
	Sable	06/15/10	02/15/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	Ermine	06/15/10	02/15/10	06/23/10	06/23/10	06/23/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh
	Long-tailed Weasel	06/15/10	02/15/10	06/23/10	06/23/10	06/23/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh
	Black-footed Ferret	06/15/10	02/16/10	07/15/10	06/23/10	06/23/10	06/23/10	None

	Ferret	06/15/10	02/16/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	Siberian Mink	06/08/10	02/16/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	American Mink	06/08/10	02/16/10	02/16/10	06/23/10	06/23/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh
	American Badger	06/08/10	02/16/10	02/16/10	06/28/10	06/28/10	06/28/10	Forehead, Top of foot, Back of Thigh, Vibrissae
	Northern Fur Seal	06/08/10	02/16/10	07/15/10	06/23/10	06/23/10	None Available	Forehead
	Sea Lion	06/08/10	02/16/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	Harbor Seal	06/07/10	02/16/10	07/15/10	06/23/10	06/23/10	None Available	Forehead
	Ringtail Cat	06/07/10	02/16/10	02/16/10	06/23/10	06/23/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh
	White-nosed Coati	06/07/10	02/16/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	Kinkajou	06/07/10	02/16/10	02/16/10	06/28/10	06/28/10	06/28/10	Forehead, Top of foot
	Raccoon	06/07/10	02/16/10	06/23/10	06/23/10	06/23/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh
	Giant Panda	06/07/10	02/16/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	Malayan Sunbear	06/07/10	02/16/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	Sloth Bear	06/07/10	02/16/10	06/23/10	06/23/10	06/23/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh
	Spectacled Bear	06/07/10	02/16/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	American Black Bear	06/07/10	02/16/10	02/16/10	06/28/10	06/28/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh

	Brown Bear	06/07/10	02/16/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	Grizzly Bear	06/18/10	06/21/10	07/15/10	06/21/10	06/21/10	06/21/10	None
	Polar Bear	06/07/10	02/16/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	Asiatic Black Bear	06/07/10	02/16/10	07/15/10	06/23/10	06/23/10	06/23/10	None
	Genet Cat	06/07/10	02/16/10	07/15/10	06/23/10	06/23/10	06/23/10	None

APPENDIX E: HAIRBASE™ MICROSCOPE PREPARATION CHECKLIST

Order	Common Name	Dorsal Plated	Ventral Plated	Tip of Tail Plated	Others Body Parts Plated
Artiodactyla	Pronghorn Antelope	06/23/10	06/23/10	None Available	Forehead
	Addax	06/15/10	06/15/10	06/15/10	None Available
	Impala	06/23/10	06/23/10	None Available	Forehead
	Kongoni Hartebeest	06/23/10	06/23/10	None Available	Forehead
	Springbok	06/23/10	06/23/10	None Available	Forehead
	American Bison	06/23/10	06/23/10	06/23/10	None Available
	Yak	06/15/10	06/15/10	06/15/10	None Available
	Java Banteng	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Domestic Cow	06/15/10	06/15/10	06/15/10	None Available
	Tamaraw	06/16/10	06/16/10	None Available	Forehead
	Sichuan Takin	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	West Caucasian Tur	06/15/10	06/15/10	06/15/10	None Available
	Goat	06/16/10	06/16/10	06/16/10	None Available
	Alpine Ibex	06/17/10	06/17/10	06/17/10	None Available
	Mainland Serow	06/18/10	06/18/10	None Available	Forehead
	Zebra Duiker	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Blue Wildebeest	06/23/10	06/23/10	None Available	Forehead
	Red-fronted Gazelle	06/23/10	06/23/10	None Available	Forehead
	Nilgiri Tahr	06/18/10	06/18/10	06/18/10	None Available
	Roan Antelope	07/02/10	07/02/10	07/02/10	Forehead, Back of Thigh
	Sable Antelope	07/02/10	07/02/10	07/02/10	None Available
	Waterbuck	06/23/10	06/23/10	None Available	Forehead
	Gerenuk	06/23/10	06/23/10	None Available	Forehead
	Dik Dik	06/23/10	06/23/10	None Available	Forehead
	Himalayan Goral	07/02/10	07/02/10	07/02/10	None Available

