HOW TO
PREPARE BIRD SPECIMENS

Part 7a – Determining skull pneumatization

Part 7b – Skeleton preparation

HOW TO PREPARE BIRD SPECIMENS

Part 7a – Determining skull pneumatization

The Migratory Bird Conventions Act regulates the take and possession of birds in Canada. The Migratory Bird Treaty Act regulates the take and possession of birds in the United States. In addition, the provinces (in Canada) and the states (in the United States) also require permits. For some species SARA, ESA, or CITES permits may be required.

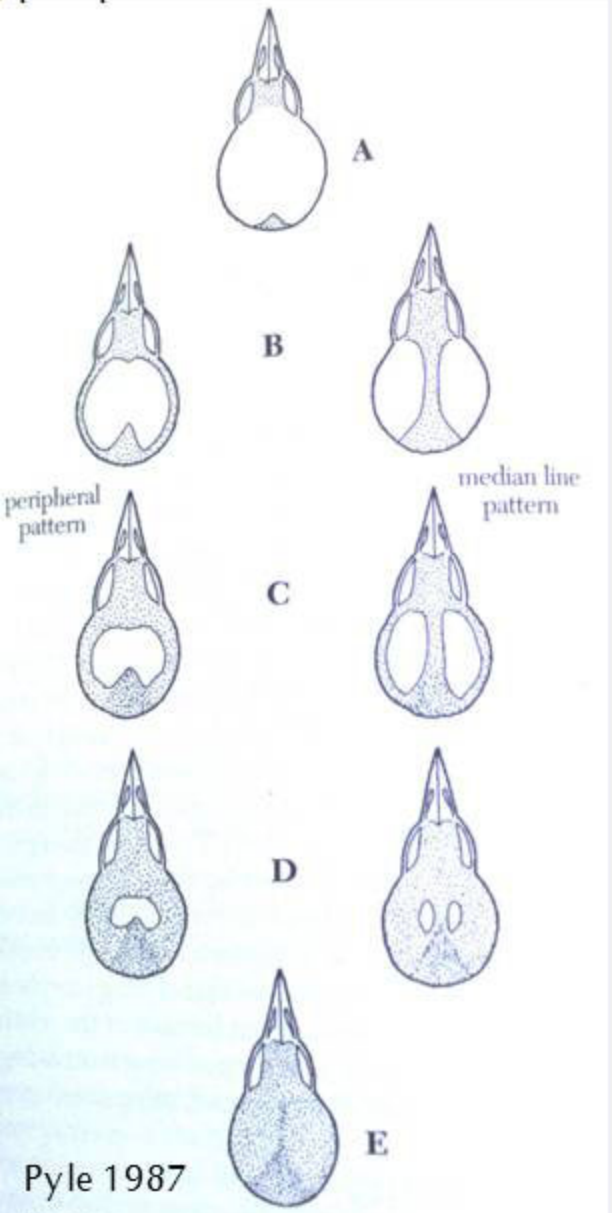
Always check the laws of your country and obtain the proper permits; failure to do so may result in civil and/or criminal penalties.

When handling dead birds, it is probably impossible to tell if a bird is infected with a pathogen that may cause human illness even if you know the cause of death to be a wound or an injury. Take reasonable precautions to protect yourself. The Ornithological Council offers a peer-reviewed fact sheet on avian zoonotic disease and safety precautions for those who handle birds in the field and in the lab.

http://www.nmnh.si.edu/BIRDNET/documents/WNV&H5N1-FactSheet.pdf

Photo taken at the Canadian Museum of Nature

peripheral vs. median line



Pyle 1987

FIGURE 11. The two common sequence patterns of skull pneumaticization. See text for details.

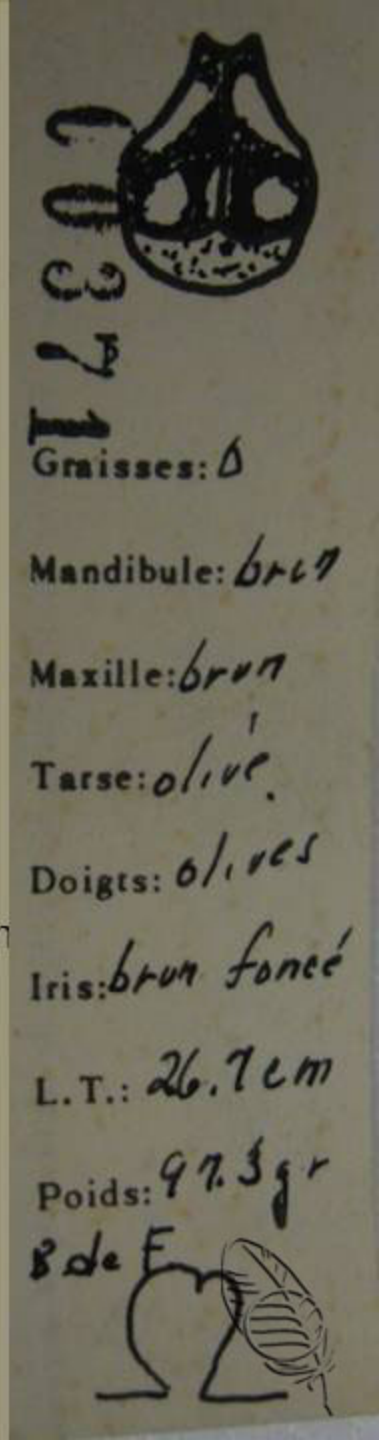
Recording Skull Ossification

Pneumatization refers to the formation of minute air spaces which occurs when a second layer of bone is added to the skull after hatching.

Pyle (1987) recommends using the simplest system of coding skulls: 0%, 25%, 50%, 75% or 100% skull ossification. Record if the skull windows follow the peripheral or the median line pattern for 25%, 50% and 75% ossification.

Rarely is skull ossification asymmetrical. If you find something odd, make a sketch on the label. Taking photos in addition is excellent, but unless they are physically attached to the specimen they do not replace the need to do a quick sketch.

Cranial and skull ossification are synonymous terms.

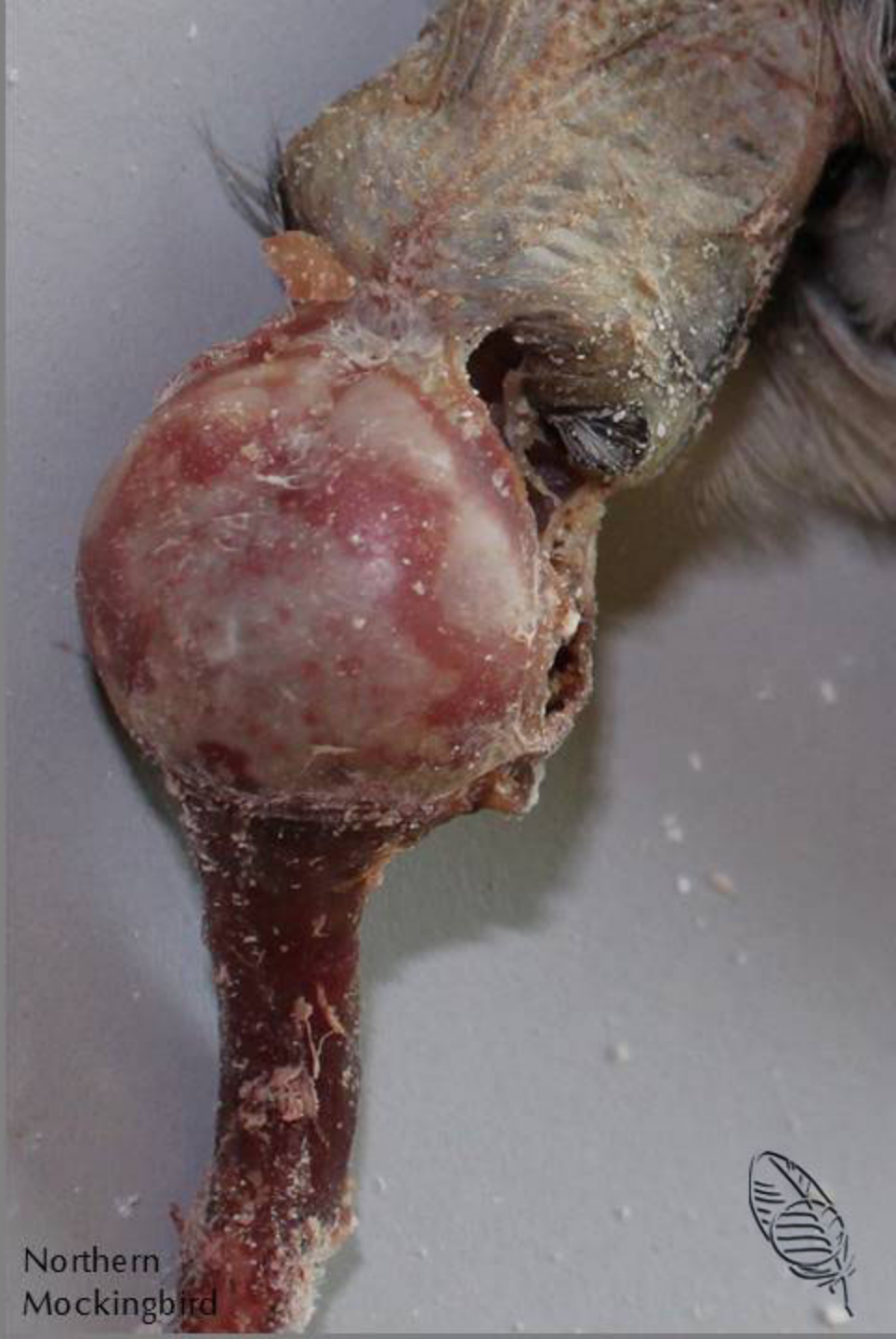


Classifying skulls using such large increments lessen individual bias.

Using increments of every 5% or 10% results in a dilemma on how this skull should be recorded.

This skull is closer to 25% than 0%. It would be recorded as 25% skull oss. (ossification).

Lab protocol will dictate if ossification is spelt out in full or abbreviated to oss.



0% Skull ossification:

Skull of hatchlings have a single bone layer. As the chick grows, a second bone layer develops under the original skull.

The two layers of bone are connected by bone columns and separated by air spaces making the skull both light and strong.

