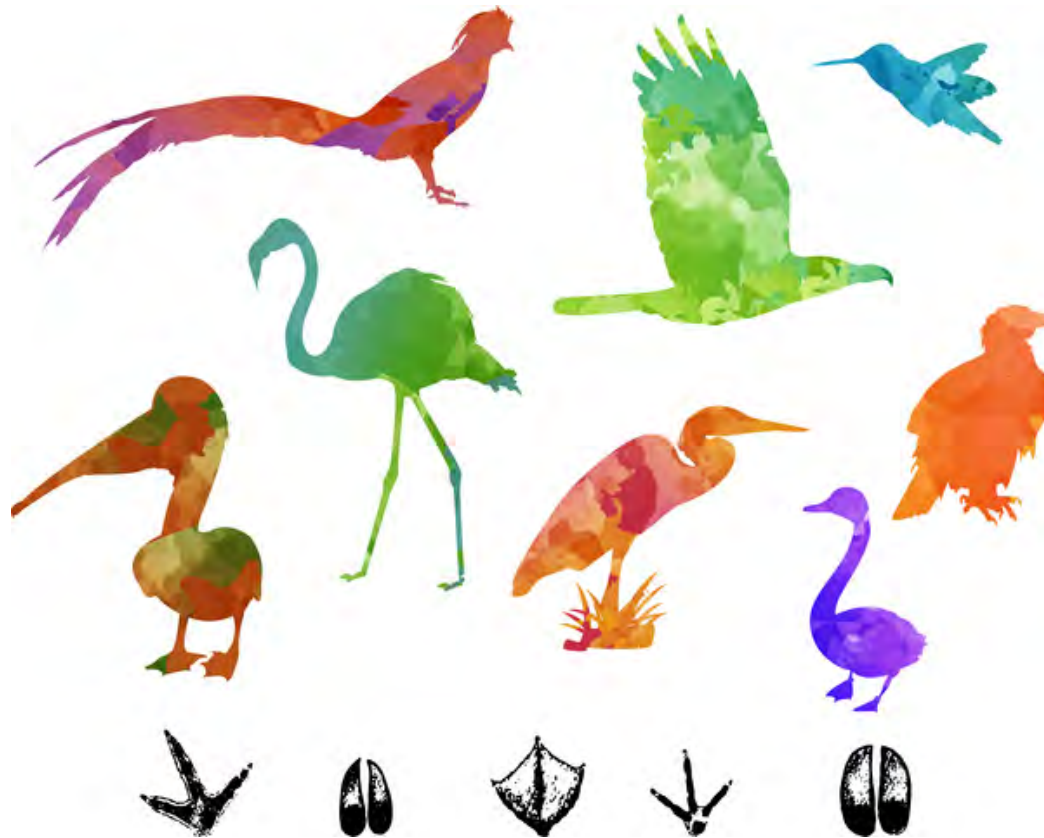


Biology of birds



Dr Sue Lewis

sue.lewis@ed.ac.uk

Biology of birds

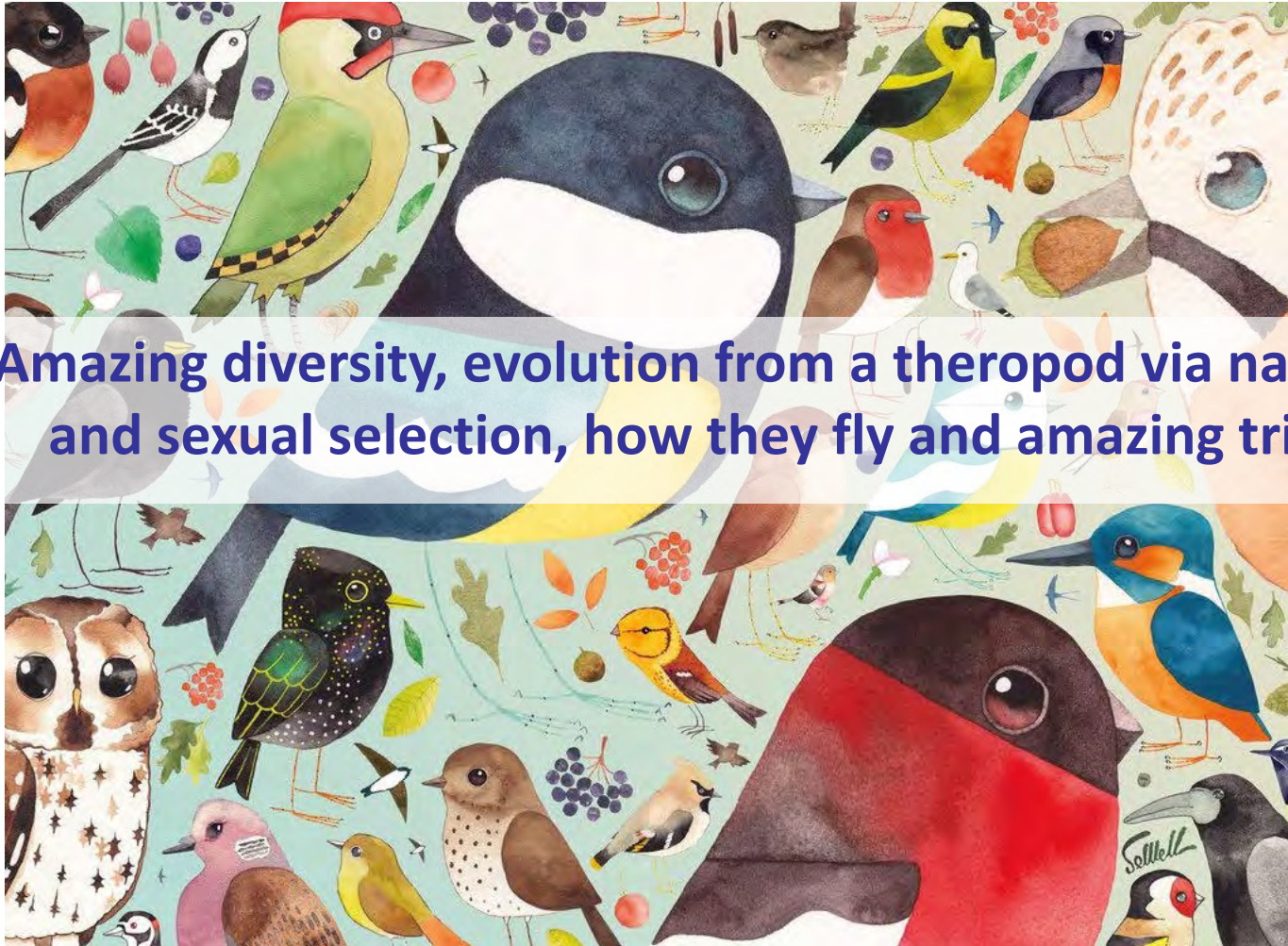


Biology of Birds



Evolution

- Amazing diversity, evolution from a theropod via natural and sexual selection, how they fly and amazing trips



Communication

🐦 Hear their unique and delightful bird song and learn about the diversity of their mating systems and how they manage to raise a chick



Ecology and Conservation



Diversity of ways in which they forage, how their populations are studied and the threats they face and the conservation solutions to protect them