	Grant's Gazelle	06/23/10	06/23/10	None Available	Forehead
	Mountain Goat	06/23/10	06/23/10	06/23/10	None Available
	Klipspringer	06/23/10	06/23/10	None Available	Forehead
	Beisa Oryx	06/23/10	06/23/10	None Available	Forehead
	Gemsbok	07/02/10	07/02/10	07/02/10	None Available
	Muskox	07/02/10	07/02/10	07/02/10	None Available
	Argali	07/02/10	None Available	None Available	Top of Foot
	Marco Polo Sheep	07/02/10	07/02/10	07/02/10	None Available
	Lincolnshire Cross Sheep	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Mountain Big Horn Sheep	06/23/10	06/23/10	06/23/10	None Available
	Dall's Sheep	06/23/10	06/23/10	06/23/10	None Available
	Chiru	07/08/10	07/08/10	None Available	Forehead
	Blue Duiker	07/08/10	07/08/10	07/08/10	None Available
	Chinese Bharal	07/08/10	07/08/10	07/08/10	None Available
	Steenbok	06/23/10	06/23/10	None Available	Forehead
	Bohor Reedbuck	06/23/10	06/23/10	None Available	Forehead
	Chamois	07/08/10	07/08/10	None Available	Forehead
	Saiga Antelope	07/08/10	07/08/10	07/08/10	None Available
	Common Duiker	07/11/10	07/11/10	07/11/10	None Available
	Cape Buffalo	07/18/10	07/18/10	None Available	Forehead
	Giant Eland	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Lowland Nyala	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Top of Foot
	Greater Kudu	06/23/10	06/23/10	None Available	Forehead
	Dromedary Camel	07/11/10	07/11/10	07/11/10	None Available
	Llama	07/11/10	07/11/10	07/11/10	None Available
	Guanaco	07/11/10	07/11/10	07/11/10	None Available

	Vicugna	07/18/10	07/18/10	07/18/10	None Available
	Moose	06/23/10	None Available	06/23/10	Forehead
	Hog Deer	07/18/10	07/18/10	07/18/10	None Available
	Roe Deer	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Elk	06/23/10	06/23/10	None Available	Forehead
	Red Deer	07/18/10	07/18/10	07/18/10	None Available
	Sika Deer	07/11/10	07/11/10	07/18/10	None Available
	Fallow Deer	07/18/10	07/18/10	None Available	Forehead
	Pere David's Deer	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Siberian Musk Deer	07/11/10	07/11/10	07/11/10	None Available
	Indian Muntjac	06/23/10	06/23/10	06/23/10	Forehead, Top of Foot, back of thigh, vibrissae
	Reeve's Muntjac	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Mule Deer	06/23/10	06/23/10	06/23/10	None Available
	White-tailed Deer	06/05/10	06/05/10	06/05/10	None Available
	Caribou	06/23/10	06/23/10	06/23/10	None Available
	Giraffe	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Top of Foot
	Okapi	06/05/10	06/05/10	06/05/10	Back of Thigh, Forehead
	Pig	06/23/10	06/23/10	06/23/10	None Available
	Wild Boar	06/23/10	06/23/10	06/23/10	None Available
	Collared Peccary	06/23/10	06/23/10	06/23/10	Unspecified
	Lesser Mouse Deer	06/23/10	06/23/10	06/23/10	None Available
Carnivora	Red Panda	06/23/10	06/23/10	06/23/10	None Available
	Golden Jackal	06/23/10	06/23/10	06/23/10	None Available
	Dog	06/23/10	06/23/10	06/23/10	None Available
	Coyote	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Grey Wolf	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot

	Dhole	06/23/10	06/23/10	06/23/10	None Available
	African Wild Dog	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae
	Raccoon Dog	06/23/10	06/23/10	06/23/10	None Available
	Grey Fox	06/23/10	06/23/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh
	Red Fox	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Cheetah	06/23/10	06/23/10	06/23/10	None Available
	Domestic Cat	06/23/10	06/23/10	06/23/10	None Available
	Ocelot	06/23/10	06/23/10	06/23/10	None Available
	Lynx	06/23/10	06/23/10	06/23/10	None Available
	Bobcat	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Clouded Leopard	06/23/10	06/23/10	06/23/10	None Available
	Lion	06/23/10	06/23/10	06/23/10	None Available
	Jaguar	06/23/10	06/23/10	06/23/10	None Available
	Leopard	06/23/10	06/23/10	06/23/10	None Available
	Sumatran Tiger	07/15/10	07/15/10	07/15/10	None Available
	Bengal Tiger	07/15/10	07/15/10	07/15/10	None Available
	Leopard Cat	07/15/10	07/15/10	None Available	Forehead
	Puma	09/13/10	09/13/10	09/13/10	None Available
	Jaguarundi	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Snow Leopard	09/13/10	09/13/10	09/13/10	None Available
	African Meerkat	None Avalable	07/15/10	07/15/10	Forehead
	Spotted Hyena	06/23/10	06/23/10	06/23/10	None Available
	Brown Hyena	07/15/10	07/15/10	07/15/10	None Available
	Striped Skunk	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Eastern Spotted Skunk	07/15/10	07/15/10	07/15/10	None Available
	Oriental small clawed otter	06/23/10	06/23/10	06/23/10	None Available

	Sea Otter	07/15/10	07/15/10	07/15/10	None Available
	Wolverine	08/01/10	08/01/10	08/01/10	None Available
	North American Otter	07/15/10	07/15/10	07/15/10	None Available
	American Marten	06/23/10	06/23/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh
	Fisher	08/01/10	08/01/10	08/01/10	Top of foot, Forehead, Vibrissae, Back of thigh
	Sable	08/01/10	08/01/10	08/01/10	None Available
	Ermine	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Long-tailed Weasel	06/23/10	06/23/10	06/23/10	Top of foot, Forehead, Vibrissae, Back of thigh
	Black-footed Ferret	08/01/10	08/01/10	08/01/10	None Available
	Ferret	08/01/10	08/01/10	08/01/10	None Available
	Siberian Mink	08/01/10	08/01/10	08/01/10	None Available
	American Mink	06/23/10	06/23/10	06/23/10	None Available
	American Badger	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Northern Fur Seal	06/23/10	06/23/10	None Available	Forehead
	Sea Lion	08/01/10	08/01/10	08/01/10	None Available
	Harbor Seal	07/15/10	07/15/10	None Available	Forehead
	Ringtail Cat	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	White-nosed Coati	06/23/10	06/23/10	06/23/10	None Available
	Kinkajou	06/23/10	06/23/10	06/23/10	Forehead, Top of foot
	Raccoon	06/23/10	06/23/10	06/23/10	None Available
	Giant Panda	06/23/10	06/23/10	06/23/10	None Available
	Malayan Sunbear	08/01/10	08/01/10	08/01/10	None Available
	Sloth Bear	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Spectacled Bear	08/01/10	08/01/10	08/01/10	None Available
	American Black Bear	06/23/10	06/23/10	06/23/10	Back of Thigh, Forehead, Vibrissae, Top of Foot
	Brown Bear	06/23/10	06/23/10	06/23/10	None Available

	Grizzly Bear	06/23/10	06/23/10	06/23/10	None Available
	Polar Bear	08/01/10	08/01/10	08/01/10	None Available
	Asiatic Black Bear	06/23/10	06/23/10	06/23/10	None Available
	Genet Cat	08/01/10	08/01/10	08/01/10	None Available