Mallard duckling

0% Skull ossification:

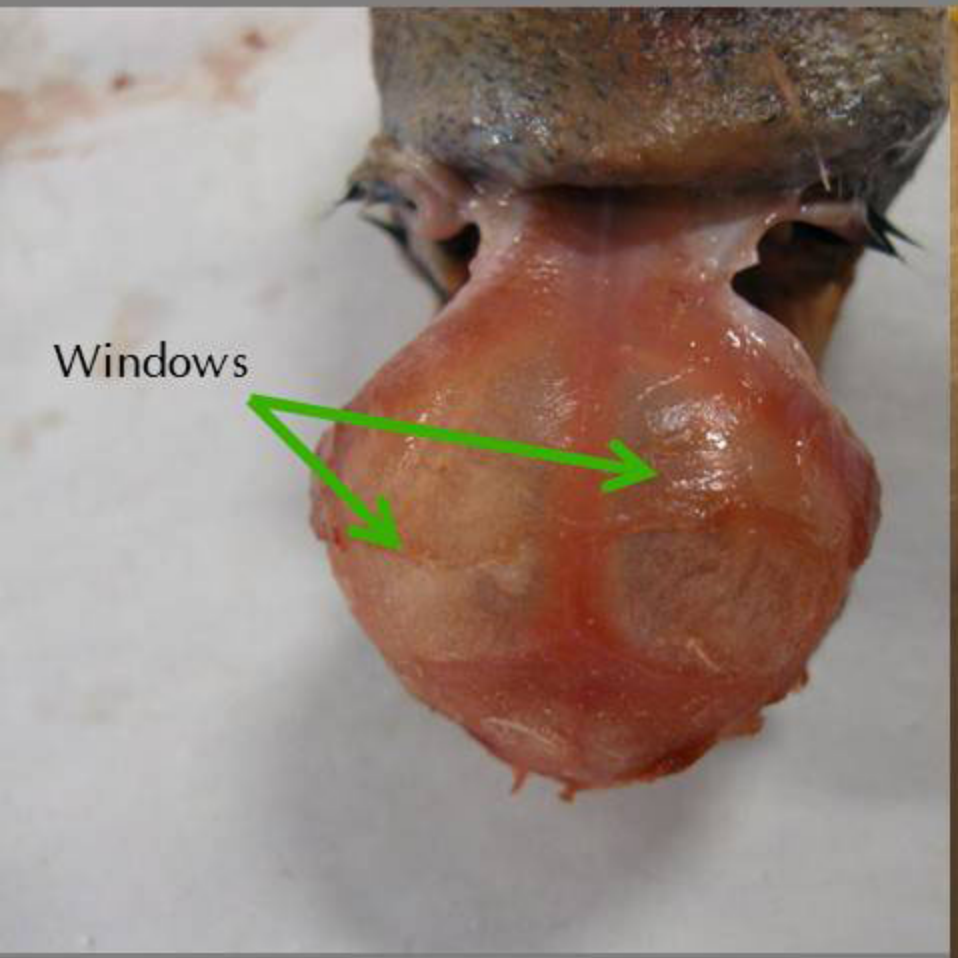
I call this a Ping-Pong ball skull.

It is so flexible that any dents created by your fingers are easily fixed by poking in the opposite direction from inside the skull.

Altamira Oriole nestling


0% Skull ossification:
Check skull transparency after removing the brain and cleaning the cranial cavity.
European Starling fledgling

25% Skull ossification - median line pattern:
Continuous window visible on top and sides of the skull.



Two different hatch year Western Tanagers by plumage

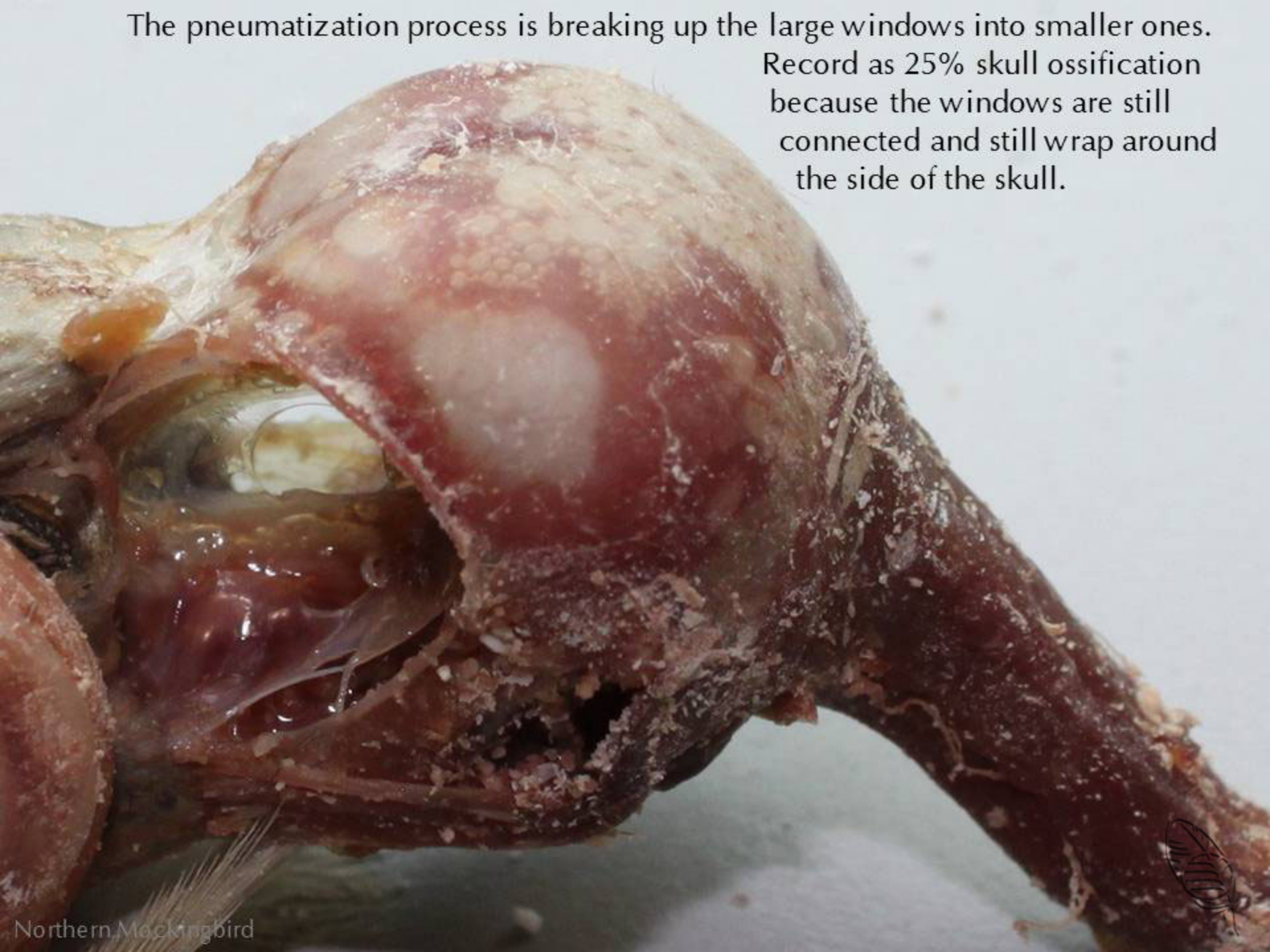
25% Skull ossification - median line pattern:

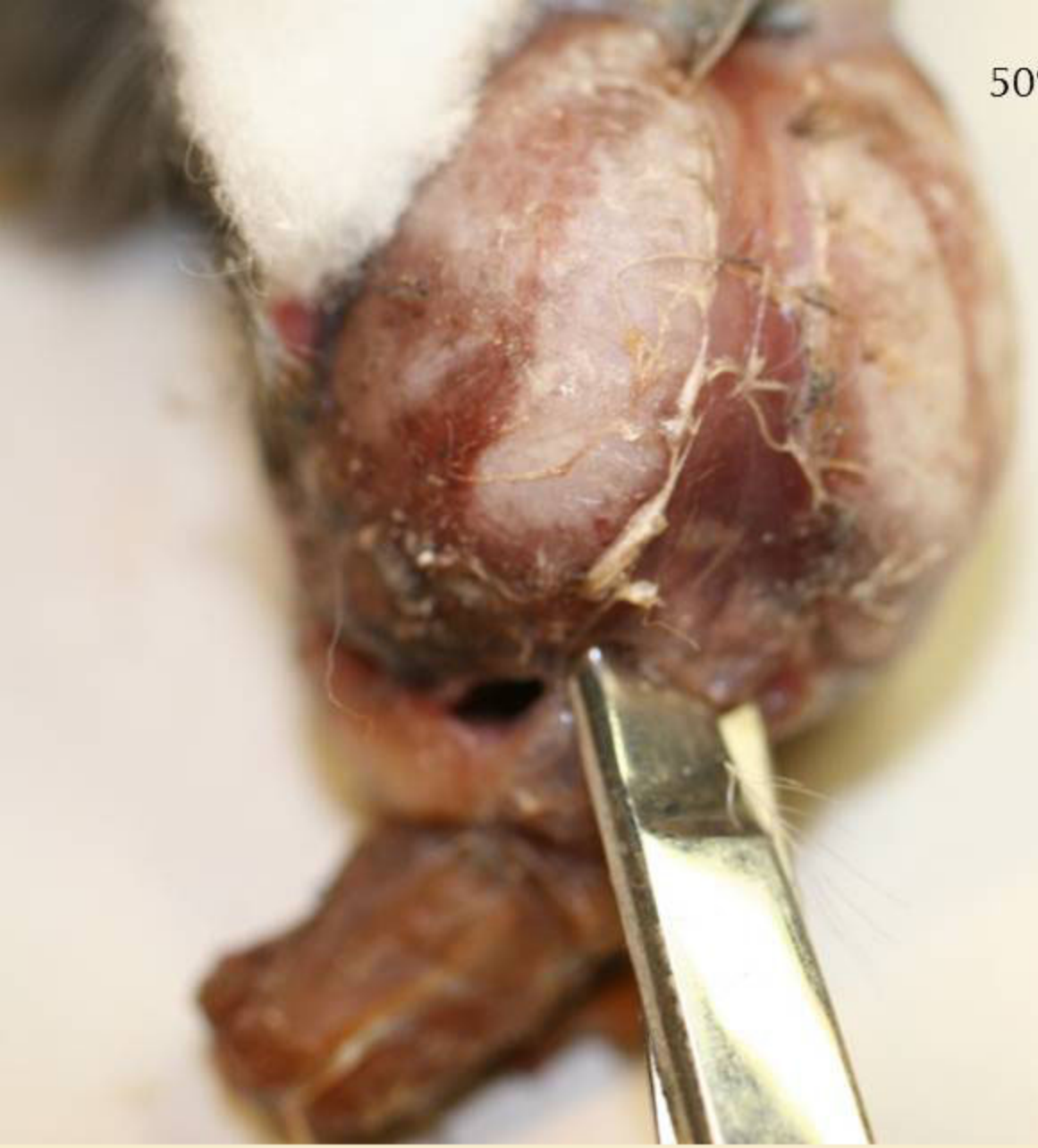
25% skulls are more robust.
Remember to look through the skull.
The medial line and windows
are obvious when
viewed from the inside.

Hatch year
Black-billed
Magpie

Recording on the label that the flight feathers are in pin supports the 25% skull ossification.

