FORENSIC ORNITHOLOGY

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INTRODUCTION

Feathers are among the most uniquely designed, beautiful structures in nature and have evolved to serve a variety of functions (e.g. protection, recognition, attraction, aerodynamics, insulation). While there are many different types of feathers on a single bird's body (e.g., contour, semiplume, down, bristle, filoplume), the contour (body, wing and tail) feathers are the most diagnostic to the casual observer. Recognizing the plumage (a collective term for all of the feathers that cover the bird's body) is one of the most common ways that we identify the many different species of birds. The individual feathers (which together make up the plumage) also vary among and within species, and even exhibit differences on a single bird's body. For example, examination of the plumage of a male Mallard Duck (*Anas platyrhynchos*) reveals different colors, shapes, textures, sizes, and patterns on most every part of the body. In addition, each contour feather is generally made up of different types of barbs - 1) Pennaceous barbs are stiff and make up the feather vanes which give color, pattern and texture to the whole feather, 2) Plumulaceous (downy) barbs are fluffy, soft barbs located at the base of most contour feathers and are thought to aid in insulation. Although these two types of barbs have homologous structures, they appear very different from each other when viewed with light microscopy. The reasons for these morphological differences are not truly known but could be due to functional constraints on each part of the feather (e.g. flight vs insulation).

Chandler (1916) was the first to thoroughly examine the microscopic variation among these two types of barbs in birds. Among other things, he found that the variation in the plumulaceous (downy) barbs of different species of birds was often significant enough to identify a taxonomic group based on microscopic analysis alone. Although his work demonstrated the importance of microscopic feather analysis to avian systematics, it has since been the basis for studies in AForensic Ornithology@ and ABird Strike Analysis@. Forensic ornithology seeks to identify birds from fragmentary feathers, bones, beaks, talons, or other trace evidence in law enforcement cases and ABird Strike Analysis@ involves examining unknown feather samples collected from bird-aircraft collisions. Data from forensic cases is often used to prosecute violators of wildlife laws; bird strike data is used by aircraft engineers to design better engines, by airport managers to alter airfield habitats to discourage bird use, and by pilots to avoid flying where birds congregate.

This lab exercise will examine the variation in the microcharacters of plumulaceous (downy) feathers of some groups of birds and demonstrate the importance of these characters to forensic ornithology and aviation safety. In reality, the identification technique is very specialized and involves a combination of comparisons of both the microscopic and macroscopic (whole feather) characters in conjunction with circumstantial evidence (locality, date, habitat). Microcharacters are typically compared to a reference collection of microslides made from known species while whole feathers are matched with specimens in museum collections for

positive identification. This method of feather identification also has applications in archeology, ecology (prey remains), food contaminants, bird-aircraft collisions (bird strikes), wildlife law enforcement, and in systematic and phylogenetic studies of birds.

LEARNING OBJECTIVES

The student will:

- learn feather topography and micro-structure
- prepare microslides of downy barbs
- examine microscopic variation in downy feather characters
- illustrate microscopic feather characters of different species
- use deductive reasoning, circumstantial clues, and physical evidence to solve cases
- experience Ahands-on@ practical applications of the feather identification technique

MATERIALS

Compound light microscope with low (40X) and high (200X-400X) objectives
microslides and labels
coverslips (22mm sq., or 22 x 50 mm)
forceps (fine-tipped for removing single barbs)
tap water (in dropping bottle with stopper/pipet)
specimens - 2 breast feathers per student of each species selected for study
unknown samples - 2 unknown feather samples per student. Samples are selected by the instructor and could be different for each student. The unknown samples can be whole feathers but several downy barbs will suffice.

PROCEDURE

Feather Structure and Topography

Contour feathers consist of a **rachis**, or main shaft, with stiff vanes on either side. In many contour feathers, a secondary structure or **afterfeather** (downy in appearance) is attached to the main feather at the **calamus**. **Vanes** on each side of the rachis are usually made up of two types of barbs. **Pennaceous barbs** are the primary branch off the rachis that further subdivides into flattened barbules. These barbules are typically characterized by having interlocking hooklets (especially on flight feathers). **Plumulaceous barbs** (downy) also branch off the rachis of most contour feathers but these barbs are located at the very base of the feather and are fluffy in appearance. [Other types of downy feathers that are not examined in this exercise include: true down - found in between feather tracts (apteria), and natal down - found on very young birds]. The tiny barbs that branch off the main feather shaft can easily be envisioned as “miniature” feathers with a central **rachilla** (= ramus, little mid-rib) and vanules on either side.

