



David Van Auken

Molt



June 9th, 2010

Molt.

- Replacement of Feathers
- Scheduled
 - Annual Molt
- Unscheduled
 - Fright molt, predator event


Molt

- Natal Plumage (at first hatching)
 - Psilopaedic
 - A few scattered down feathers
 - Ptilopaedic
 - Dense, fuzzy down feathers


Molt.

- Soon replaced by more substantial down
 - Same follicles in some species, different in others
- In a few weeks, juvenile feathers begin




Molt.

- Juvenile Feathers replaced by adult plumage
- Adults molt after breeding
 - May molt before breeding





Arthur Morris



Arthur Morris

Molt

- Feather wear can function like molt

Arthur Morris


Molt Terminology.

- Basic Plumage = Non-breeding (winter)
- Alternate Plumage = Breeding (summer)
- Molts are named for the new plumage:
 - e.g., going from basic to alternate plumage is pre-alternate molt

Molt Terminology


Age	Molt	Plumage
0 – 1 month	Prejuvinal Molt	Juvenal
1 – 3 months	First Prebasic Molt	Basic 1
8 – 10 months	First Prealternate Molt	Alternate 1
1 + years	Second Prebasic Molt	Basic 2
1 + years	Second Prealternate Molt	Alternate 2

Molt Terminology



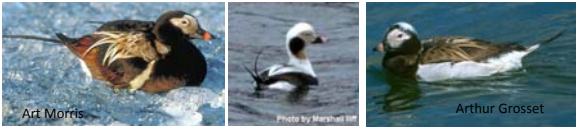
Molt Terminology.

- One molt is probably the primitive condition
 - Molt is energetically demanding
 - 1 molt/year keeps up with normal feather wear
- Species in harsher environments molt more
 - Also removes parasites




Molt Terminology.

- Some species have 3 or even 4 partial molts per year
- Some ducks lose all flight feathers simultaneously
 - Very vulnerable for a few weeks
- Oldsquaw has three overlapping partial molts



Molt Sequence

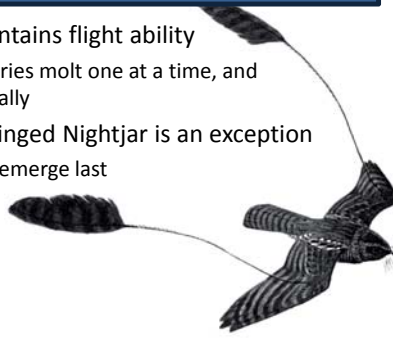
- Usually maintains flight ability
 - e.g., primaries molt one at a time, and symmetrically



Whitefish Point Bird Observatory


Molt Sequence.

- Usually maintains flight ability
 - e.g., primaries molt one at a time, and symmetrically
- Standard-winged Nightjar is an exception
 - Standards emerge last




Central Avian Adaptation.

- Birds have mastered all forms of flight
 - Hovering, diving, flying upside down, soaring
- Many components to flight:
 - Taking off, maneuvering, stabilizing, landing
- Constant adjustments
 - Filoplumes

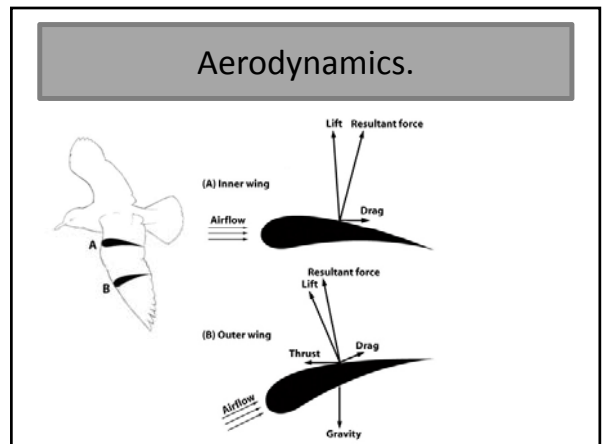


Energetically Expensive.

- Takes a lot of energy to take off
- More efficient overall
 - 10 gram bird uses < 1% of the energy to travel over a distance compared to a 10 gram mouse
- Strong selection for maximum efficiency

Aerodynamics.

- Gravity and drag must be overcome
 - Gravity = weight
 - Drag = turbulence + friction
- Lift (up) and thrust (forward)



Aerodynamics.

- Wings change the pattern of air circulation
 - Faster moving = less pressure (Bernoulli principle)

More importantly, moves air downward

↑ Lift

Aerodynamics.

- Amount of lift increases due to:
 - Airspeed
 - Deflected air volume (wing area)
- Lift needed for take-off can come from wind, jumping from a height, or from running

Aerodynamics.

- Angle of Attack
 - Orientation of wing to airflow
 - Greater angle = Greater lift, until stalling

Aerodynamics.

- Angle of Attack

(A) Angle of attack 0°

(B) Angle of attack 5°

(C) Angle of attack 15°

Wing stall

Aerodynamics.

- Slotted Wings
 - Each primary becomes a little wing

Aerodynamics.

- Slotted Wings

Steep angle of attack

Severe turbulence (lift reduced dramatically)

Steep angle of attack with alula present

Laminar flow over top of wing restored by alula

Turbulence reduced by alula (allows steep angle of attack, generating greater lift, without much reduction of lift due to turbulence)

Aerodynamics.