APPENDIX F: HAIRBASE™ IMAGING AND WEBPAGE DESIGN CHECKLIST

Order	Common Name	Dorsal Images Taken	Ventral Images Taken	Tip of Tail Images Taken	Other Body Part Images Taken	SEM Image Taken	Images Photoshopped	Images Uploaded	Images Checked	Webpage Complete
Artiodactyla	Pronghorn Antelope	10/11/10	10/11/10	None Available	Forehead	06/23/10	10/14/10	10/14/10	10/18/10	10/18/10
	Addax	10/11/10	10/11/10	10/11/10	None	None Available	10/14/10	10/14/10	10/18/10	10/18/10
	Impala	10/11/10	10/11/10	None Available	Forehead	06/23/10	10/14/10	10/14/10	10/18/10	10/18/10
	Kongoni Hartebeest	10/11/10	10/11/10	None Available	Forehead	None Available	10/14/10	10/14/10	10/18/10	10/18/10
	Springbok	10/11/10	10/11/10	None Available	Forehead	None Available	10/14/10	10/14/10	10/18/10	10/18/10
	American Bison	10/12/10	10/12/10	10/12/10	None	06/23/10	10/15/10	10/15/10	10/18/10	10/18/10
	Yak	10/12/10	10/12/10	10/12/10	None	None Available	10/15/10	10/15/10	10/18/10	10/18/10
	Java Banteng	10/12/10	10/12/10	10/12/10	None	None Available	10/15/10	10/15/10	10/18/10	10/18/10
	Domestic Cow	10/12/10	10/12/10	10/12/10	None	06/23/10	10/15/10	10/15/10	10/18/10	10/18/10
	Tamaraw	10/12/10	10/12/10	None Available	Forehead	None Available	10/15/10	10/15/10	10/18/10	10/18/10
	Sichuan Takin	10/12/10	10/12/10	10/12/10	None	None Available	10/15/10	10/15/10	10/18/10	10/18/10
	West Caucasian Tur	10/12/10	10/12/10	10/12/10	None	None Available	10/15/10	10/15/10	10/18/10	10/18/10
	Goat	10/18/10	10/18/10	10/18/10	None	None Available	10/21/10	10/21/10	10/25/10	10/25/10
	Alpine Ibex	10/18/10	10/18/10	10/18/10	None	None Available	10/21/10	10/21/10	10/25/10	10/25/10
	Mainland Serow	10/18/10	10/18/10	None Available	Forehead	None Available	10/21/10	10/21/10	10/25/10	10/25/10
	Zebra Duiker	10/18/10	10/18/10	10/18/10	None	None Available	10/21/10	10/21/10	10/25/10	10/25/10
	Blue Wildebeest	10/18/10	10/18/10	None Available	Forehead	None Available	10/21/10	10/21/10	10/25/10	10/25/10