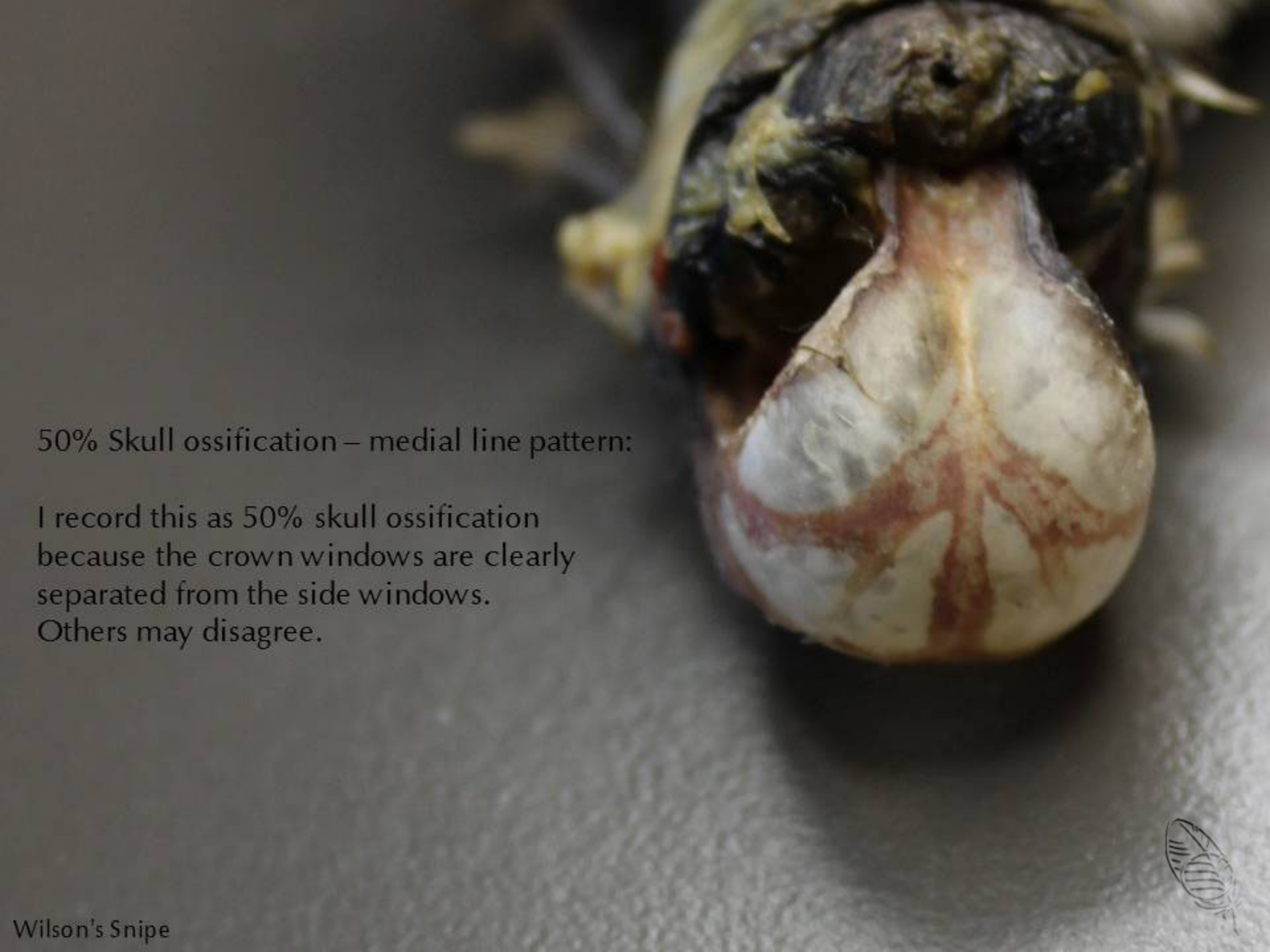

25% Skull ossification:
Although there are no windows, the skull pneumatization is too far advanced to record as 0% skull ossification.
White-throated Nuthatch


The pneumatization process is breaking up the large windows into smaller ones.
Record as 25% skull ossification because the windows are still connected and still wrap around the side of the skull.
Northern Mockingbird



50% Skull ossification
– medial line pattern:

Crown windows no longer continuous with smaller side windows.



50% Skull ossification – medial line pattern:

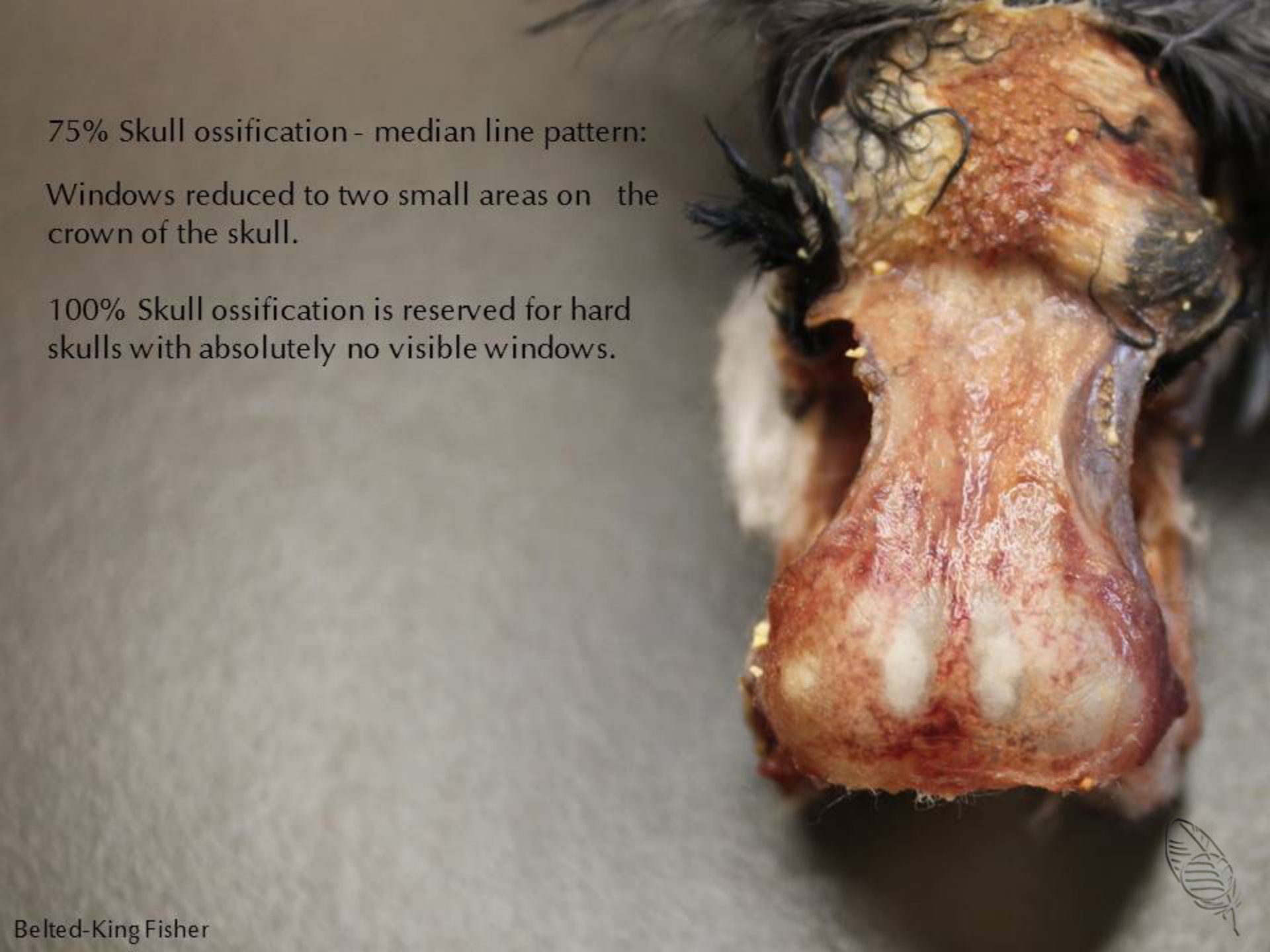
I record this as 50% skull ossification because the crown windows are clearly separated from the side windows.
Others may disagree.

Wilson's Snipe

75% Skull ossification - median line pattern:

Windows reduced to two small areas on the crown of the skull.

100% Skull ossification is reserved for hard skulls with absolutely no visible windows.



Belted-King Fisher

Never assume that a bird with skull windows is a juvenile.

Complete skull pneumatization never occurs in several bird orders. Larger Columbiformes never exhibit 100% skull ossification. Skull pneumatization is complete at 75% skull ossification.

Find a local reference book:

- For North America use: Pyle,1987. Identification Guide to North American Birds
- Check the bird banding guide for your region

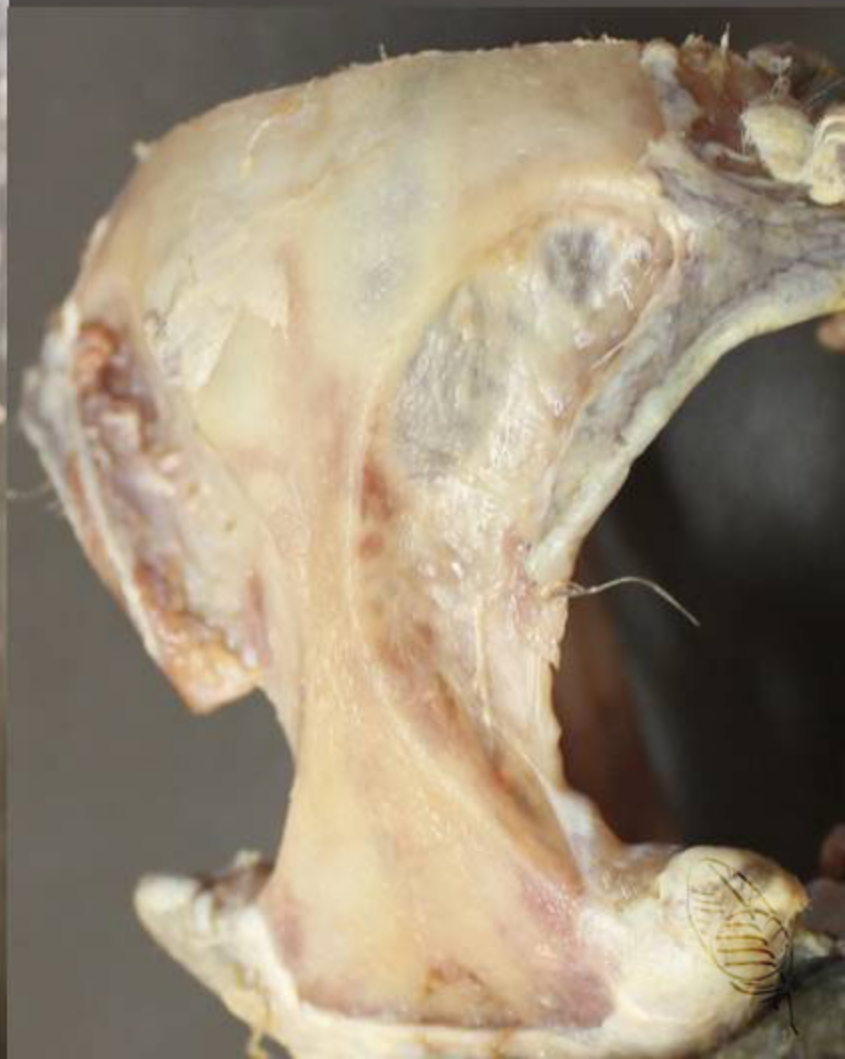
Adult Band-tailed Pigeon by plumage

75% Skull ossification:

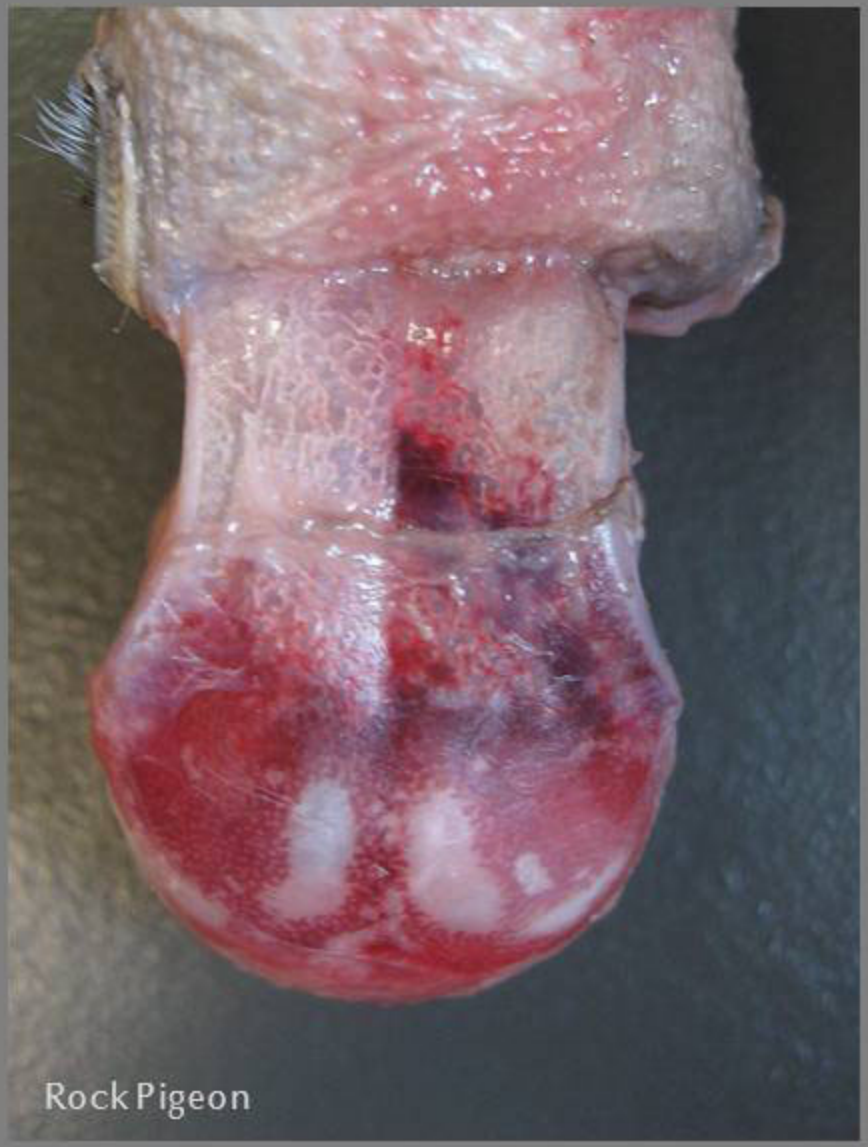
On June 5th, 1990 this Laysan Albatross was banded on Whale-Skate Atoll.
In 2004, it was recovered as fisheries by-catch.

It is not a juvenile!

Different light exposures of the same adult plumage Laysan Albatross skull.

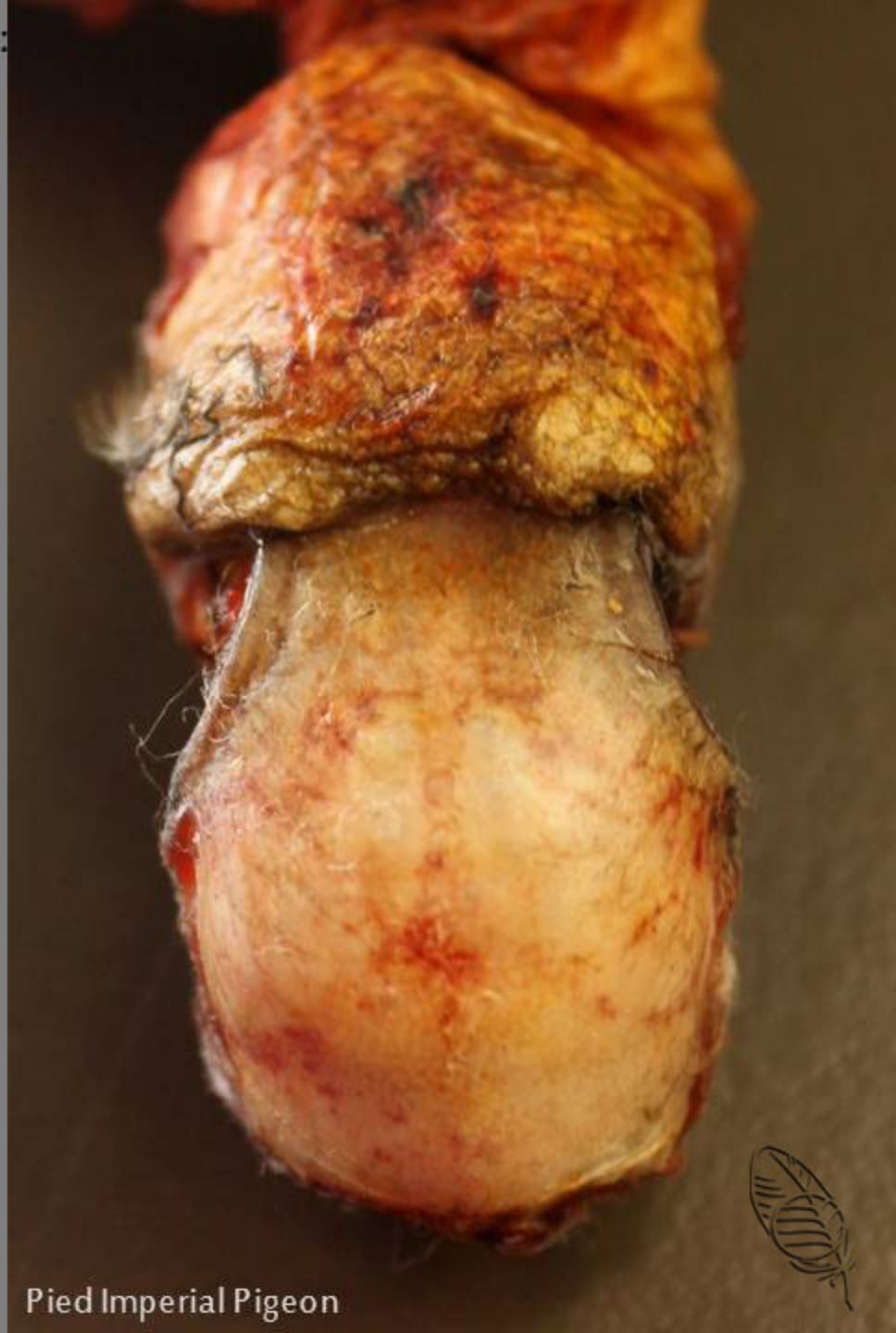


75% Skull ossification - median line pattern:



Rock Pigeon

Note how easily the "incomplete" skull ossification could have been missed for the Pied Imperial Pigeon.



Pied Imperial Pigeon

These Brown Creepers collided with a skyscraper on migration. The bird on the right has extensive skull trauma.

Skull ossification is not always discernable. When in doubt record as:

- Skull trauma, skull oss. unknown

The correct notation for the bird on the right is:

- Skull trauma, 75% skull oss.

Photo taken at The Field Museum

Never make assumption. Check every bird.

Hummingbirds skull are not supposed to pneumatize – yet this adult does have windows. It was recorded as 75% skull ossification.

Document unusual finding on the prep sheet, on the label, and photograph if possible. Have another person collaborate your findings.

Woodpecker, hummingbird, and other taxa have tongues that curved around the top the skull.

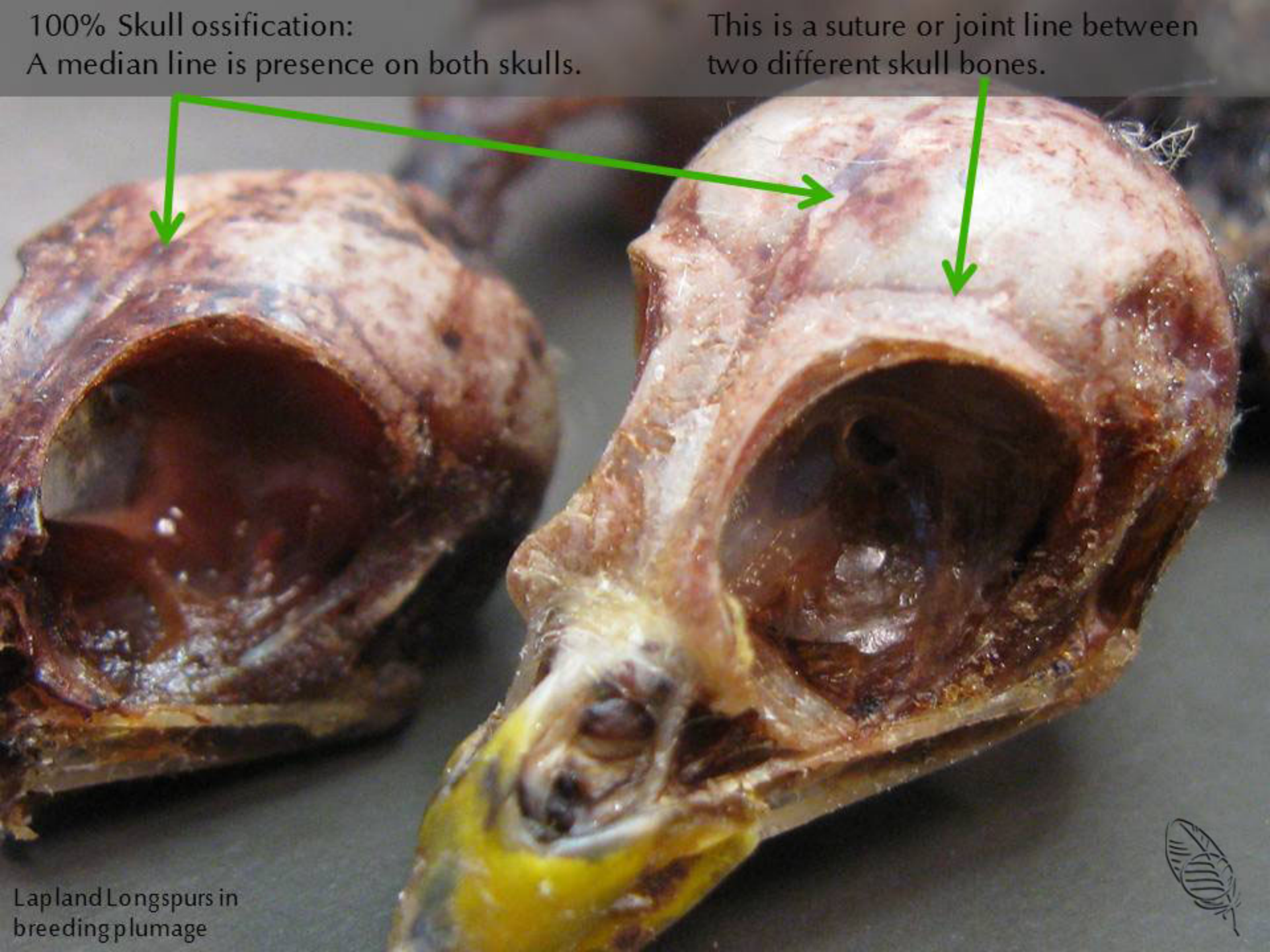
•Do not confuse the tongue for a medial line