Avian diversity and classification



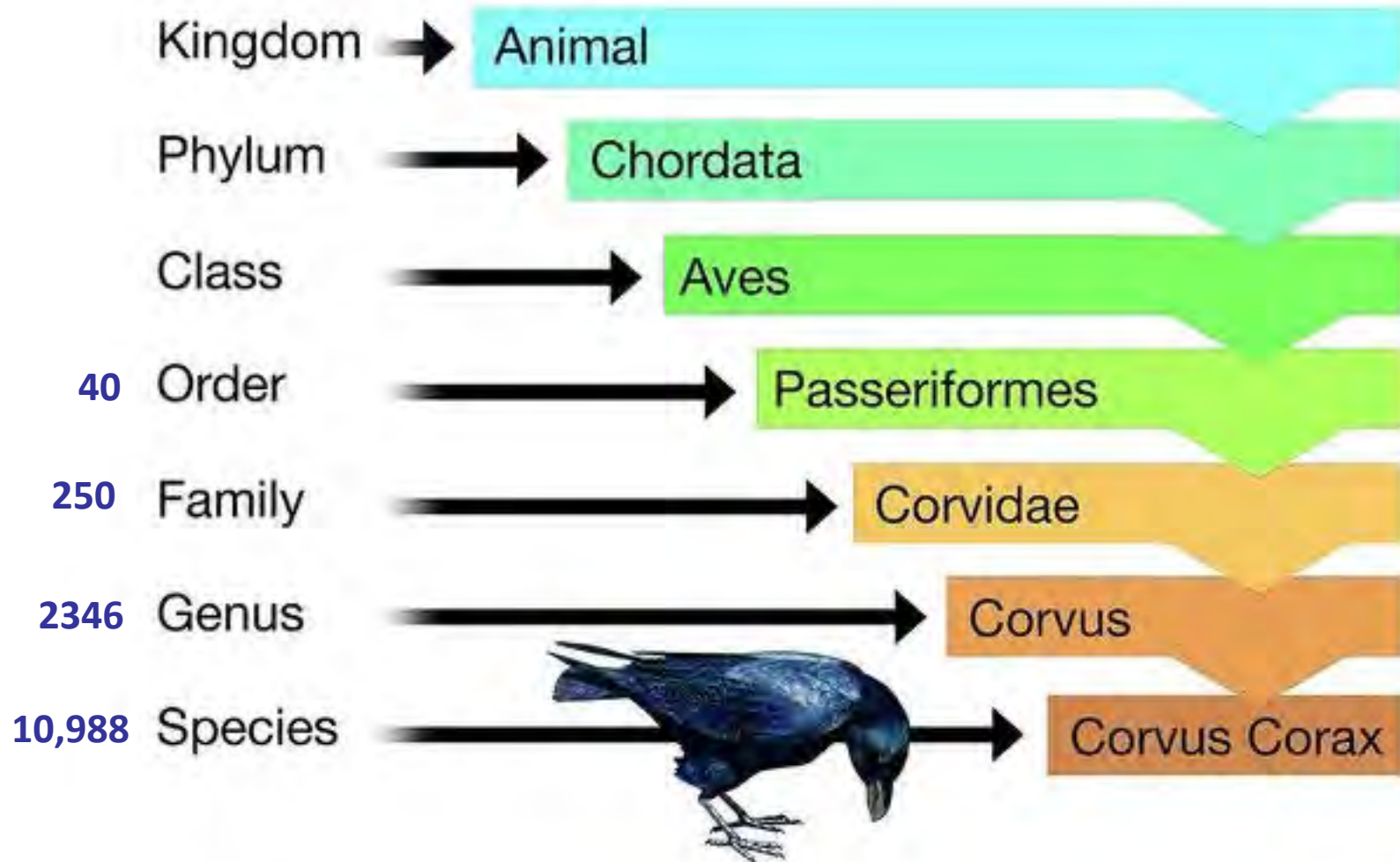
Dr Sue Lewis

sue.lewis@ed.ac.uk

Classifying avian diversity

- 🐦 Today there are 10,988 species of living birds
- 🐦 That is a lot of birds!
- 🐦 Some scientists are interested in organising these into different groups - *classification*
- 🐦 All organisms are classified into different taxonomic levels

Hierarchy of taxonomic levels



Origins of birds

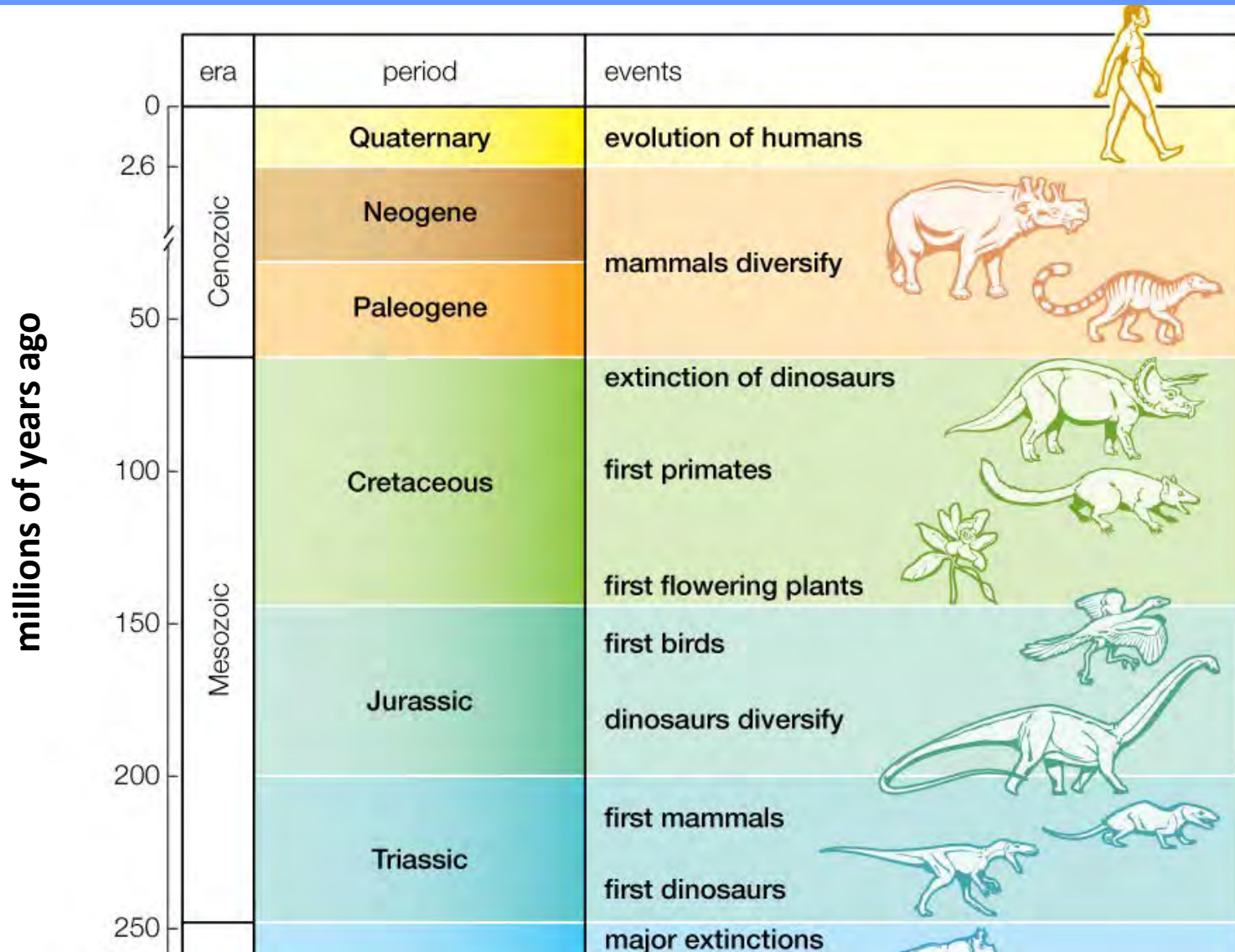


Fig. 2.01 All living birds share a common ancestor. Despite their incredible diversity in forms and ways of life, all living birds—including the (A) African Wood-Owl (*Strix woodfordii*), (B) Orange-headed Thrush (*Geokichla citrina*), and (C) Tufted Puffin (*Fratercula cirrhata*)—descend from a common avian ancestor that lived about 150 million years ago. (Photographs by: A, Roger Wasley; B, Shashi Shankar Hosur; C, Christopher Wood.)

Origins of birds

- 🐦 **Nearly all experts now feel confident that birds are the living descendants of dinosaurs, a diverse group of reptiles that originated about 245 million years ago**