Vanule (like vane) is the collective term for all the barbules that branch off the rachilla. A **barbule** is the smallest unit of the feather, divided into a base and a pennulum, and can be visualized as a stalk of single cells (segments) which are differentiated along the axis. The **base** is the most proximal portion of the stalk, attaches to the rachilla, and is typically a flattened cell(s) that is straplike in appearance. The remaining segments of the stalk make up the **pennulum**. The cells along the pennulum are elongate and often expanded near the distal end to form **nodes**. Sometimes these nodes have various associated structures such as spines, prongs, points, or rings that vary among groups of birds . The morphological variation in the microscopic characters of the **node**, **internode** (segment between nodes), and pigmentation patterns along the plumulaceous barb is what aids in the identification of groups of birds from feather fragments alone.

Microslide Preparation

Obtain feather samples of different species from lab instructor. In order to avoid contamination of feather types work with only one species or unknown sample at a time. Label the microslide, place it on a clean surface and put a few drops of water on the slide so that most of the microslide is covered with a thin aqueous layer. Using the forceps, remove downy barbs from the base of the whole feather of one species and gently lay four or five barbs onto the water. Water will allow the barbules to spread evenly. The most diagnostic barbs are usually found near the mid-section of the downy area of the feather. Gently place a coverslip on the microslide.

A different mounting method is required for permanent microslides (Laybourne and Dove, 1994). If permanent mounts are preferred, use Flo-TEXX7 mounting medium (Columbia Diagnostics, Inc., 8001 Research Way, Springfield, VA. 22153. 703-569-7511) or other products that have a similar refractive index to water.

Examination and Illustration

Species: Chicken (*Gallus gallus*); Mallard (*Anas platyrhynchos*); Mourning Dove (*Zenaida macroura*); American Robin (*Turdus migratorius*); Ring-necked Pheasant (*Phasianus colchicus*).

Examine the downy barbs and barbules with the light microscope at low (40X) and high (200-400X) power. Notice the length of the barbule, location of the expanded nodes along the barbule, shape of the structures at the nodes, patterns of pigmentation along the pennulum, internode length, changes in node type along the pennulum, and the amount of pigment on the whole barb and barbule. Illustrate downy characters from barbs of the five species provided under high power and describe the differences and/or similarities. These illustrations can be used in the following case examples.

Casework

Now that you have knowledge of downy microstructures, apply your knowledge to help solve the cases below.

Case #1

A Fish and Wildlife agent arrested a suspect for poaching ducks out of season. The agent's only hard evidence (non-circumstantial) was a knife that he found in the suspect's boat. The knife had fresh blood and a small piece of downy feather attached to the blade. Although the suspect admitted that the knife was hers, she denied poaching and claimed that she was not a duck hunter. The agent confiscated the knife, removed the feather evidence and sent the feather samples to your lab for identification.

Remove the unknown down sample from a plastic bag and make a microslide. Examine the fluffy downy barbs and barbules for specific characters noted in the illustration part of this lab.

Questions: Assuming that all Anseriformes (the avian order that includes ducks, geese and swans) have similar structures to those illustrated previously in this exercise, can we determine whether or not the feather sample belongs to a species within this avian order?

What microcharacters can be used to support or refute your analysis? Does your analysis help prove that the suspect is innocent? Why or why not?

Case #2

On Thanksgiving day, a Boeing 727 Aircraft experienced engine trouble shortly after takeoff at JFK Airport in New York. The plane aborted takeoff and landed safely without incident but upon inspection of the engine, considerable physical damage was noted and many fragmentary pieces of fuzz and debris were found attached to the bent fan blades. The investigators suspected that a bird was ingested into the engine and caused the engine to shutdown. The debris was sent to you for bird strike confirmation.