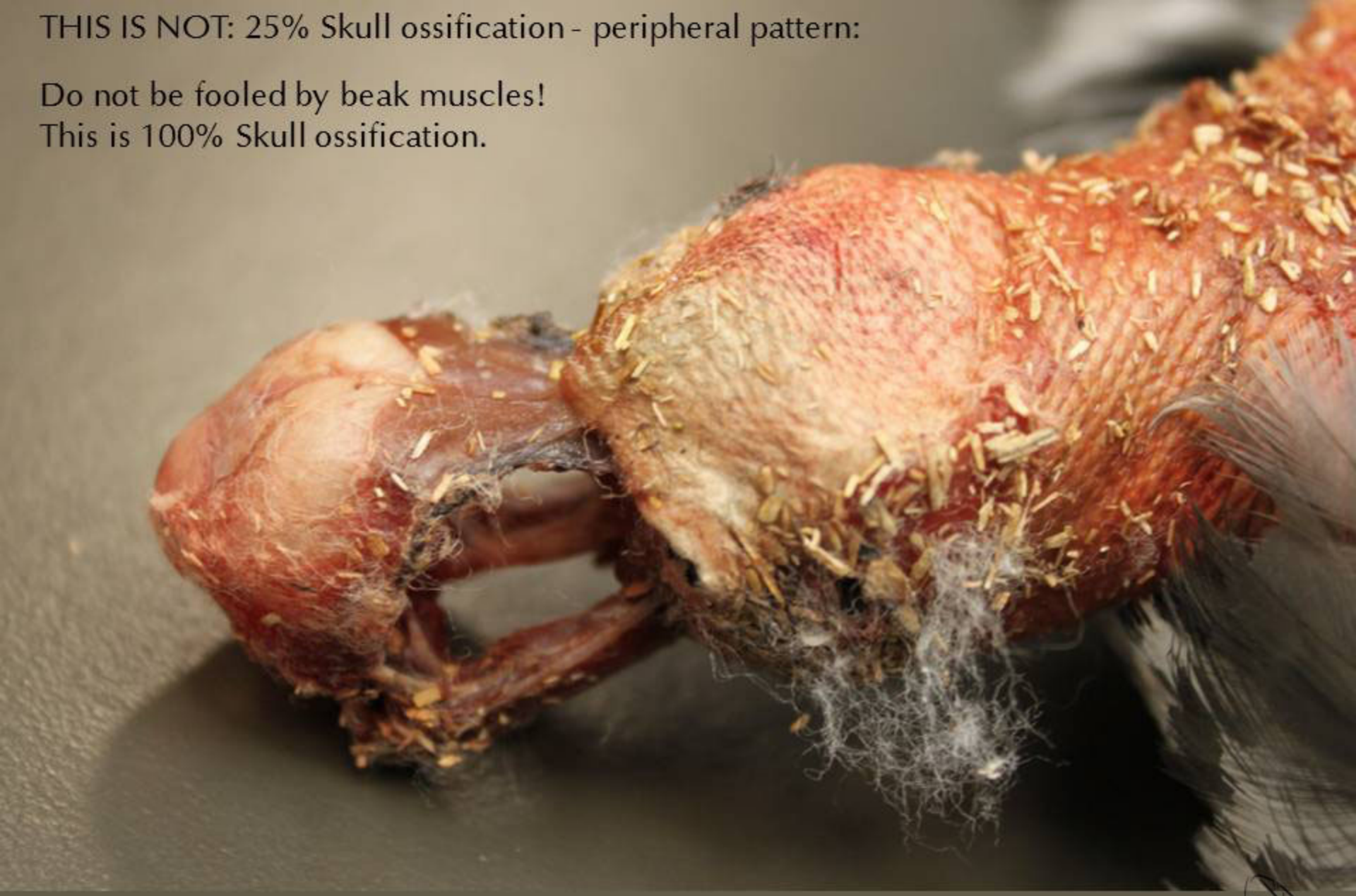
Adult male Rufous Hummingbird by plumage


100% Skull ossification:
These skulls are completely opaque.
Great Horned Owl
2.5 years by wing moult

100% Skull ossification:
Sometimes skulls are uniform in texture with no skull sutures visible.

Western Screech Owl
adult by wing moult


100% Skull ossification:
A median line is presence on both skulls.
This is a suture or joint line between two different skull bones.
Lapland Longspurs in breeding plumage



Ancient Murrelet in breeding plumage

HOW TO
PREPARE BIRD SPECIMENS

Part 7b – Skeleton preparation

The Migratory Bird Conventions Act regulates the take and possession of birds in Canada. The Migratory Bird Treaty Act regulates the take and possession of birds in the United States. In addition, the provinces (in Canada) and the states (in the United States) also require permits. For some species SARA, ESA, or CITES permits may be required.

Always check the laws of your country and obtain the proper permits; failure to do so may result in civil and/or criminal penalties.

When handling dead birds, it is probably impossible to tell if a bird is infected with a pathogen that may cause human illness even if you know the cause of death to be a wound or an injury. Take reasonable precautions to protect yourself. The Ornithological Council offers a peer-reviewed fact sheet on avian zoonotic disease and safety precautions for those who handle birds in the field and in the lab.

http://www.nmnh.si.edu/BIRDNET/documents/WNV&H5N1-FactSheet.pdf

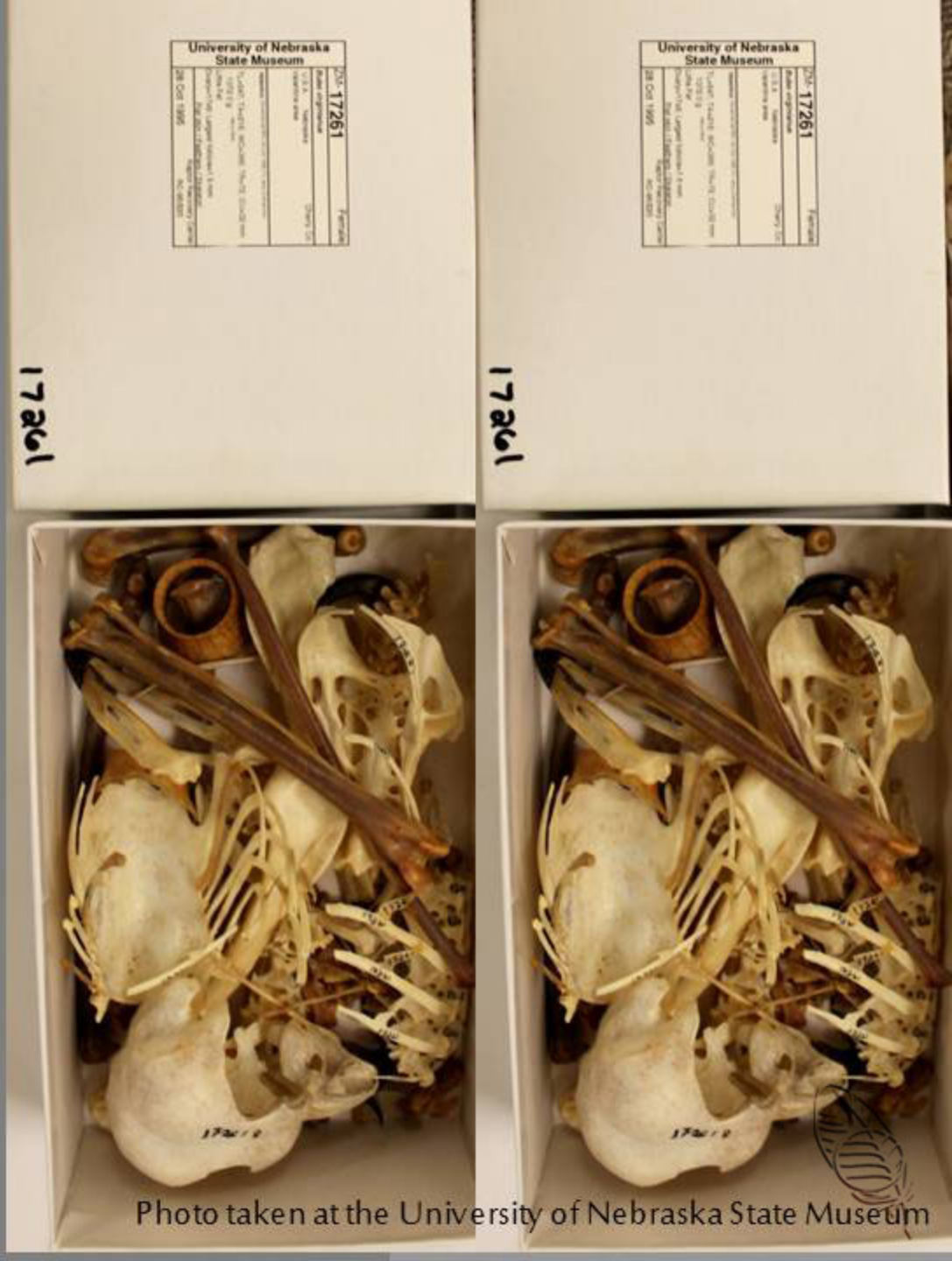


Photo taken at the University of Nebraska State Museum

Use one of the following skeleton prep methods:

- Dermestid beetles
- Maceration
- Boiling
- Natural systems

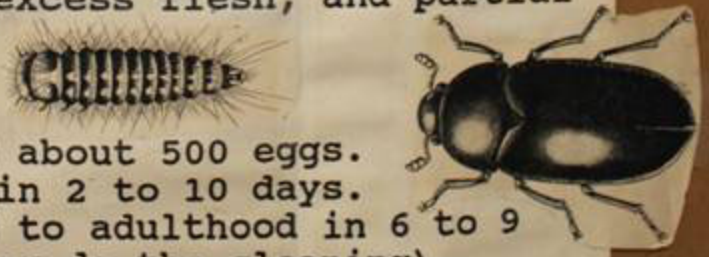
BUGS BARE BONES

Common name: Hide or Carrion Beetle
Scientific name: Dermestes maculatus

Belong to the family: Dermestidae
Family contains about 700 species of which about 25 are found in Illinois.

A colony this size can clean 20 to 25 mice overnight. Larger items may be left in for up to a week.

They do not eat living or recently dead animals. Specimens are prepared for bugging by skinning, eviscerating, removal of excess flesh, and partial drying.



Life Cycle
Female lays about 500 eggs.
Eggs hatch in 2 to 10 days.
Larvae grow to adulthood in 6 to 9 weeks (they do the cleaning).
Larvae pupate for 7 to 14 days.
Adults live about 3 months.