	Red-fronted Gazelle	10/21/10	10/21/10	None Available	Forehead	06/23/10	10/22/10	10/22/10	10/25/10	10/25/10
	Nilgiri Tahr	10/21/10	10/21/10	10/21/10	None	None Available	10/22/10	10/22/10	10/25/10	10/25/10
	Roan Antelope	10/21/10	10/21/10	10/21/10	None	None Available	10/22/10	10/22/10	10/25/10	10/25/10
	Sable Antelope	10/21/10	10/21/10	10/21/10	None	None Available	10/22/10	10/22/10	10/25/10	10/25/10
	Waterbuck	10/21/10	10/21/10	None Available	Forehead	None Available	10/22/10	10/22/10	10/25/10	10/25/10
	Gerenuk	10/21/10	10/21/10	None Available	Forehead	None Available	10/22/10	10/22/10	10/25/10	10/25/10
	Dik Dik	11/08/10	11/08/10	None Available	Forehead	06/23/10	11/11/10	11/11/10	11/15/10	11/15/10
	Himalayan Goral	11/08/10	11/08/10	11/08/10	None	None Available	11/11/10	11/11/10	11/15/10	11/15/10
	Grant's Gazelle	11/08/10	11/08/10	None Available	Forehead	06/23/10	11/11/10	11/11/10	11/15/10	11/15/10
	Mountain Goat	11/08/10	11/08/10	11/08/10	None	06/23/10	11/11/10	11/11/10	11/15/10	11/15/10
	Klipspringer	11/08/10	11/08/10	None Available	Forehead	None Available	11/11/10	11/11/10	11/15/10	11/15/10
	Beisa Oryx	11/08/10	11/08/10	None Available	Forehead	None Available	11/11/10	11/11/10	11/15/10	11/15/10
	Gemsbok	11/09/10	11/09/10	11/09/10	None	None Available	11/12/10	11/12/10	11/15/10	11/15/10
	Muskox	11/09/10	11/09/10	11/09/10	None	None Available	11/12/10	11/12/10	11/15/10	11/15/10
	Argali	11/09/10	None Available	None Available	Top of Foot	None Available	11/12/10	11/12/10	11/15/10	11/15/10
	Marco Polo Sheep	11/09/10	11/09/10	11/09/10	None	None Available	11/12/10	11/12/10	11/15/10	11/15/10
	Lincolnshire Cross Sheep	11/09/10	11/09/10	11/09/10	None	None Available	11/12/10	11/12/10	11/15/10	11/15/10
	Mountain Big Horn Sheep	11/18/10	11/18/10	11/18/10	None	06/23/10	11/19/10	11/19/10	11/22/10	11/22/10
	Dall's Sheep	11/18/10	11/18/10	11/18/10	None	None Available	11/19/10	11/19/10	11/22/10	11/22/10
	Chiru	11/18/10	11/18/10	None Available	Forehead	None Available	11/19/10	11/19/10	11/22/10	11/22/10

	Blue Duiker	11/18/10	11/18/10	11/18/10	None	06/23/10	11/19/10	11/19/10	11/22/10	11/22/10
	Chinese Bharal	11/18/10	11/18/10	11/18/10	None	None Available	11/19/10	11/19/10	11/22/10	11/22/10
	Steenbok	11/18/10	11/18/10	None Available	Forehead	06/23/10	11/19/10	11/19/10	11/22/10	11/22/10
	Bohor Reedbuck	11/18/10	11/18/10	None Available	Forehead	06/23/10	11/19/10	11/19/10	11/22/10	11/22/10
	Chamois	12/06/10	12/06/10	None Available	Forehead	None Available	12/09/10	12/09/10	01/10/11	01/10/11
	Saiga Antelope	12/06/10	12/06/10	12/06/10	None	None Available	12/09/10	12/09/10	01/10/11	01/10/11
	Common Duiker	12/06/10	12/06/10	12/06/10	None	None Available	12/09/10	12/09/10	01/10/11	01/10/11
	Cape Buffalo	12/06/10	12/06/10	None Available	Forehead	None Available	12/09/10	12/09/10	01/10/11	01/10/11
	Giant Eland	12/06/10	12/06/10	12/06/10	None	None Available	12/09/10	12/09/10	01/10/11	01/10/11
	Lowland Nyala	12/06/10	12/06/10	12/06/10	None	None Available	12/09/10	12/09/10	01/10/11	01/10/11
	Greater Kudu	12/07/10	12/07/10	None Available	Forehead	06/23/10	12/10/11	12/10/11	01/10/11	01/10/11
	Dromedary Camel	12/07/10	12/07/10	12/07/10	None	None Available	12/10/11	12/10/11	01/10/11	01/10/11
	Llama	12/07/10	12/07/10	12/07/10	None	None Available	12/10/11	12/10/11	01/10/11	01/10/11
	Guanaco	12/07/10	12/07/10	12/07/10	None	None Available	12/10/11	12/10/11	01/10/11	01/10/11
	Vicugna	12/07/10	12/07/10	12/07/10	None	None Available	12/10/11	12/10/11	01/10/11	01/10/11
	Moose	12/07/10	None Available	12/07/10	Forehead	06/23/10	12/10/11	12/10/11	01/10/11	01/10/11
	Hog Deer	12/07/10	12/07/10	12/07/10	None	None Available	12/10/11	12/10/11	01/10/11	01/10/11
	Roe Deer	12/07/10	12/07/10	12/07/10	None	None Available	12/10/11	12/10/11	01/10/11	01/10/11
	Elk	12/13/10	01/03/11	None Available	Forehead	06/23/10	01/06/11	01/06/11	01/17/11	01/17/11
	Red Deer	12/13/10	01/03/11	01/03/11	None	None Available	01/06/11	01/06/11	01/17/11	01/17/11
	Sika Deer	12/13/10	01/03/11	01/03/11	None	None Available	01/06/11	01/06/11	01/17/11	01/17/11