Origins of birds



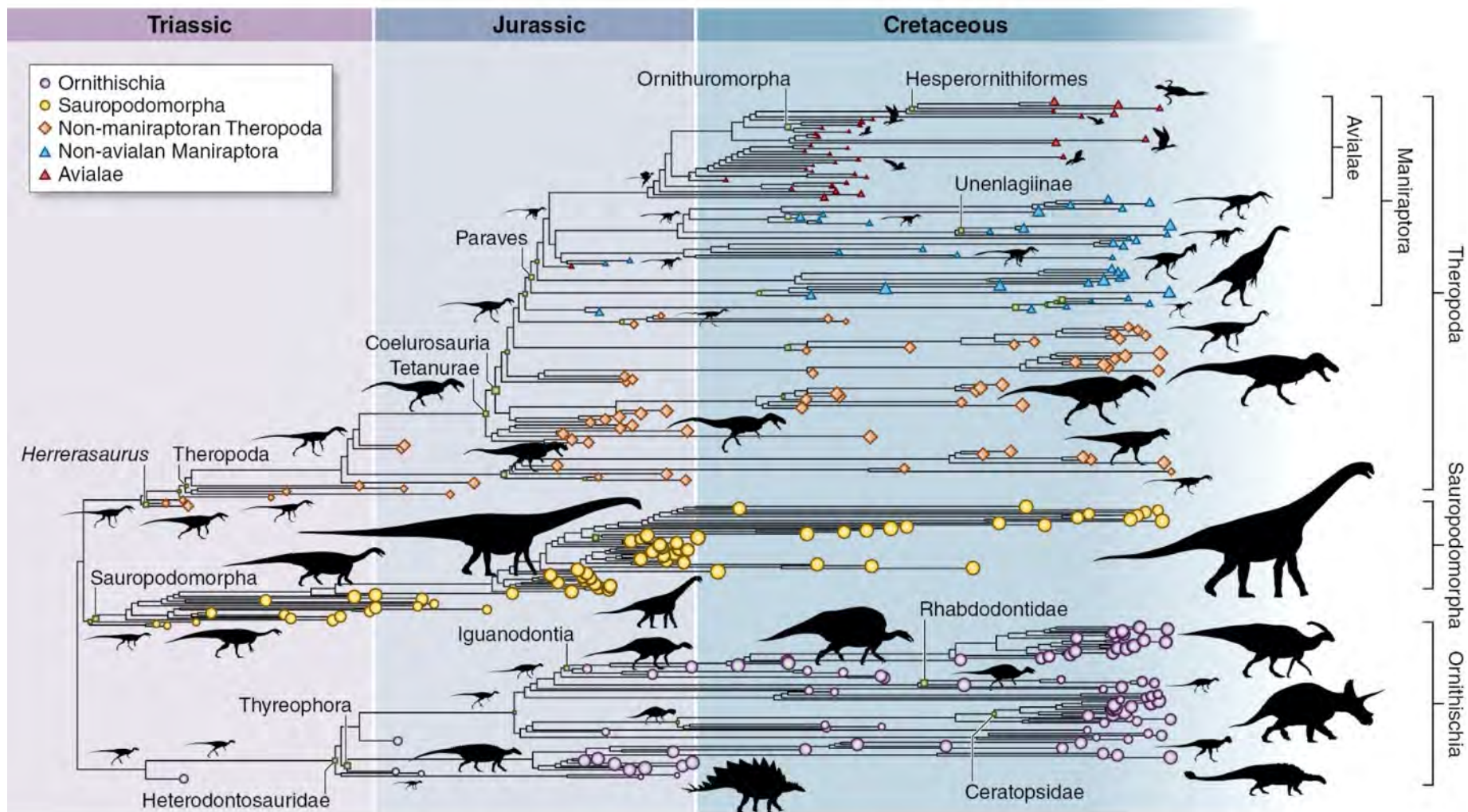


Fig. 2.21 Birds form a subgroup of dinosaurs. This phylogenetic tree shows one widely accepted view of how modern birds (top right) might have evolved from carnivorous dinosaurs. Key evidence for this version of the avian evolutionary tree comes from late Jurassic fossils unearthed in China and South America. (From Benson et al. 2014.)

Origins of birds

- ✿ Dinosaurs became the most dominant group of land animals until the *mass extinction* (ending the *Cretaceous* period) at 66 million years
- ✿ This end-*Cretaceous* event also caused the demise of many other groups of terrestrial and marine organisms and animals
- ✿ Early *Tertiary*, the few groups of surviving birds diversified rapidly - environment more hospitable
- ✿ Birds refilled many niches opened up by the extinction
- ✿ Rapid *radiation* gave rise to many modern birds orders

How birds evolve



Adaptations

- 🐦 **World is full of birds that seem precisely adapted to their particular way of life**

Adaptations

- Barn owls have such acute hearing - can localize and catch prey in total darkness



Adaptations

- 🐧 Emperor penguins have special traits that allow them to swim underwater for more than 10 minutes



Adaptations

- Bar-headed geese routinely fly over the world's highest mountains



Adaptations



🐦 Nocturnal potoos - feathers match roosting tree bark

Evolutionary diversity of birds



*Spectacular diversity of avian morphologies and behaviours
match the fundamental challenges faced by birds*

Natural selection

- 🐦 ***Natural selection* provides the underlying evolutionary explanation for how these various adaptations have arisen in birds and all other forms of life on earth**
- 🐦 **Charles Darwin and Alfred Wallace (1850s) – “survival of the fittest”**
- 🐦 **Under the process of *natural selection*, individual birds with advantageous traits, will on average, exhibit higher survival and have more offspring than individuals without these traits**
- 🐦 **Advantageous traits will increase in the population over time**

Sexual selection

- ***Sexual selection* is a special form of *natural selection* that involves the differential reproductive success of individuals that arises specifically from competition over mating opportunities**
- **Sexual selection can involve competition to attract members of the opposite sex or direct competition with members of the same sex**
- **Sexual selection has produced some of the most conspicuous and spectacular traits of birds**

Sexual selection



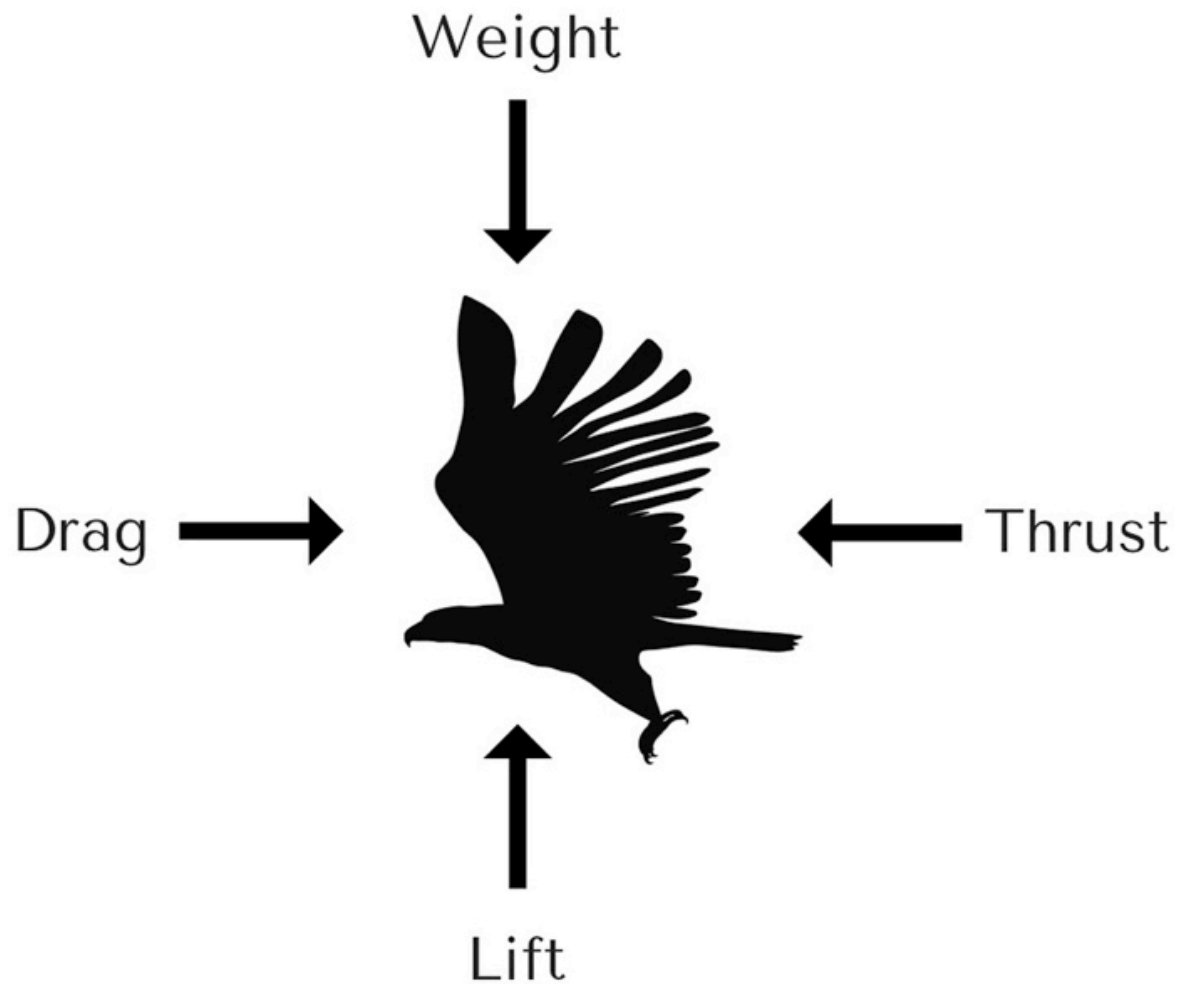
Sexual selection



Avian flight



Forces of flight



Thrust (flapping)