Remove the bits and pieces of debris and dirt from the bag and search for any type of feather evidence. Prepare a microslide and examine the debris.

Questions: Is there feather in the sample? If so, can we determine to what group of birds the feather belongs? Considering all of the circumstantial evidence (and use of Bird Field Guides if necessary), what are the possible species that could have been involved in this bird strike? What could the airport managers do to prevent this type of accident from happening again?

Note to Instructors: See attached SUGGESTIONS for additional information.

REFERENCES

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Lucas, A. M., and P. R. Stettenheim. 1972. Avian Anatomy-Integument. 2 vol., Agric. Handbook 362, U.S. Dept. Of Agriculture, Washington, DC.

FORENSIC ORNITHOLOGY: SUGGESTIONS FOR INSTRUCTORS

Description of Laboratory Exercise

This lab is designed to introduce students to microscopic feather analysis and explain the applications of feather identification to wildlife law enforcement and aviation safety. Whole feather anatomy, microscopy, illustration, and 'detective investigation' are used to demonstrate the practical applications of the technique of microscopic feather identification.

Illustration of feather microstructures for microscopic examination will familiarize students with nodal morphology, pigmentation patterns and overall feather anatomy. Downy barbules of different species illustrated at high power will emphasize the variation of nodal structures and pigmentation patterns among different groups of birds (e.g. Galliformes and Anseriformes). This exercise will complement other general feather labs that explain feather types, feather tracts, functions, etc. This lab exercise deals only with the variation in plumulaceous (downy) feather barbs. Do not attempt to identify birds using microscopic analysis of pennaceous barbs. However, microscopic comparisons of the two different types of barbs could be a part of this lab to show students the vast differences in the barb-types of one feather.

Preparation:

To avoid contamination, be sure that students work only with one species or sample at a time. Temporary mounts using water are sufficient for the purposes of this lab. If more permanent mounts are preferred use Flo-Texx mounting medium (Columbia Diagnostics, Inc. 8001 Research Way, Springfield, Va. 22153 (703) 569-7511) or other products that have the same refractive index as water. Inexperienced students may find it easier to work with small coverslips (22mm sq.).

Casework:

Actual case examples are used to demonstrate the practicality of feather identification to Forensic Ornithology in Wildlife Law Enforcement (case #1) and aviation safety (case #2). Instructors can use their imaginations to invent new cases as long as simple examples of birds from different orders are used as unknowns; the casework becomes much more difficult when closely related species are used and this could confuse students. If a collection of museum study skins is available, talons, beaks, etc. can be used to supplement feather evidence.

Case 1

The key to this case depends on the unknown feather sample that the instructor chooses to use; Chicken feathers clear the suspect whereas duck feathers help prove her guilt. All that we can really determine from this case is that the knife was used to clean some species of duck but this evidence is usually enough to be admitted into court cases.