	Fallow Deer	12/13/10	01/03/11	None Available	Forehead	None Available	01/06/11	01/06/11	01/17/11	01/17/11
	Pere David's Deer	12/13/10	01/03/11	01/03/11	None	None Available	01/06/11	01/06/11	01/17/11	01/17/11
	Siberian Musk Deer	12/13/10	01/03/11	01/03/11	None	None Available	01/06/11	01/06/11	01/17/11	01/17/11
	Indian Muntjac	12/13/10	01/03/11	01/03/11	None	None Available	01/06/11	01/06/11	01/17/11	01/17/11
	Reeve's Muntjac	12/14/10	01/04/11	01/04/10	None	None Available	01/07/11	01/07/11	01/17/11	01/17/11
	Mule Deer	12/14/10	01/04/11	01/04/10	None	06/23/10	01/07/11	01/07/11	01/17/11	01/17/11
	White-tailed Deer	12/14/10	01/04/11	01/04/10	None	None Available	01/07/11	01/07/11	01/17/11	01/17/11
	Caribou	12/14/10	01/04/11	01/04/10	None	None Available	01/07/11	01/07/11	01/17/11	01/17/11
	Giraffe	12/14/10	01/04/11	01/04/10	None	None Available	01/07/11	01/07/11	01/17/11	01/17/11
	Okapi	12/14/10	01/04/11	01/04/10	None	None Available	01/07/11	01/07/11	01/17/11	01/17/11
	Pig	12/14/10	01/04/11	01/04/10	None	None Available	01/07/11	01/07/11	01/17/11	01/17/11
	Wild Boar	12/14/10	01/04/11	01/04/10	None	None Available	01/07/11	01/07/11	01/17/11	01/17/11
	Collared Peccary	12/15/10	01/10/11	01/10/11	Unspecified	None Available	01/13/11	01/13/11	01/17/11	01/17/11
	Lesser Mouse Deer	12/15/10	01/10/11	01/10/11	None	None Available	01/13/11	01/13/11	02/07/11	02/07/11
Carnivora	Red Panda	12/15/10	01/10/11	01/10/11	None	06/23/10	01/13/11	01/13/11	02/07/11	02/07/11
	Golden Jackal	12/16/10	01/10/11	01/10/11	None	None Available	01/13/11	01/13/11	02/07/11	02/07/11
	Dog	12/16/10	01/10/11	01/10/11	None	None Available	01/13/11	01/13/11	02/07/11	02/07/11
	Coyote	12/16/10	01/10/11	01/10/11	None	06/23/10	01/13/11	01/13/11	02/07/11	02/07/11
	Grey Wolf	12/16/10	01/10/11	01/10/11	None	06/23/10	01/13/11	01/13/11	02/07/11	02/07/11
	Dhole	09/07/10	09/07/10	09/07/10	None	None Available	09/09/10	09/09/10	09/13/10	09/13/10
	African Wild Dog	09/07/10	09/07/10	09/07/10	None	None Available	09/09/10	09/09/10	09/13/10	09/13/10