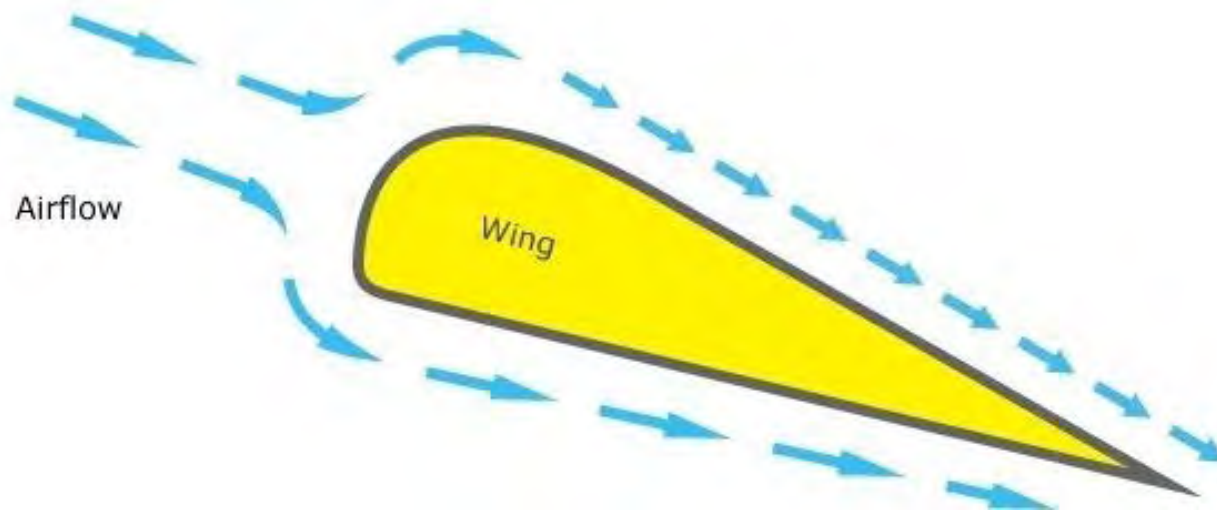


Thrust (running)



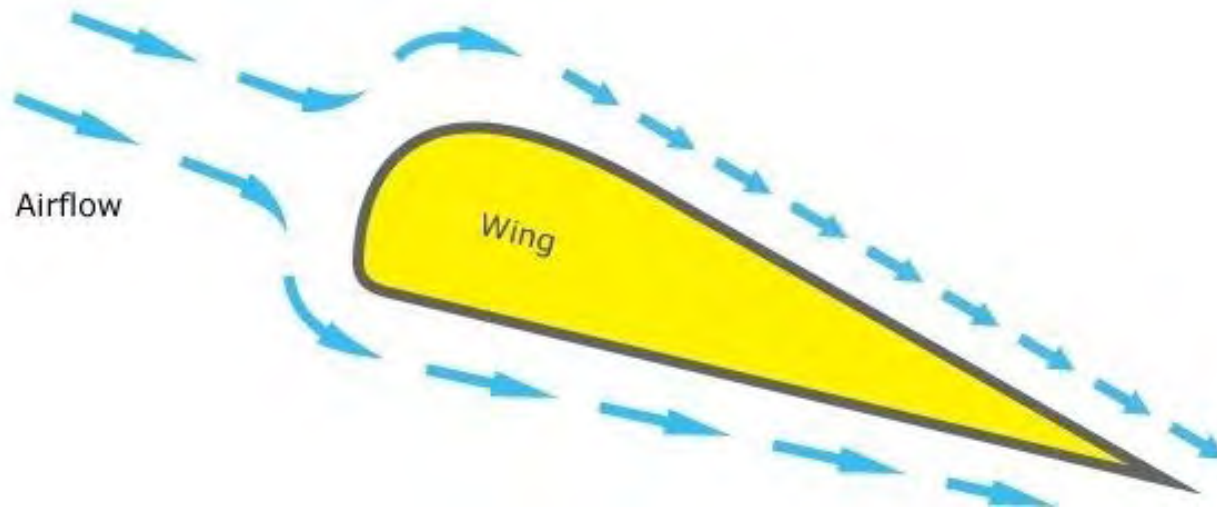
Lift (Bernoulli)

- ✿ Normally, air moves along smoothly in streams
- ✿ Airflow is disturbed when a wing moves through it, and air divides and flows around the wing and meets up



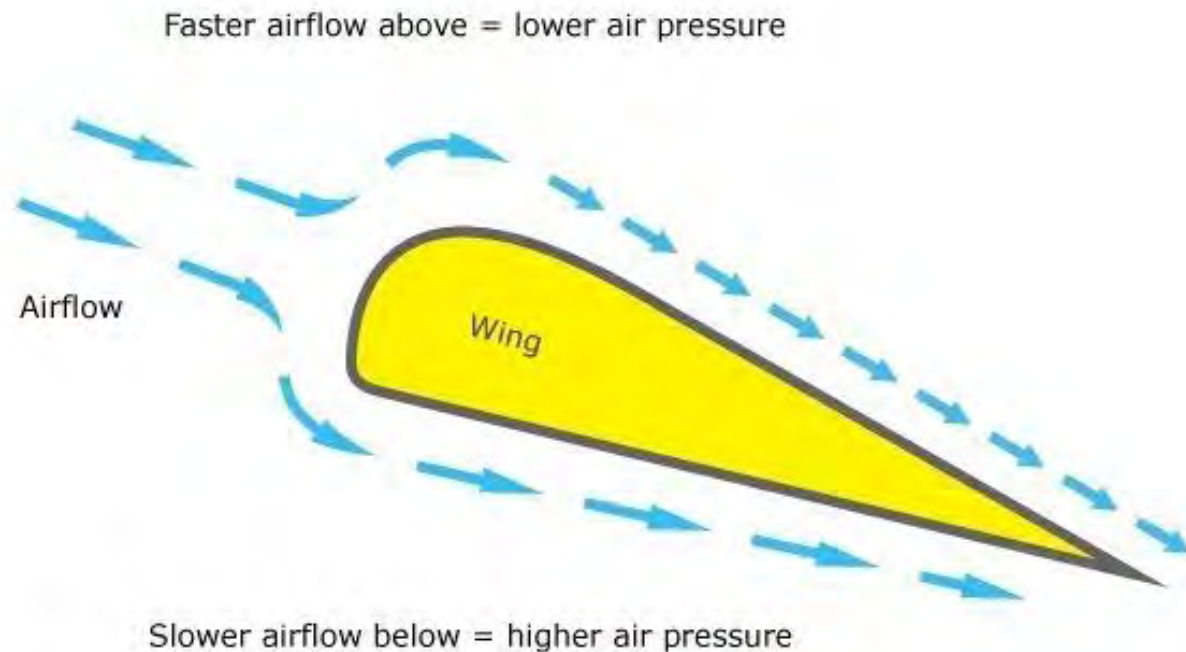
Lift (Bernoulli)

- The top surface of the wing is curved
- The air moving across the top of the wing goes faster than the air travelling under the bottom (to catch up)



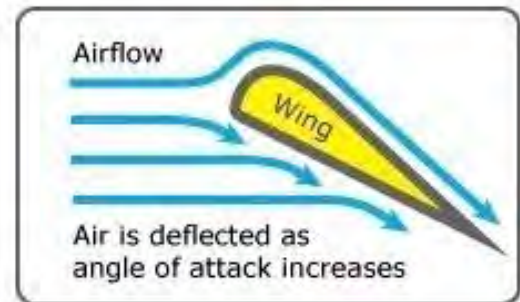
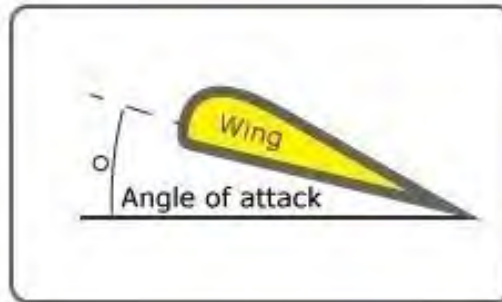
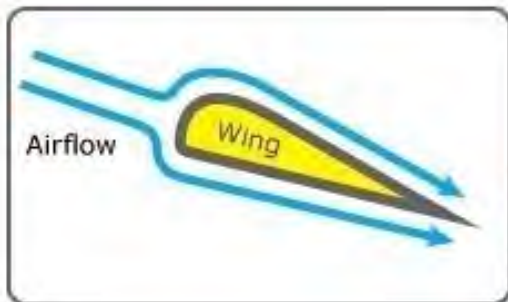
Lift (Bernoulli)

