EEB 4260: Ornithology

Flight

Class Business:

The starting draft of your Avian Ordinal Summary is due TODAY (Mon, 2/16), by 5 p.m., via email. Look at the Guidelines for the Avian Ordinal Summary Assignment for details about what is expected to be present in this early draft. Late submissions lose one point per day.

Reading for this lecture:

Required. Gill: Chapter 5.

Optional. Procter & Lynch: Pages 117, 136-139, 148-151, 156-163.

1. How to get airborne?

A) WEIGHT (GRAVITY) VS. LIFT

. i) In order to get into the air, a bird (or any other object) needs to generate enough **lift** to counteract the gravitational effects of its weight that would otherwise cause it to fall to Earth. Therefore, two things that will facilitate flight are reducing body mass and increasing lift.

. ii) Many features of birds are a direct result of changes that reduce or relocate their mass. These include the loss, reduction, and fusion of various skeletal structures

(see comparison of birds to therapod dinosaurs in Lecture 2): laying eggs rather than carrying young internally: limits on body size.

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iii) One way to create lift is when air flows around an airfoil. Because the distance across the top of an airfoil is greater than the distance along the bottom, the air on top is forced to travel faster than that below. This creates reduced pressure on top of the airfoil, resulting in upward lift and causing the airfoil to rise. This is known as the Bernoulli effect. Lift also can be generated by simply deflecting air downwards, e.g., by angling a flat surface into the wind.

B) GENERATING AIRFLOW

. i) In order to create lift, a bird needs the air around its wings to be moving. The faster the air flows, the greater potential there is to generate lift. Consequently, on a windy day some birds can take off simply by facing into the wind and opening their wings at an angle that deflects air down.

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. ii) Alternatively, a bird can generate air flow by jumping off from a high perch. As the bird falls, the airspeed increases, creating the lift that allows the bird to start flying.

iii) A third option is for the bird to generate airflow by running into the wind. Small birds can create enough lift simply by jumping into the air and quickly beating their wings a couple of times.

C) THRUST AND DRAG

. i) Once a bird is airborne, it needs to be able to move through the air. This requires that the bird produce sufficient **forward thrust** to overcome the **drag** that inhibits movement through the air.

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. ii) **Profile drag** is caused by friction between the bird and the air. This form of drag increases at higher airspeeds.

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iii) **Induced drag** is caused by turbulence, which reduces lift. This form of drag is more of a problem at slow air speeds.iv) Birds create thrust by beating their wings.

(BE WARNED – THE AERODYNAMICS OF BIRD FLIGHT IS INCREDIBLY COMPLICATED. BOTH MY DISCUSSION AND THAT IN THE TEXT BOOK PROVIDE ONLY A VERY SIMPLISTIC TREATMENT OF THE TOPIC. IN REALITY THERE IS A LOT MORE GOING ON IN TERMS OF THE WAY THE

BIRDS MANIPULATE THE POSITIONS OF THEIR WINGS AND INDIVIDUAL FEATHERS IN ORDER TO BALANCE THESE VARIOUS FORCES AND MAKE FLIGHT HAPPEN.)

2. Flight style depends on wing shape

A) SHAPE

. i) **Wing loading** (the bird's mass divided by its wing area) influences how costly it is for birds to fly.

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. ii) Birds with low wing loading (i.e., big wings relative to the bird's overall size) find it much easy to fly than birds with high wing loading (relatively small wings).

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. iii) Wing length is also important because longer wings generate more lift, and a thin leading edge to the wing reduces friction (and thus profile drag).

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. iv) Pointed wing tips reduce turbulence (and thus induced drag), again aiding with fast flight.

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B) Flight style (Note these are very broad generalizations.)

. i) Gliders tend to have long, narrow wings.

. ii) Flappers tend to have shorter, broader wings.

. iii) Long, narrow, pointed wings tend to confer speed.

. iv) Shorter, broad, rounded wings help with maneuverability.

. v) Hovering is extremely difficult, requires special forms of flapping flight to be done effectively, and is energetically a very expensive way to fly.

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3. Origins of Flight

A) TWO MAIN THEORIES

. i) **Cursorial ("ground-up") theory.** Assumes that the ancestors of birds lived on the ground and that the evolution of feathers helped with thermoregulation, prey capture, and/or balance while running. Eventually feathers became big enough that they could allow birds to get airborne. Advocates of a dinosaur origin of birds (see Lecture 2) tend to prefer this explanation.

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. ii) **Arboreal ("trees-down") theory.** This idea suggests that early birds lived in the trees and that feathers arose because they provided advantages when leaping from branch to branch. Eventually, these leaps turned into sustained flight. Those who do not think birds evolved from dinosaurs tend to advocate this explanation.

. iii) Recently discovered fossils showing that ground-dwelling therapod dinosaurs had feathers, lend support for the first argument.

. iv) But, it is also possible that both theories are at least partially correct. E.g., if birds lived both on the ground and in the trees (as turkeys do today). **A NEW theory**, based on observations of how some birds use their wings to run up slopes (**Wing-assisted Incline Running**), suggests that small increases in wing surface evolved incrementally because they were an advantage for ground-living dinosaurs when they were scaling trees (e.g., to get away from bigger predators)

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4. Consequences of flight

A) IT'S NOT ALL GRAVY!Much of bird biology revolves around flight, and the anatomy and physiology of birds have been greatly shaped by the requirements imposed by a life in the air. Although flight provides numerous advantages and opportunities that are not open to animals that cannot fly, birds also are constrained in many ways because they fly. For example:

- Diversity of general body form is fairly low, because of constraints on skeletal structure.

- Live birth is apparently not an option for birds. Note, that eggs are NOT an adaptation for flight (e.g., by reducing weight), since the ancestors of birds also laid eggs. But, birds seem unable to evolve live birth unlike other vertebrate groups.

- Flight is not compatible with some lifestyles. E.g., penguins have lost the ability to fly because their wings have evolved in such a way that allows very efficient underwater swimming, but that precludes flight.

- Powered flight is “expensive”, both in terms of building the apparatus needed to fly and in obtaining the energy needed to actually fly.

B) FLIGHTLESSNESSSome birds have become flightless, in cases where the costs of flight are just too great compared to the advantages of flight, or the costs of not flying.Examples of situations where flightlessness seems to pay include:

- Birds that live on islands where there are no predators.

- Birds that dive and feed underwater. These birds may be able to avoid predators by taking to the water, and wings that are large enough for flight may hinder underwater swimming.

- Birds that are very big and can outrun predators.