	Raccoon Dog	09/07/10	09/07/10	09/07/10	None	None Available	09/09/10	09/09/10	09/13/10	09/13/10
	Grey Fox	09/07/10	09/07/10	09/07/10	None	None Available	09/09/10	09/09/10	09/13/10	09/13/10
	Red Fox	08/16/10	08/16/10	08/16/10	None	06/23/10	09/09/10	09/09/10	09/13/10	09/13/10
	Cheetah	09/07/10	09/07/10	09/07/10	None	06/23/10	09/09/10	09/09/10	09/13/10	09/13/10
	Domestic Cat	09/07/10	09/07/10	09/07/10	None	None Available	09/09/10	09/09/10	09/13/10	09/13/10
	Ocelot	08/16/10	08/16/10	08/16/10	None	None Available	09/09/10	09/09/10	09/13/10	09/13/10
	Lynx	09/08/10	09/08/10	09/08/10	None	None Available	09/09/10	09/09/10	09/13/10	09/13/10
	Bobcat	09/08/10	09/08/10	09/08/10	None	06/23/10	09/09/10	09/09/10	09/13/10	09/13/10
	Clouded Leopard	09/08/10	09/08/10	09/08/10	None	None Available	09/09/10	09/09/10	09/13/10	09/13/10
	Lion	08/16/10	08/16/10	08/16/10	None	06/23/10	09/09/10	09/09/10	09/13/10	09/13/10
	Jaguar	09/13/10	09/13/10	09/13/10	None	None Available	09/16/10	09/16/10	09/20/10	09/20/10
	Leopard	09/13/10	09/13/10	09/13/10	None	06/23/10	09/16/10	09/16/10	09/20/10	09/20/10
	Sumatran Tiger	09/13/10	09/13/10	09/13/10	None	None Available	09/16/10	09/16/10	09/20/10	09/20/10
	Bengal Tiger	09/13/10	09/13/10	09/13/10	None	None Available	09/16/10	09/16/10	09/20/10	09/20/10
	Leopard Cat	08/16/10	08/16/10	None Available	Forehead	None Available	09/16/10	09/16/10	09/20/10	09/20/10
	Puma	09/14/10	09/14/10	09/14/10	None	None Available	09/17/10	09/17/10	09/20/10	09/20/10
	Jaguarundi	09/14/10	09/14/10	09/14/10	None	None Available	09/17/10	09/17/10	09/20/10	09/20/10
	Snow Leopard	09/14/10	09/14/10	09/14/10	None	None Available	09/17/10	09/17/10	09/20/10	09/20/10
	African Meerkat	None Available	09/14/10	09/14/10	Forehead	None Available	09/17/10	09/17/10	09/20/10	09/20/10
	Spotted Hyena	09/14/10	09/14/10	09/14/10	None	None Available	09/17/10	09/17/10	09/20/10	09/20/10
	Brown Hyena	09/14/10	09/14/10	09/14/10	None	None Available	09/17/10	09/17/10	09/20/10	09/20/10