- Because the air on top of the wing is moving faster there is lower air pressure above the wing than below the wing - difference in air pressure creates lift



Lift (Newton)

- ✈ However we now we believe that lift is better described by *angle of attack*, from Newton's third law of motion
- ✈ Amount of lift depends on the speed and density of the air around the wing *and* the angle of the wing
- ✈ Speeding up/increasing angle of attack forces more air downwards, producing lift



Wing shape

- 🐦 **Wing shape is important for determining the flight capabilities of a bird**
- 🐦 **Different shapes correspond to different trade-offs between advantages such as speed, low energy use, and manoeuvrability**

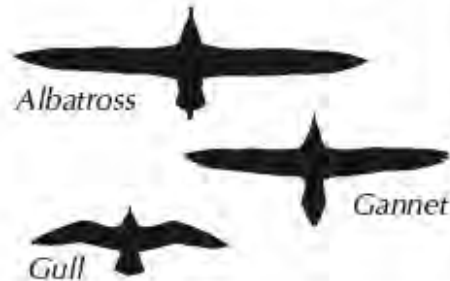
Swift



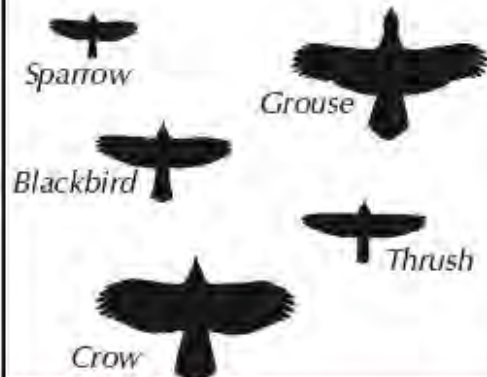
Slotted Wing



Gliding Wing



Elliptical Wing



High-Speed Wing

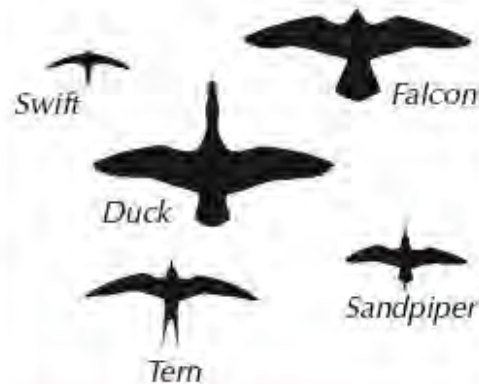


Figure 5-34. Major Wing Types: The tremendous diversity of bird wings have been classified by ornithologists into four major types based on both shape and flight performance. Although these categories are imposed by humans onto a characteristic that actually varies through a continuum, they are helpful in making sense of the overwhelming variety of bird wings. See text for detailed descriptions of each wing type and the flight styles that make use of it.

Designed for flight

- Wings - enable the force of lift
- Lightweight, smooth feathers – reduces the forces of weight and drag
- Light bones – hollow with air sacs and thin, tiny cross pieces to make bones stronger – this reduces the force of weight



Designed for flight

- ❦ **Beak, instead of heavy, bony jaws and teeth – reduces the force of weight**
- ❦ **Enlarged breastbone called a sternum for flight muscle – this helps with the force of thrust**
- ❦ **Streamlined body – this helps reduce the force of drag**

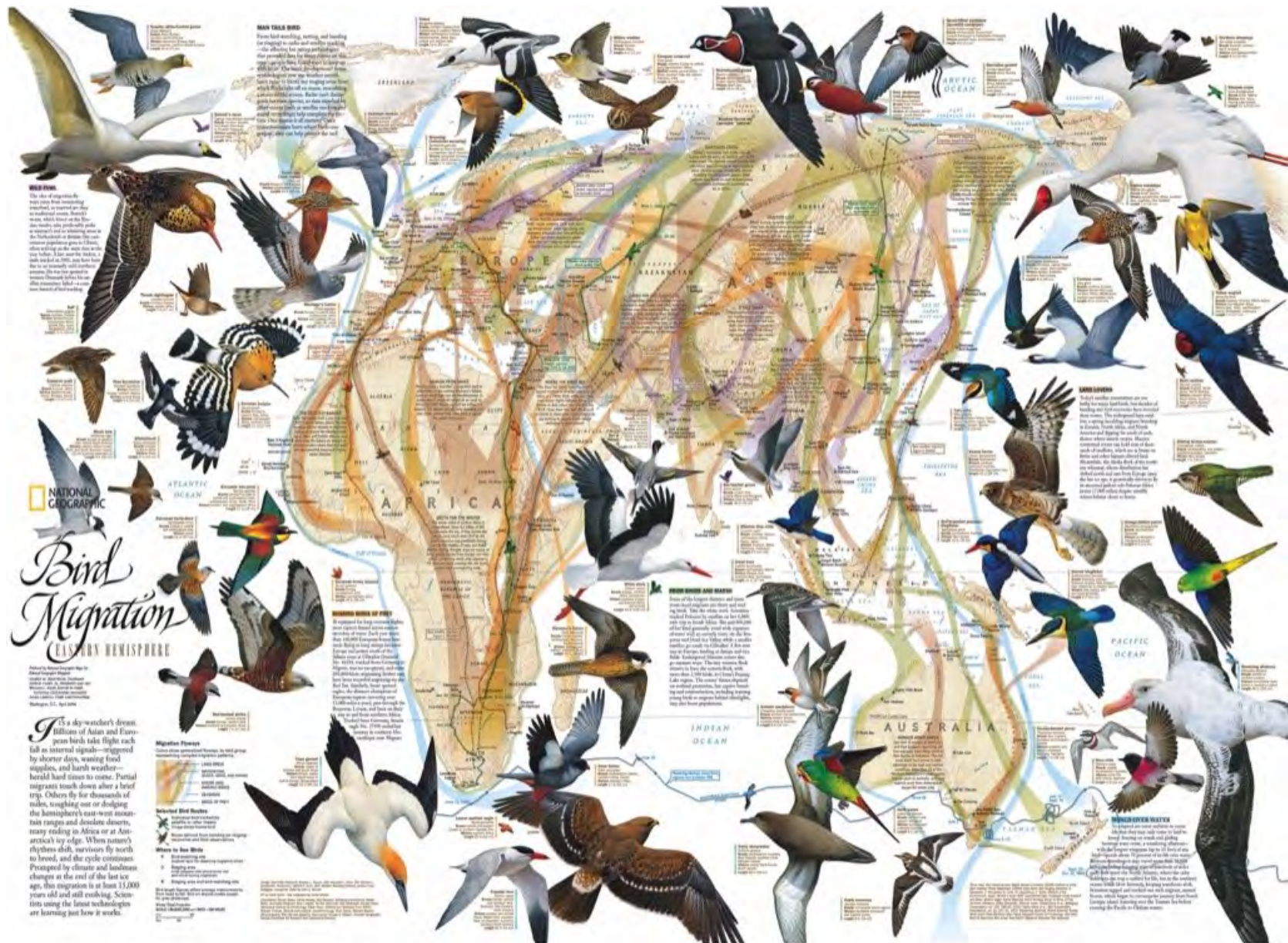


Avian migration



Avian migration

- 🐦 **Migration - regular seasonal movements of individuals away from, and back to, the breeding grounds**
- 🐦 **Billions of birds worldwide migrate between summer breeding and wintering grounds**
- 🐦 **At least 4,000 species of bird (40%) are regular migrants**
- 🐦 **Migrating birds can cover thousands of miles in their annual travels, often traveling the same course year after year with little deviation**
- 🐦 **But migration carries *high costs* in predation and mortality**



Bird Migration

[illegible]

It's a sky-watcher's dream. Billions of Asian and European birds take flight each fall in internal signals—triggered by shorter days, waning food supplies, and harsh weather—before hard times to come. Partial migrants took off after a brief trip. Others fled for thousands of miles, reaching a new breeding or wintering habitat. The long-distance hunters and the desert dwellers, many ending in Africa or at Antarctica's icy edge. When nature's rhythms shift, survivors fly north to breed, and the cycle continues. Preempted by climate and land-use changes at the end of the last ice age, this migration is at least 13,000 years old and still evolving. Scientists using the latest technologies are learning just how it works.