Photo taken at The Field Museum

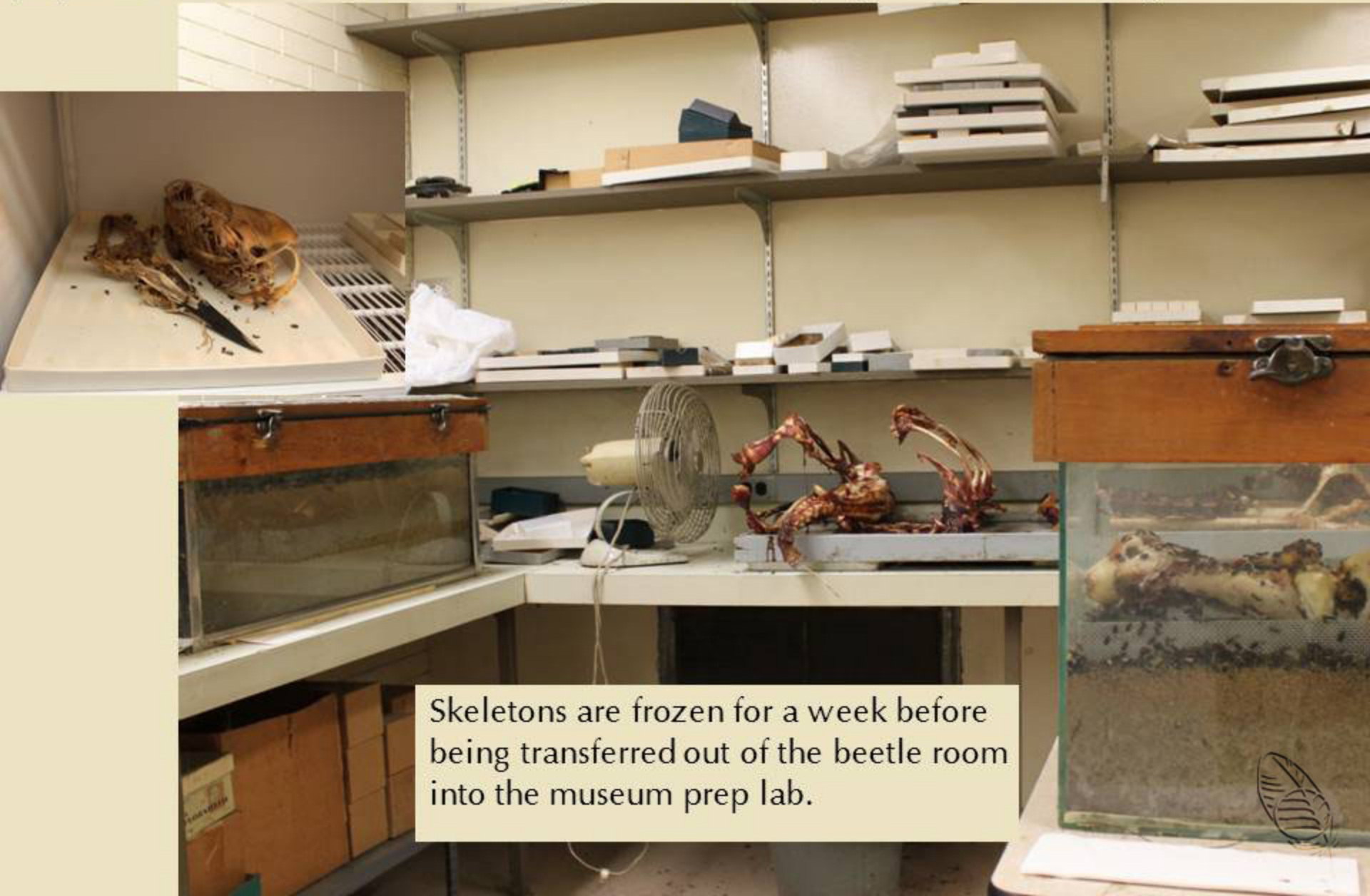
DERMESTID BEETLES:
A No. 1 priority of natural history museum is effective pest management. Having beetle colonies inside a museum is counter intuitive.

The best solution is to locate the beetle lab in a trailer, shed, or different building.

In warm climates, a fish tub or a discarded chest freezer is a cheap solution.

Photos taken at the TCWC, Texas A & M University

It is rare to find a self-contained beetle lab inside a museum. The Field Museum beetle lab has a double door entry system. It contains 5 beetle colonies, work benches for sorting prepared skeletons into cardboard trays, and a -80°C upright freezer for killing beetles.



Skeletons are frozen for a week before being transferred out of the beetle room into the museum prep lab.

The Louisiana State University Museum of Natural Science beetle room has few constraints. The beetles roam free.

This beetle room is separated from the prep room by 3 doors. It is the same building as the museum but there is no internal staircase linking the areas.

A "Bug Room" houses beetle colonies but does not have work space.
Two easy steps to contain the beetles are:

- Close the exterior door BEFORE opening the self-contained beetle colony
- Install tangle-foot barriers around the threshold

Photos taken at the University of Washington Burke Museum

If possible, house the colonies in a restricted area or secure with a lock.

If the beetles must be housed in the prep room, consider creating a "Mini Bug Room" using a fridge with a functional door seal.

Make sure that:

- Each colony has a tightly fitting lid
- Colony tank walls are slippery (remove silicon vertical seams from aquariums)

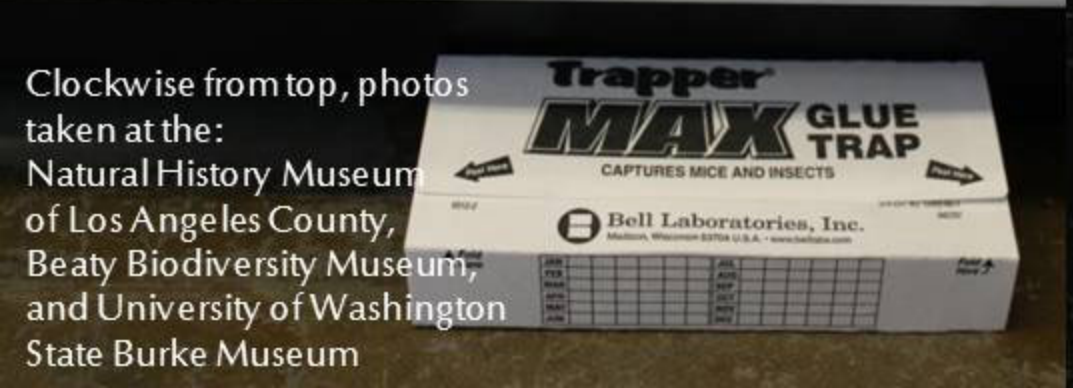
Purchase non-flying dermestids. Ask your supplier at what temperature the beetles sprout wings. For the UBC colonies, the temperature must exceed 28°C.

Flying insects are next to impossible to control, make sure your colony is composed of CRAWLING insects.

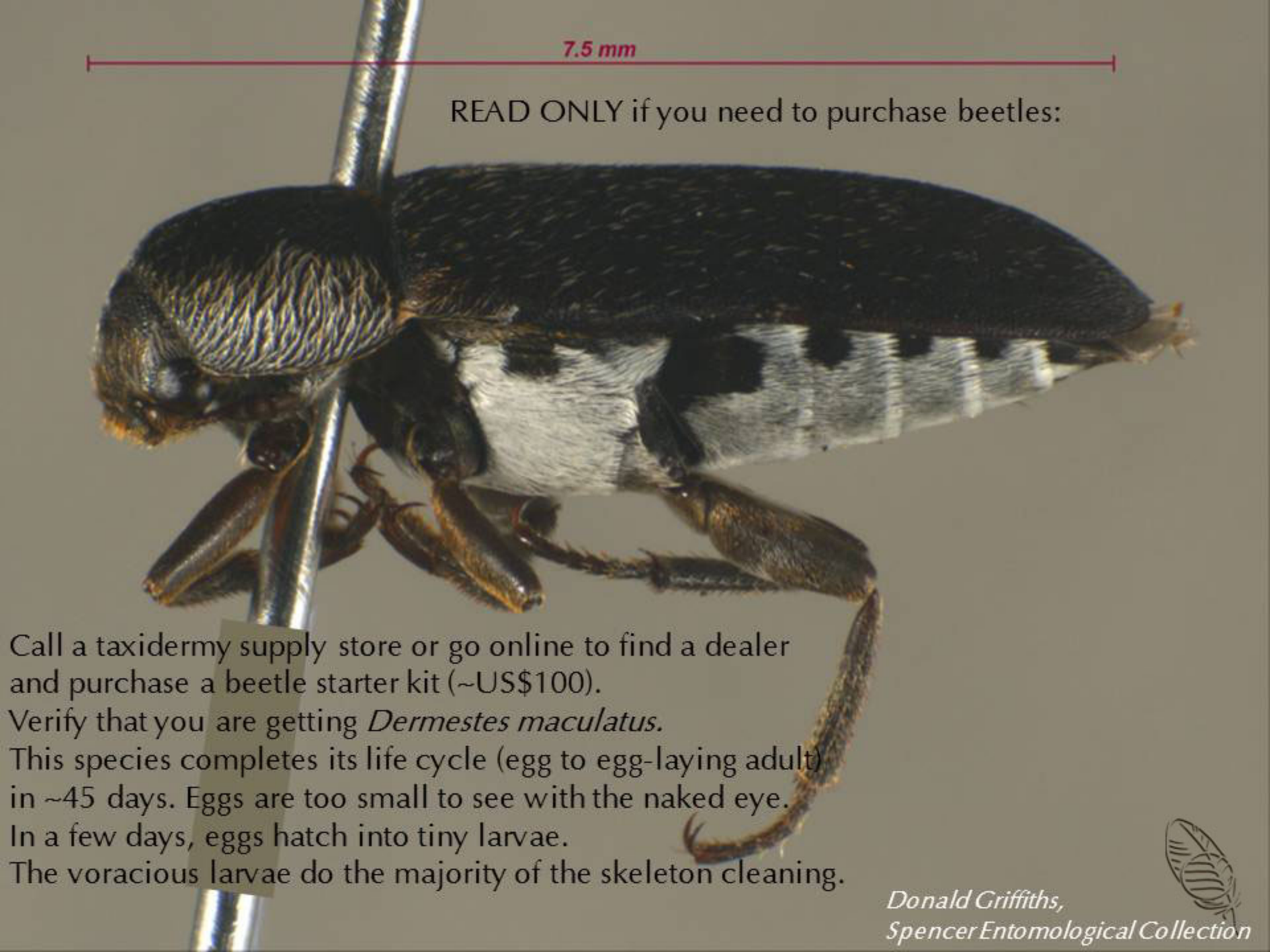
Photo taken at the University of Nebraska State Museum

Install a beetle monitoring system in the drawers and on the floor of the collection.

Set up a schedule to visually check for beetle and other pest infestations.



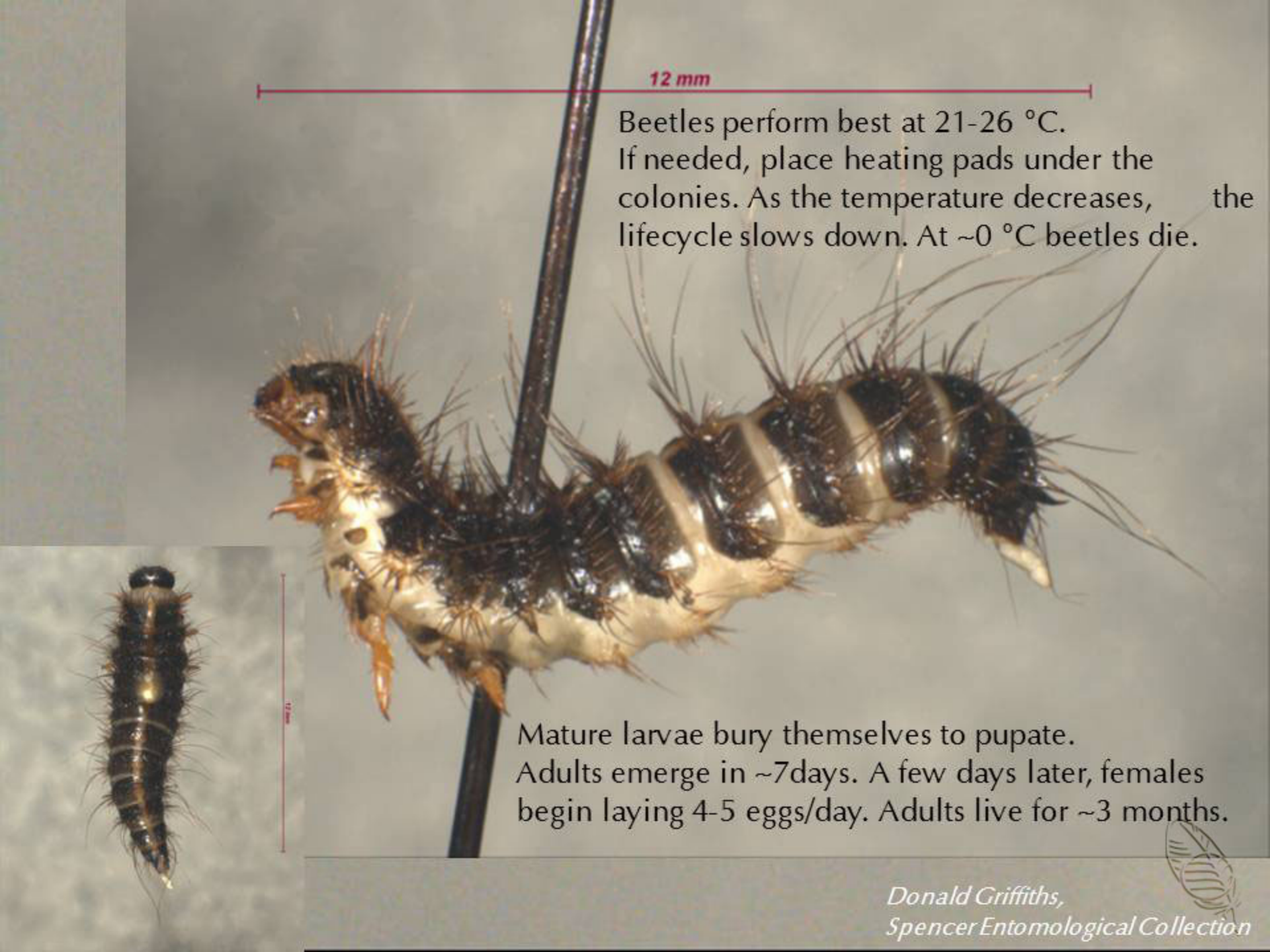
Clockwise from top, photos taken at the:
Natural History Museum of Los Angeles County,
Beaty Biodiversity Museum,
and University of Washington State Burke Museum