	Striped Skunk	08/16/10	08/16/10	08/16/10	None	06/23/10	09/17/10	09/17/10	09/20/10	09/20/10
	Eastern Spotted Skunk	09/20/10	09/20/10	09/20/10	None	None Available	09/23/10	09/23/10	09/27/10	09/27/10
	Oriental small clawed otter	09/20/10	09/20/10	09/20/10	None	None Available	09/23/10	09/23/10	09/27/10	09/27/10
	Sea Otter	09/20/10	09/20/10	09/20/10	None	None Available	09/23/10	09/23/10	09/27/10	09/27/10
	Wolverine	09/20/10	09/20/10	09/20/10	None	None Available	09/23/10	09/23/10	09/27/10	09/27/10
	North American Otter	09/20/10	09/20/10	09/20/10	None	None Available	09/23/10	09/23/10	09/27/10	09/27/10
	American Marten	09/20/10	09/20/10	09/20/10	None	None Available	09/23/10	09/23/10	09/27/10	09/27/10
	Fisher	09/20/10	09/20/10	09/20/10	None	None Available	09/23/10	09/23/10	09/27/10	09/27/10
	Sable	08/16/10	08/16/10	08/16/10	None	None Available	09/24/10	09/24/10	09/27/10	09/27/10
	Ermine	09/21/10	09/21/10	09/21/10	None	06/23/10	09/24/10	09/24/10	09/27/10	09/27/10
	Long-tailed Weasel	09/21/10	09/21/10	09/21/10	None	06/23/10	09/24/10	09/24/10	09/27/10	09/27/10
	Black-footed Ferret	09/21/10	09/21/10	09/21/10	None	None Available	09/24/10	09/24/10	09/27/10	09/27/10
	Ferret	09/21/10	09/21/10	09/21/10	None	None Available	09/24/10	09/24/10	09/27/10	09/27/10
	Siberian Mink	09/21/10	09/21/10	09/21/10	None	None Available	09/24/10	09/24/10	09/27/10	09/27/10
	American Mink	09/21/10	09/21/10	09/21/10	None	06/23/10	09/24/10	09/24/10	09/27/10	09/27/10
	American Badger	09/21/10	09/21/10	09/21/10	None	06/23/10	09/24/10	09/24/10	09/27/10	09/27/10
	Northern Fur Seal	08/16/10	08/16/10	None Available	Forehead	None Available	09/24/10	09/24/10	09/27/10	09/27/10
	Sea Lion	09/27/10	09/27/10	09/27/10	None	06/23/10	09/30/10	09/30/10	10/04/10	10/04/10
	Harbor Seal	09/27/10	09/27/10	None Available	Forehead	06/23/10	09/30/10	09/30/10	10/04/10	10/04/10

	Ringtail Cat	09/27/10	09/27/10	09/27/10	None	None Available	09/30/10	09/30/10	10/04/10	10/04/10
	White-nosed Coati	09/27/10	09/27/10	09/27/10	None	06/23/10	09/30/10	09/30/10	10/04/10	10/04/10
	Kinkajou	09/27/10	09/27/10	09/27/10	None	None Available	09/30/10	09/30/10	10/04/10	10/04/10
	Raccoon	09/27/10	09/27/10	09/27/10	None	06/23/10	09/30/10	09/30/10	10/04/10	10/04/10
	Giant Panda	09/27/10	09/27/10	09/27/10	None	None Available	09/30/10	09/30/10	10/04/10	10/04/10
	Malayan Sunbear	08/16/10	08/16/10	08/16/10	None	None Available	09/30/10	09/30/10	10/04/10	10/04/10
	Sloth Bear	09/28/10	09/28/10	09/28/10	None	None Available	10/01/10	10/01/10	10/04/10	10/04/10
	Spectacled Bear	09/28/10	09/28/10	09/28/10	None	None Available	10/01/10	10/01/10	10/04/10	10/04/10
	American Black Bear	09/28/10	09/28/10	09/28/10	None	None Available	10/01/10	10/01/10	10/04/10	10/04/10
	Brown Bear	09/28/10	09/28/10	09/28/10	None	06/23/10	10/01/10	10/01/10	10/04/10	10/04/10
	Grizzly Bear	09/28/10	09/28/10	09/28/10	None	None Available	10/01/10	10/01/10	10/04/10	10/04/10
	Polar Bear	09/28/10	09/28/10	09/28/10	None	06/23/10	10/01/10	10/04/10	10/04/10	10/4/10
	Asiatic Black Bear	08/16/10	08/16/10	08/16/10	None	06/23/10	10/01/10	10/04/10	10/04/10	10/4/10
	Genet Cat	09/28/10	09/28/10	09/28/10	None	06/23/10	10/01/10	10/04/10	10/04/10	10/4/10

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