Migratory Flows

Subjected Blood Vessels

- **Improve their marketing results in other ways**
Image alone makes for
- **More optimal from branding on shipping**
responsive and their observations

Where to See Birds
 5. <http://www.birds.org>

[illegible]

Avian migration

- 🐦 **Pole to pole: Arctic tern flies thousands km year from Arctic breeding grounds to Antarctic wintering grounds**
- 🐦 **In a life time (30 years) a tern can travel 2.5 million km - like flying to the moon and back 3 times!**



Arctic tern migration

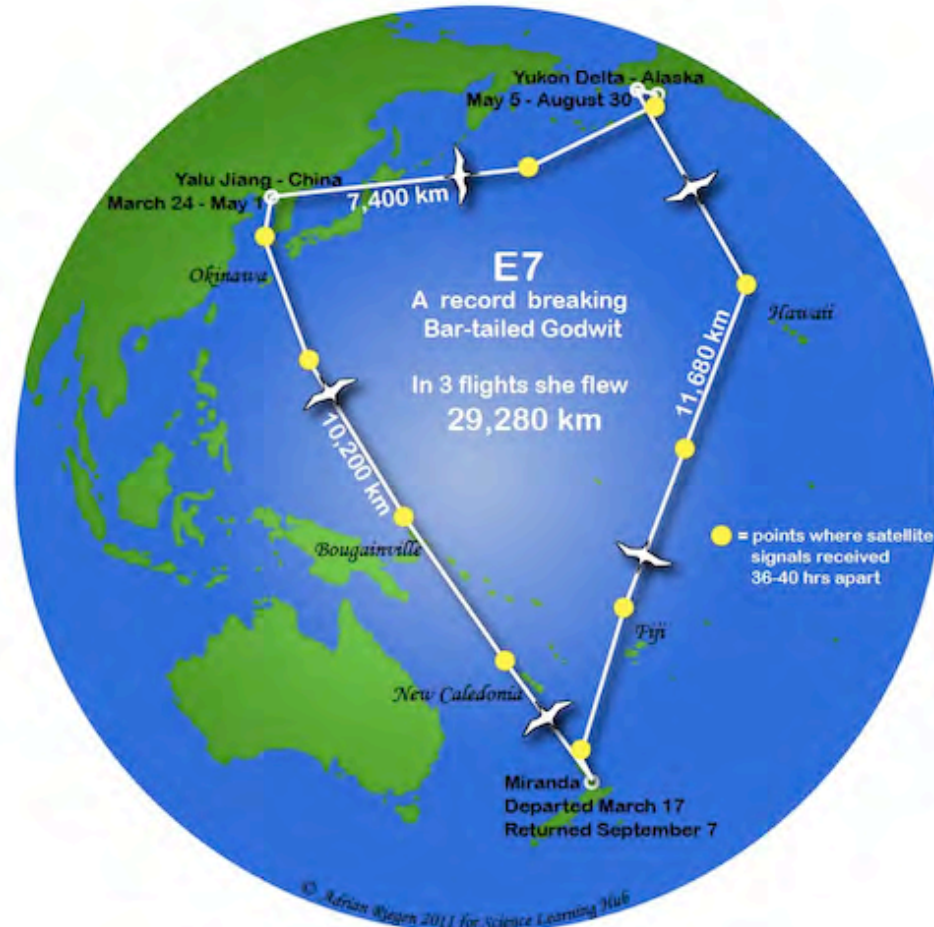


Avian migration

- ❗ **Pole to pole: Arctic tern flies thousands km year from Arctic breeding grounds to Antarctic wintering grounds (max 96,000 km)**
- ❗ **Pacific crossing: bar-tailed godwits have the longest nonstop flight of any bird**



Bar tailed godwit migration



12,000 km
in 7 days!!

Avian migration

- 🐦 **Pole to pole: Arctic tern flies thousands km year from Arctic breeding grounds to Antarctic wintering grounds (max 96,000 km)**
- 🐦 **Pacific crossing: bar-tailed godwits have the longest nonstop flight of any bird (max 12,000 km in 7 days)**
- 🐦 **Mountain crossing: bar-headed geese migrate over the Himalayas at heights of > 7,000 m above sea level**