READ ONLY if you need to purchase beetles:

Call a taxidermy supply store or go online to find a dealer and purchase a beetle starter kit (~US$100).
Verify that you are getting *Dermestes maculatus.*
This species completes its life cycle (egg to egg-laying adult) in ~45 days. Eggs are too small to see with the naked eye.
In a few days, eggs hatch into tiny larvae.
The voracious larvae do the majority of the skeleton cleaning.

Donald Griffiths,
Spencer Entomological Collection



Beetles perform best at 21-26 °C.
If needed, place heating pads under the colonies. As the temperature decreases, the lifecycle slows down. At ~0 °C beetles die.

Mature larvae bury themselves to pupate.
Adults emerge in ~7days. A few days later, females begin laying 4-5 eggs/day. Adults live for ~3 months.

Donald Griffiths,
Spencer Entomological Collection

Additional information on Dermestariums can be found at:

http://www.ummz.umich.edu/mammal/dermestarium

Food supply controls the population. If you need to process a large batch of skeletons, it is important to build up the colony 3-4 months in advance.

Usually the "Bug Room" is shared by all vertebrate departments.

Background photo taken at The Field Museum
Inset photo taken at the University of Alberta-Edmonton

Overtime, a "frass" (shed carapaces and excrement) layer accumulates. Larvae crawl through the frass and pupate.

Old colonies work best; clean only when the frass is so high that there is a danger of the beetles escaping (2-5 years).

When starting a new colony, provide pupate habitat with either a 10-15 cm of medium-size dry dog food or 5-7 layers of corrugated cardboard.

Top photo taken at the TCWC, Texas A & M University
Bottom photo taken at the University of Nebraska State Museum

The paper strips act as ramps between the frass layer and the carcasses.
Paper towels act as highways enabling the beetles to move between food items and in and out of the frass.

Depending on humidity, spray paper towels lightly with water 1-2 times per week.

Clockwise from top, photos taken at the: University of Alberta-Edmonton, University of Nebraska State Museum, and TCWC, Texas A & M

Always set up at least two colonies.

Occasionally a salvage bird contains a toxic substance that causes 100% beetle mortality.
If you divide a corpse, only initially feed it to one colony.
Be extra careful if a bird has been under veterinary care.

Photo taken at the USFWS National Fish and Wildlife Forensics Lab

It is more time efficient to preparing several birds at the same time:

- Attach a leg label
- Record external morphology data
- Rough the birds [1]
- Use a scalpel to cut the skin of larger birds
- Internal morphology (sex, bursa, skull pneumatization, fat level) is measured, quantified, and recorded at a different lab bench

[1] Roughing is a slang term for removing the skin and feathers.

This lab bench is setup with 3 roughing stations. Each person sits in front of a green garbage bag. Feathers and skin go into the bag.

http://www.youtube.com/watch?v=mmM24MnEiOI

Never rush data collection.
Meticulously record the external and internal data.

The research value of the finished skeleton is in its associated data. Keeping track of DNA samples and the skeleton (or partial-skeleton and voucher), increases the utility of all the components. If the identify of a component is in doubt, it must be labelled as data-less.

Photos taken at The Field Museum and the Royal British Columbia Museum

Small birds:

- Eviscerate only (see Brown Creeper on the previous slide)

Mid-size birds:

- Eviscerate
- Remove breast muscles

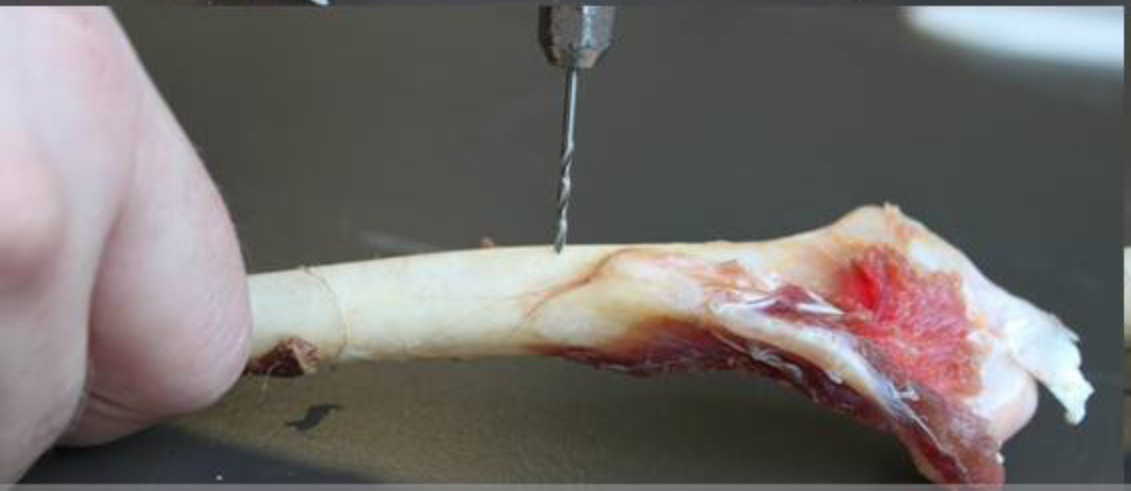
Large birds:

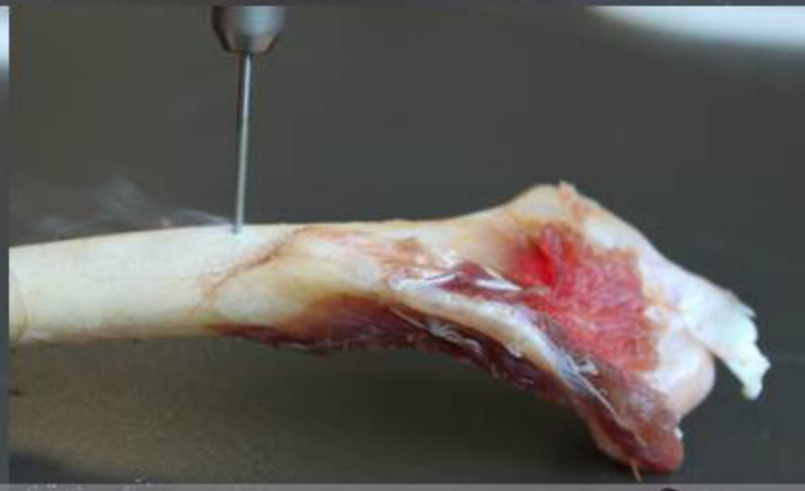
- Eviscerate
- De-flesh body, legs, and wings
- Remove eyes and puncture; drain the vitreous humour
- Place eyes and other misc. bones in the body cavity
- Bind the cavity with string to prevent bone loss

The cut off between mid-size and large birds is variable. Emaciated birds that have reabsorbed their muscle tissue may need very little de-fleshing.

Remove fat regardless of bird size.

Photo taken at
the University of Washington Burke Museum





Drill holes in large humerus and femurs bones gives beetles access to the marrow. Marrow left inside of bones darken them. Over time oils from marrow leeches out, turns rancid, and results in a sticky-greasy patina.

To prevent mildew, air dry medium or large prepared birds. Use a fume hood, or an electric fan, or place in the hottest ventilated area available.

Photo taken at the University of Nebraska State Museum

Beetle colonies have natural ups and downs. Two colonies may work well while a third one slows down for 2-3 months despite identical conditions.

If beetle productivity decreases, consider "spicing up" the bird carcasses by soaking them in beef or chicken broth.

Air dry afterwards.

Photo taken at the Louisiana State University Museum of Natural Science

Store a supply of prepared birds by:

- By freezing
- In 70% ethanol

Look closely at the jar, it contains mammals and birds. Only do this after tissue (DNA) samples have been collected.

Photo taken at the TCWC, Texas A & M University

Partial skeletons (multi-preps) are the norm in some museums but are prepared only for rarely obtained species in others.

Tissue sample, partial skeleton, spread wing, and shmoo.
(skeleton & wing not finished)

Put the prepared birds in the colony, each in it own tray.

Photos taken at The Field Museum

Shake the skeleton gently to return the beetles and larvae to the colony. Freeze to kill bugs and eggs (2 weeks @ -25°C, 1 week @ -80°C).

Wash previously frozen skeletons to remove dead beetles, larvae, and eggs:

- Soak for a few minutes in individual containers to loosen adhered bugs
- Use a wash bottle to thoroughly flush out the inside of the skull
- Place skeleton on a paper towel to dry
- Pour the container water through a screen, check for bones
- Do not start the next bird until you have double checked your work area for mislaid bones

Photos taken at The Field Museum

Finished bones are various shades of beige or brown. Opinions differ on the next step:

YES: A hydrogen peroxide bath chemically removes trace bits of tissue or cartilage, whitens the bones slightly, plus kills any remaining beetle eggs.

NO: Ethically whitening bones with hydrogen peroxide adds a step in what is already a labour intensive process.

Whiten bones are preferred for displays. Submerge bones in hydrogen peroxide. How long depends on size of the bird and the strength of the peroxide. Rinse thoroughly.

Photo taken at the Louisiana State University Museum of Natural Science

Using a .05-.2 fine point permanent pen, neatly write the specimen number on every bone.

Not numbering all the bones introduces ambiguity.
Whether the bones were put away correctly by the last person cannot be verified.

Photo taken at The Field Museum

The Field Museum produces 3,000-4,000 avian skeletons annually from salvaged window collisions. http://vimeo.com/3917100

Numbering all these bones is a huge undertaking. During migration season, skeletons are boxed temporarily with only the skull, breastbone, and a few other key bones numbered in order to make space for next week's batch. When time permits, all the bones are numbered. Partial numbering is not recommended, and can only be justified when an exceptionally high volume of skeletons are produced.

Boxed skeletons are easy to store and label.
Another storage option is clear vials.

At TCWCV, Texas A&M University, each skeleton box or vial has a computer generated label plus a prep label.