- Drag
 - Profile Drag = friction
 - Induced Drag = turbulence
- At high airspeed:
 - Profile Drag increases
 - Induced Drag decreases

Aerodynamics.

- Peregrine Falcon

Aerodynamics

- Flying in Formation
 - Reduces induced drag

Kinds of Flight

- Soaring and Gliding
 - Use rising air: **thermals** and updrafts

Kinds of Flight

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Kinds of Flight.

- Soaring and Gliding
 - Use rising air: thermals and **updrafts**

Øyvind Tangen

Kinds of Flight

- Flapping
 - Thrust generated by primaries

The diagram shows a helicopter from a side profile. On the left, the rotor is shown in a vertical position with an upward arrow labeled 'Lift on rotor'. Below the fuselage, a downward arrow is labeled 'Weight'. On the right, the rotor is shown in a horizontal position with an upward arrow labeled 'Lift on rotor'. A horizontal arrow pointing forward from the fuselage is labeled 'Thrust', and a horizontal arrow pointing backward from the fuselage is labeled 'Drag on fuselage'. A downward arrow from the fuselage is labeled 'Weight'.

Kinds of Flight

- Flapping
 - Thrust generated by primaries

The diagram shows four different flight postures of a hummingbird. Top left: 'Forward 28 miles per hour (top speed)'. Top right: 'Forward 8.6 miles per hour'. Bottom left: 'Hovering'. Bottom right: 'Backward flight'. To the right of the hummingbird illustrations, the text '53 beats/second' is written.

Kinds of Flight

- Flapping
 - Thrust generated by primaries

The top part of the diagram shows a flock of birds in flight, with their wings in various stages of the flapping cycle. The bottom part shows a sequence of six wing strokes. The first three are labeled 'Downstroke' and the last three are labeled 'Upstroke'.

Kinds of Flight

- Flapping
 - Thrust generated by primaries
- Wings are independent
- ~50 muscles control wing movements
- Birds increase speed by increasing thrust, not frequency

Kinds of Flight.

- Flapping
 - Thrust generated by primaries

Leading-edge Vortices

The diagram shows a bird's wing in profile with arrows indicating the flow of air over the surface. Small arrows pointing upwards from the leading edge of the wing represent vortices.

Kinds of Flight.

- Birds have well-controlled landings

The diagram shows three birds in different stages of landing. The first is in a steep descent, the second is with wings spread wide, and the third is with wings spread and feet extended, about to land on a branch.

Kinds of Flight.

- Tail Functions
 - Steering and Braking
 - Add lift by improving airflow and reducing turbulence

Kinds of Flight.


- Intermittent Flight
 - Flapping and Gliding
 - Cooper's Hawk
 - Flapping and Retracting Wings
 - Woodpeckers

Flight Comparisons.

	Plane	Bird
Speed (body lengths/second)	32	140 swift
Roll (degrees/second)	720	5000 Barn Swallow
G forces	8-10	10-14

Wing Size and Shape

- Wing Loading
 - Wing area to body mass ratio (g/cm^2)



Wing Size and Shape.

- Wing Loading
 - Wing area to body mass ratio (g/cm^2)



James P. Smith
Thick-billed Murre $2.6 g/cm^2$



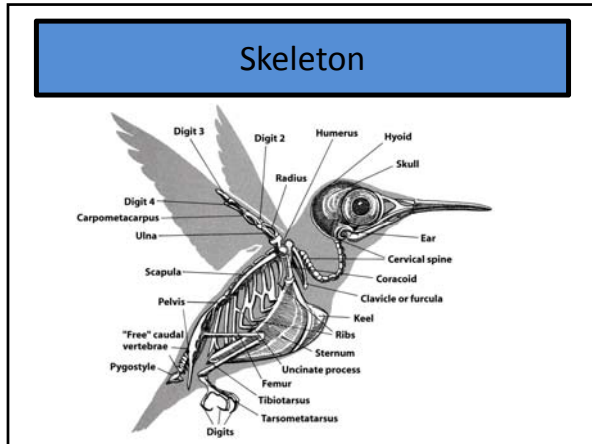
Cosmin Nahaiciuc
Yellow Warbler $0.1-0.2 g/cm^2$

Wing Size and Shape.

- Aspect ratio
 - Ratio of lift to drag
- Longer, more narrow wings good for speed and efficiency
 - Not good for maneuverability




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Skeleton.

- Keel: muscle attachment
- Coracoid, scapula, and furcula: resist pressure
- Uncinate Processes
- Fused hand bones
- Wing can fold
- Hollow Bones

Flight Muscles.

- Pectoralis: 35% of body mass
 - Pulls wing down
- Supracoracoideus
 - Pull wings up

Flight Muscles.

- Red Muscle vs. White Muscle
- Red
 - sustained power from aerobic respiration
- White
 - powerful short bursts through anaerobic metabolism

Flightless Birds

- Flight is a primitive character
 - (all birds have wings)

Bones and muscles require energy
Some birds have lost the ability to fly, saving them energy investment

Common on islands without mammalian predators
Diving birds are less buoyant if they have smaller wings