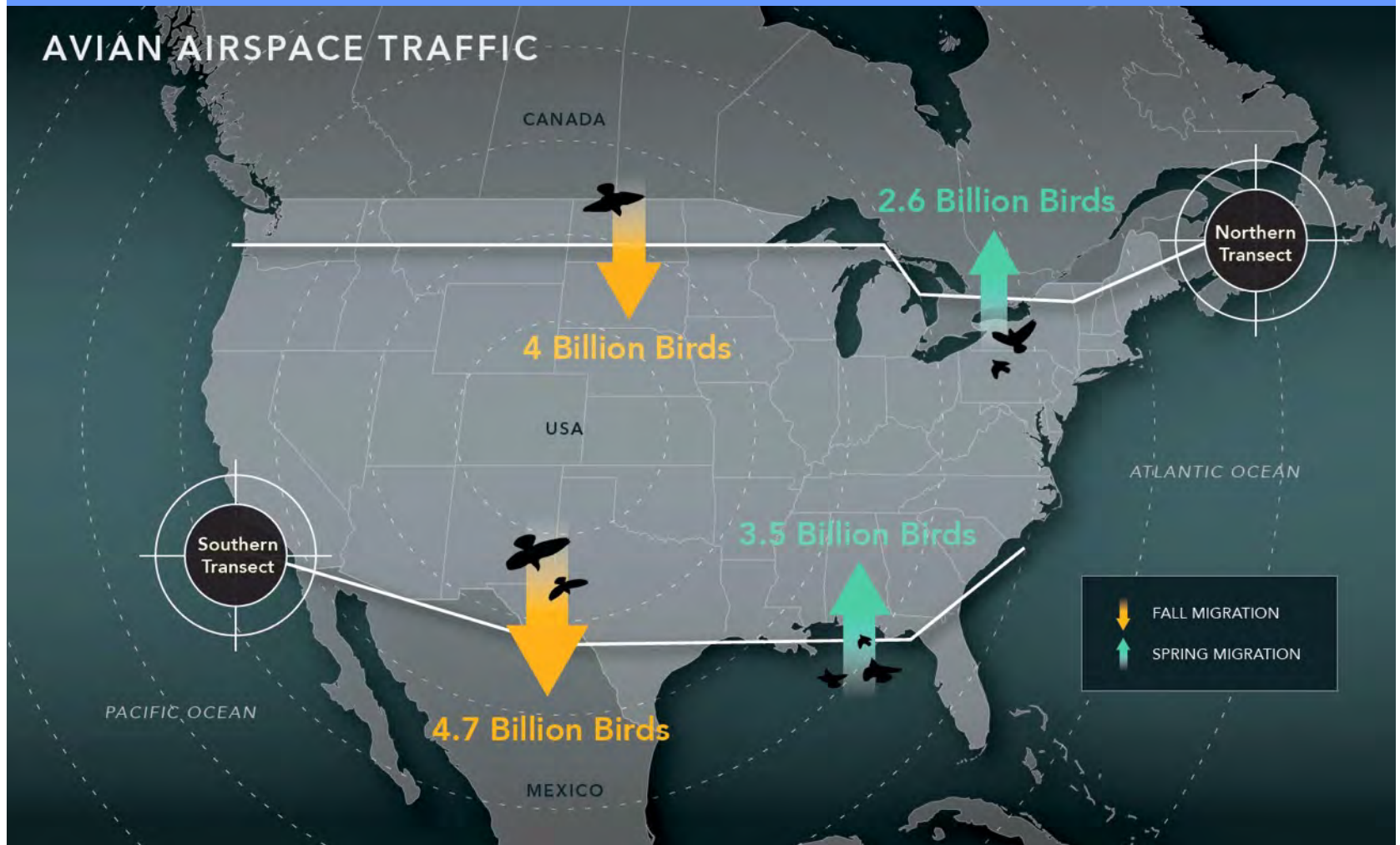


Bar-headed goose migration



<https://www.bbc.co.uk/news/science-environment-30799436>

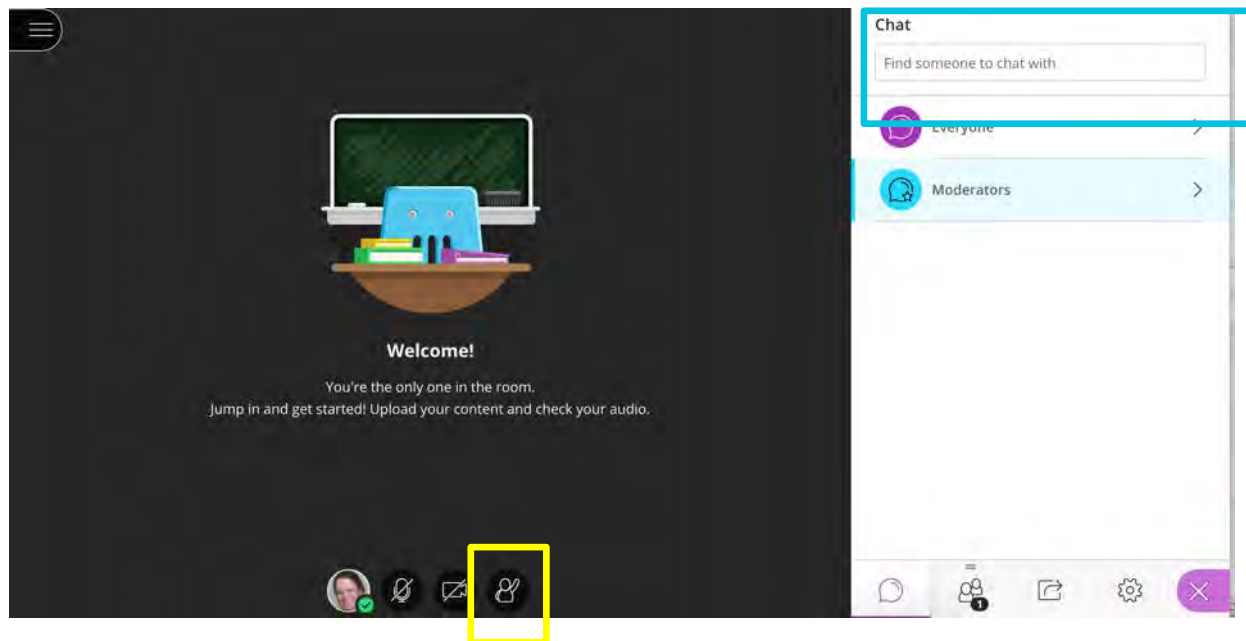
Migration maps



Dokter et al. Seasonal abundance and survival of North America's migratory avifauna determined by weather radar. Nat Ecol Evol (2018), <https://doi.org/10.1038/s41559-018-0666-4>

Questions?

- 🐦 Press the raise hand icon (yellow box)
- 🐦 Send your question in the chat box (blue box) in the collaborate panel when I call your name



Bird song



Bird song

- 🐦 Of the more than 10,000 known bird species, around 4,000 are songbirds
- 🐦 Songbirds are in *Passeriformes* family
- 🐦 Passerines are often called perching birds
- 🐦 Feet adapted for perching - three toes point forward, one backward

Bird song

- 🐦 Birds use sound to communicate - *defend* resources and *attract* mates
- 🐦 Some individuals produce complex and elaborate sounds
- 🐦 Energetically demanding - don't do it all the time
- 🐦 Almost every species can be identified solely by the sounds they make
- 🐦 Song is often thought of as a behaviour of male birds
- 🐦 Females sing in the tropics

Blackbird (melodic)



Song thrush (repeats)



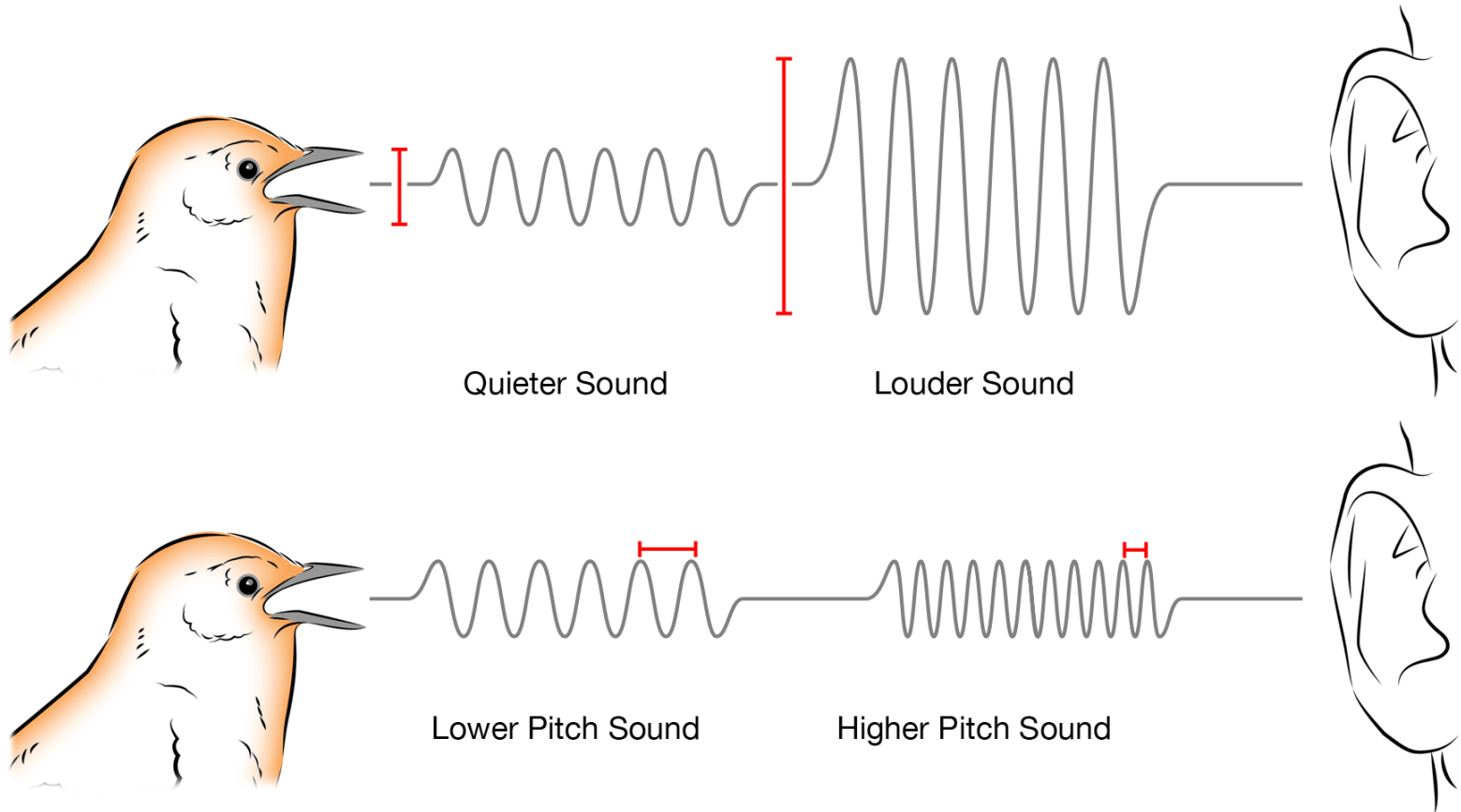
Wren (intense trill)



Sound waves

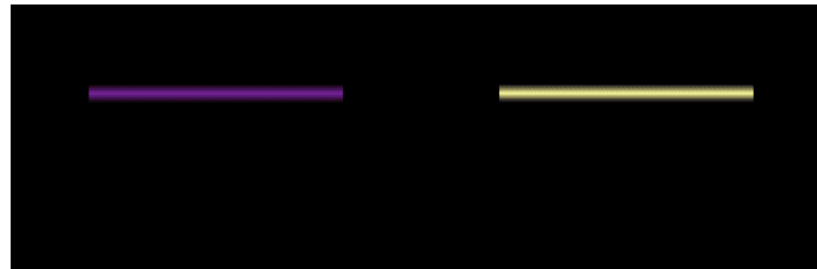
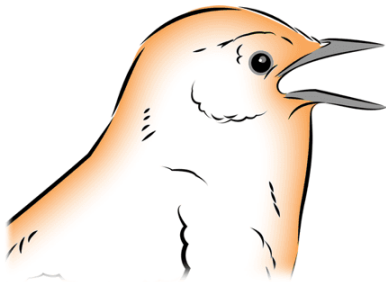
- 🐦 **Sound is the vibration of molecules**
- 🐦 **Air molecules that have been set into motion by a vibrating sound source—like bird's voice box—bump into each other**
- 🐦 **This creates a cascade of movement that we call a pressure wave because it moves outward in bands of increased air pressure**
- 🐦 **Because your eardrum is sensitive to tiny differences in pressure, you detect the airborne vibrations that enter your ear as sound**