WATER MACERATION:

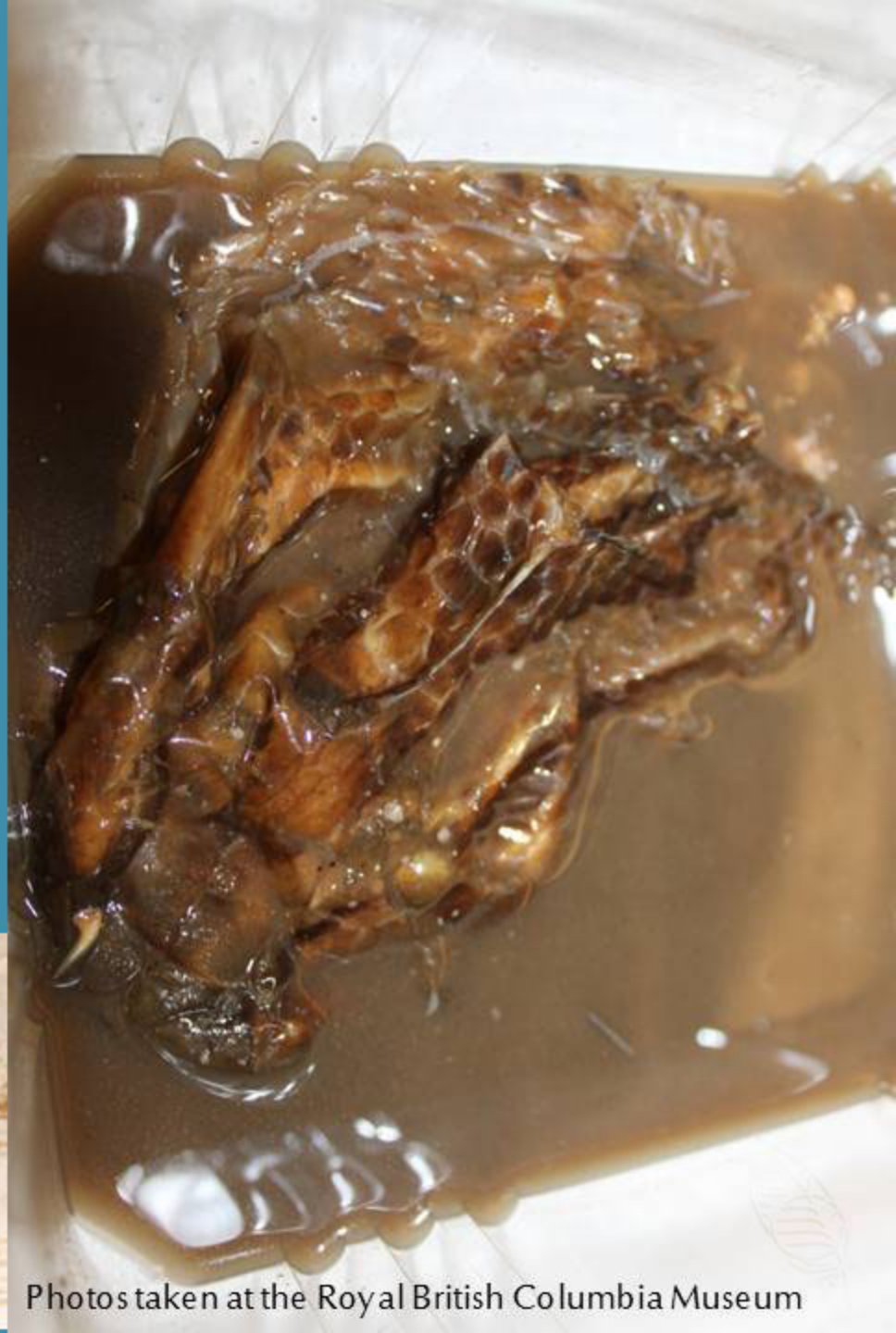
- Put bird in whole or roughed, eviscerated, and de-fleshed (Although not necessary for small and medium sized birds, de-fleshing speeds the process and reduces the volume of muck to be sorted through later)
- Put carcass in air tight container
- Add tap water and wait for the naturally occurring putrefying bacteria to multiply
- Bacteria work best in an anaerobic environment
- Change water only if bacteria stop working
- Place in a well ventilated, warm location
- Using a heating pad or incubator to raise the water to 30-40°C fast tracks the process

Photos taken at The Field Museum and the Royal British Columbia Museum

After a brown sludge develops:

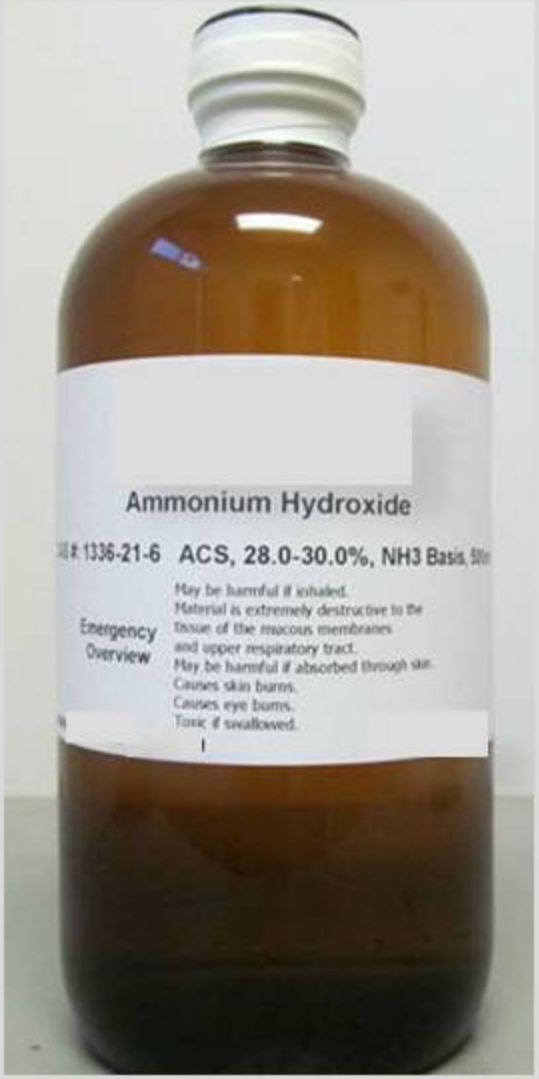
- Check progress when your colleagues are not working, preferably under a fume hood
- When the meat separates easily from the bones (~2-3 weeks) pour into a fine sieve, rinse, and pick out the bones
- Assemble the skeleton on a tray to double check all bones are present
- Because of the amount of waste, it is very easy to lose bones
- Remove the maceration smell by soaking in household ammonia (3% ammonium hydroxide) which whiten the bones slightly

Maceration avoid housing beetles in a museum.



Photos taken at the Royal British Columbia Museum

Using chemical reagent strength ammonium hydroxide (7-30%) is a faster variation of water Maceration.



BOILING:

- Rough, and de-flesh
- Remove all fat
- Place in a cooking pot with enough water to cover the bones
- Heat to boiling point then simmer for 15-120 minutes depending on size
- Repeatedly skim liquid fat off the top of the water
- Simmering bones in fatty water results in greasy yellow skeletons
- As soon as the meat can be removed from the bones, pour the pot contents into a fine sieve
- Do not overcook
- Rise with cold water
- Assemble the skeleton on a tray to double check all bones are present

Boiling weakens bones. The advantage is speed.
Boiling may be the only option if you are in the field.

NATURAL SYSTEMS:

Place roughed or unroughed bird in a mesh bag. For large birds, use multiple bags; with coarse mesh for the large bones, fine mesh (nylon stocking) for digits.

Do one of the following:

- Suspend bags in a pond, or in the ocean
- Suspend bags from a tree, or other structure
- Bury bags in soil, or in a manure pile

Make sure that:

- None of the bones can fallout of the bags
- Nothing with teeth can damage the bones
- No predator or person carries the bags away

Depicted is a modified bird cage suspended from a tree. Red ants will clean these skulls in 2-3 months. Sun bleaches the bones white.

Note: Extremely large animals (whales) are usually skeletonized by burial or submersion in the ocean.

See Part 11- Flat skins, shmoos, and other types of study skins for ideas on educational displays using skeletons

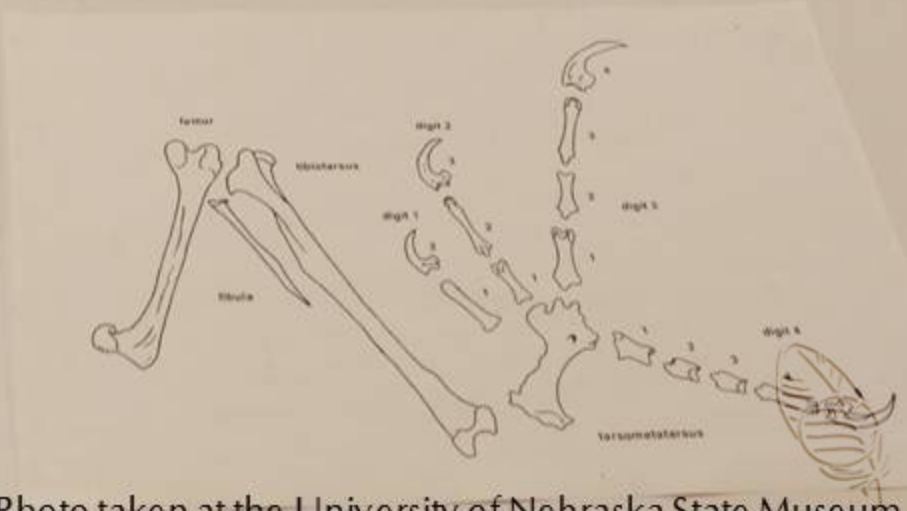


Photo taken at the University of Nebraska State Museum

IN MEMORIUM

DR. REX KENNER

Former Curator of the Cowan Tetrapod Collection who encouraged me to begin this project.

Special thanks to David Willard, Thomas Labedz, Ben Marks, Eve Szabo, Gavin Hawks, Eugene Makela, Steven W. Cardiff, Glen Browning, Pepper Trail, Don Griffiths, Karen Needham, Stephen Hinshaw, Ellen Paul, and all the museum curators and collection managers who has helped and encouraged me to complete this project. I take full responsibility for any remaining mistakes.

Without the technical assistance of Derek Tan, this project would never have gotten off the drawing board. Dr. Darren Irwin kindly suggested and made the arrangements for this series to be posted on the Beaty Biodiversity Museum website. A huge thank you to the staff and volunteers at the Cowan Tetrapod Collection for providing space and creating a terrific work environment.

Unless otherwise indicted, all pictures were taken by the author at the Cowan Tetrapod Collection, University of British Columbia Beaty Biodiversity Museum.

OTHER PRESENTATIONS IN THIS SERIES

Introduction: The look of the bird & A few things to look for
- Part 1 - Spread wings, a good way to start
- Part 2 - Skinning your first bird
- Part 3 - Other skinning methods
- Part 4 - Stuffing your first bird
- Part 5 - Other stuffing and pinning methods & Bird parts
- Part 6 - Sexing birds using gonads (includes 2 quizzes with answer sheets)
- Part 7 - Determining skull pneumatization & Skeleton preparation
- Part 8 - DNA tissue sampling & Gut analysis
- Part 9 - Washing skins for ectoparasites & Drying washed skins
- Part 10 - Recording fat levels & Cleaning fatty or stinky skins
- Part 11 - Flat skins, shmoos, and other types of study skins
- Part 12 - Preserving eggs and shell fragments (in prep)
- Part 13 - Determining cause of death
- Part 14 - Labelling: the most important step

To download another PowerPoint presentation in this series go to:

http://www.beatymuseum.ubc.ca/research/birds