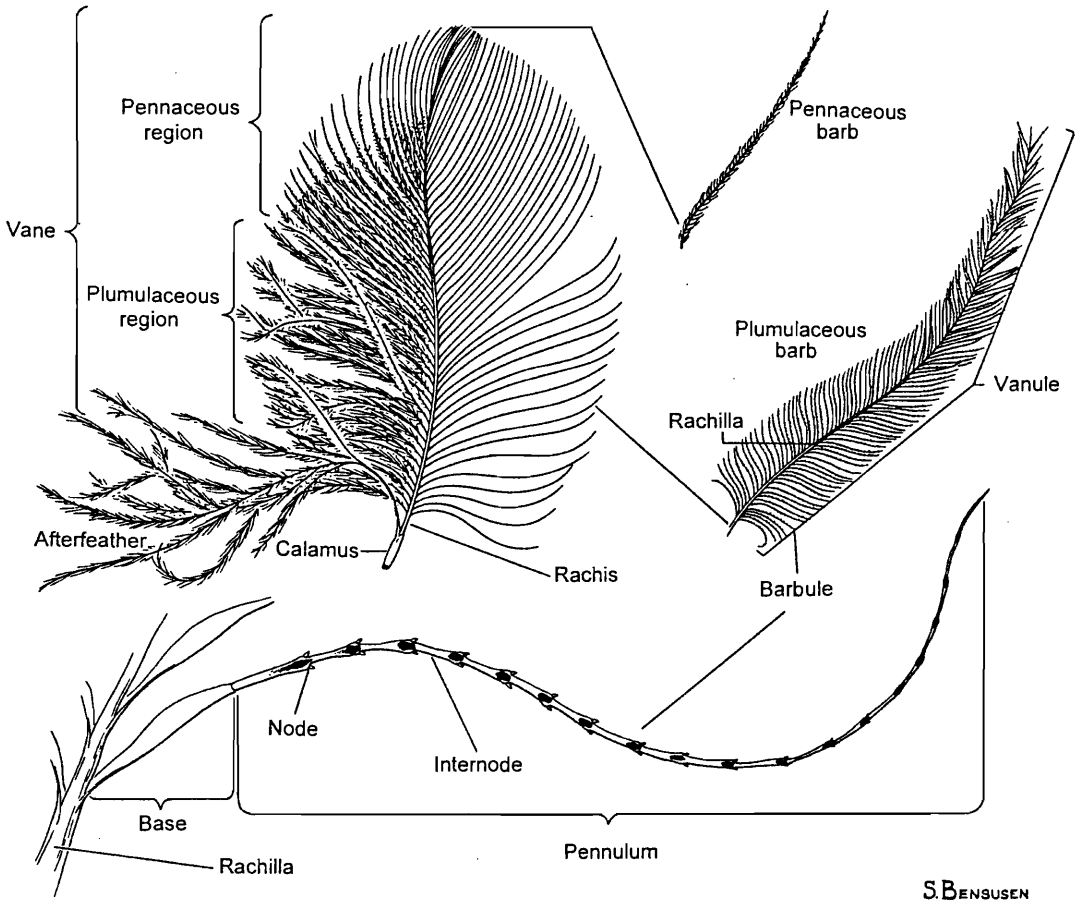
Diagnostic whole feathers could be supplemented in this case to help pinpoint the species involved but a collection of museum reference specimens would be needed for comparison of whole feathers.

Case 2

A duck sample should be used for this exercise. The microcharacters that are diagnostic for Anseriformes are triangular shaped nodes located on the distal part of the barbules. A realistic sample would be a small envelope containing unknown fibers (e.g. cotton, plastic) with some downy barbs mixed in. Feather evidence found in the sample would confirm a bird strike. The student could assume that several species of ducks occur in the New York area during the winter (Thanksgiving) to determine what species could be involved. Airport managers would use some habitat management program (i.e. spray insects, grass management) or wildlife management program such as pyrotechnics, falconry, cracker shells, etc. to discourage birds from landing on or near the airfield and to prevent this from happening in the future. If no feather parts are found in the samples that the instructor provides, then we cannot determine if a bird strike occurred.

Concluding remarks

Additional cases using feathers from prey remains, owl pellets, or possible anthropological artifacts can be created to demonstrate other practical applications of feather identification. This lab can be expanded by adding examination/illustration and comparisons of different down types (natal vs. adult), or by comparing the microscopic pennaceous barb structures to those of the plumulaceous barbs.



FEATHER STRUCTURE

Contour feathers consist of a **rachis** with stiff vanes on either side and in most cases, an **afterfeather** attached at the **calamus**. **Vanes** are formed by two types of barbs on most feathers: stiff, **pennaceous barbs** that have interlocking hooklets and form the surface of a feather, and **plumulaceous barbs** (downy) that have a fluffy appearance and are located at the base of the feather. The down of the plumulaceous feather is different from the true down that is found between feather tracts (apteria) and on very young birds. **Barbs** consist of a **rachilla** with **vanules** on either side which in turn branch into barbules. **Barbules** are the smallest division of the feather and are made up of a **base** and a **pennulum**. The morphological variation in the microscopic characters of the **node**, **internode** and pigmentation patterns along the plumulaceous barb is what aids in the identification of groups of birds.