Visualising sound



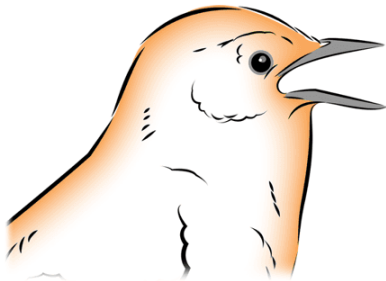
Waveform Summary

Visualising sound



Quieter Sound

Louder Sound



Lower Pitch Sound

Higher Pitch Sound



Spectrogram Summary

Calls

- ***Call* is an avian vocalisation that is shorter and simpler than a typical song and used to communicate a nearby threat and/or an individual's location**
- **Calls less likely to function exclusively in mate attraction or territory defence**
- **Calls have a variety of communicative functions with different calls frequently serving different roles**

Robin song and call



How birds sing

- 🐦 **Songbirds *learn* their songs and perform them using a specialized voice box**
- 🐦 **The vast majority of non-songbird species (e.g. raptors, seabirds) make simpler sounds (calls) that are instinctual**
- 🐦 **Some birds (e.g. chaffinch) have a sensitive period when they learn their songs (e.g. when they are in the nest)**
- 🐦 **Other birds (e.g. nightingale and starling) are open-ended learners and keep learning songs throughout their lives - can have complex repertoires (nightingale can sing 1-200 songs and starling is also a mimic)**

Mating systems



Monogamy

- 🐦 ***Social monogamy***: one male mates with one female



Social monogamy

- 🐦 **Social monogamy - most common avian mating system**
- 🐦 **Even though >90% of bird species are socially monogamous, most also engage in extra pair copulations (EPC) that can lead to extra pair paternity (EPP)**
- 🐦 **In the socially monogamous three-toed woodpecker, approx. 10% of the nestlings have a different father to the social father, raising them at the nest**
- 🐦 **Extra pair copulations even occur in species with life long social monogamy, such as the albatross**

Polygyny

🐦 ***Polygyny*: one male mates with several females**



Polygyny

- 🐦 **Polygyny occurs in just 2% of birds**
- 🐦 **Most striking form of polygyny exhibited by birds occurs at leks**
- 🐦 **Lek: an aggregation of males that engage in competitive mating displays toward visiting females**

Lek polygyny



Lek polygyny – birds of paradise



Polyandry

- 🐦 ***Polyandry*: one female mates with several males**



Polyandry

- 🐦 Polyandry is the most rare mating system
- 🐦 In phalaropes, *sex-role reversal* has occurred, where females compete aggressively with one another for mates whilst courting males
- 🐦 The males they mate with carry out all parental duties once the eggs have been laid in their nest
- 🐦 In polyandrous species, the female is the brighter sex



Fig. 9.21 Sex-role reversal in Wilson's Phalaropes (*Phalaropus tricolor*). In this species, females (right) exhibit brighter plumage and aggressively compete for males (left), which incubate eggs and provide parental care without female help. (Photograph by Larry Jordan.)

Polygynandry

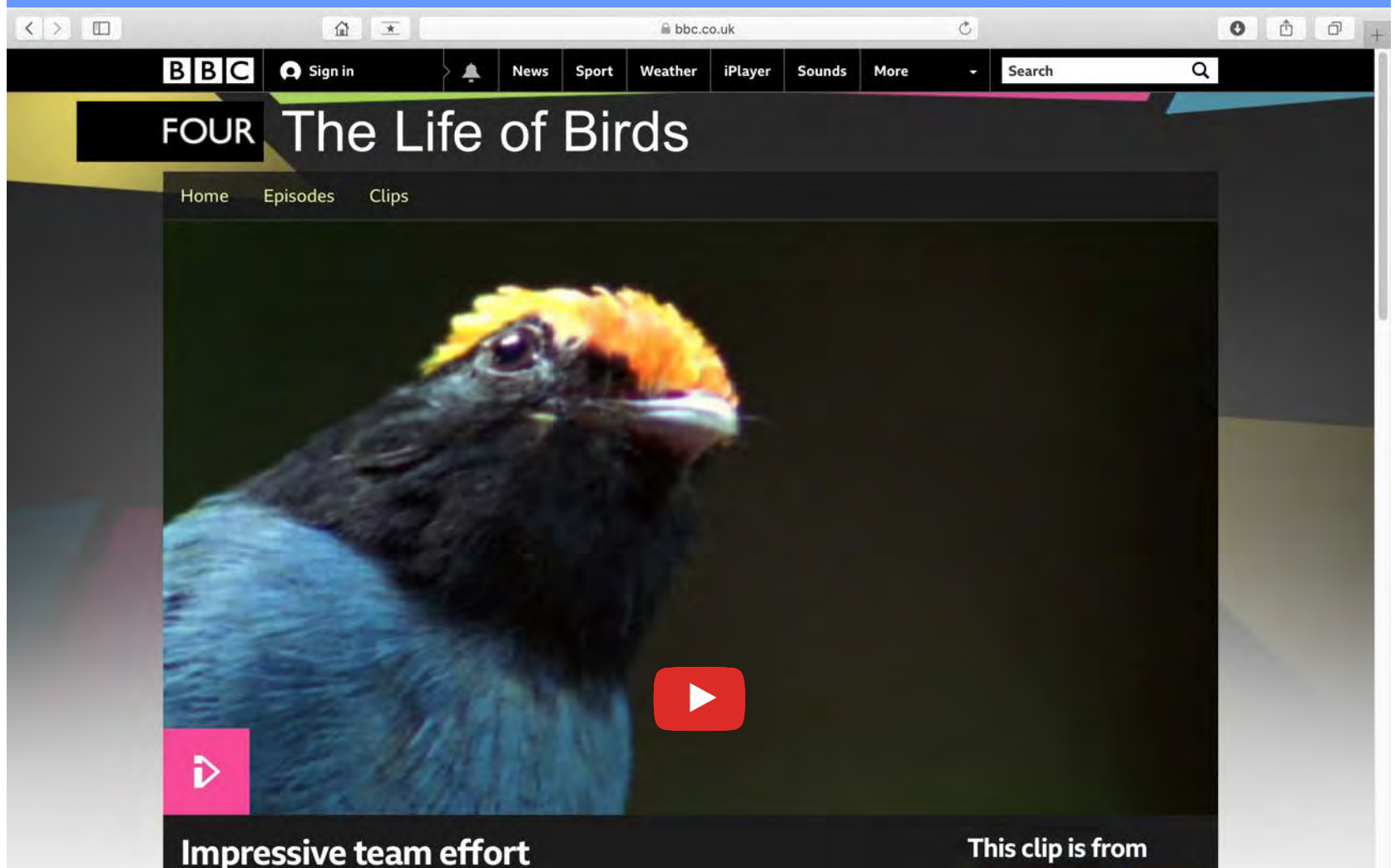
- 🐦 ***Polygynandry***: both males and females have multiple mating systems during a breeding season (very rare, occurs occasionally in dunnocks)



“Cooperative” lek polygyny



“Cooperative” lek polygyny



<https://www.bbc.co.uk/programmes/p00m3n86>

Breeding biology



Nests and nest building

- 🐦 **Most birds construct nests primarily to hold and protect their eggs, and to keep them together so that a parent can incubate them at the proper temperature**
- 🐦 **A simple scrape in the ground serves as an adequate nest for some birds**
- 🐦 **A few birds that lay only one egg at a time have forgone nests altogether and incubate their single egg in other ways**

Nests and nest building

- 🐦 Penguins incubate their eggs (and brood their chicks) on top of their feet



Nest types



Nest types



Nest building

- 🐦 Males and females play various roles in nest construction, depending on the species
- 🐦 In hummingbirds and most other lekking avian groups in which there is strong sexual selection on males, the female builds the nest entirely on her own
- 🐦 Opposite is true for polyandrous species, such as phalaropes, in which the male builds the nest



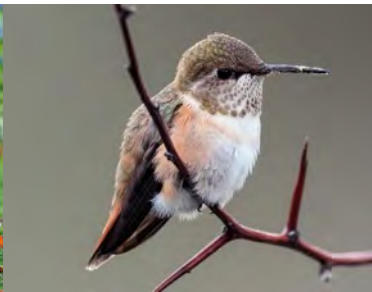
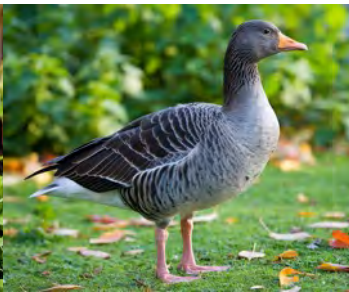
Incubation

- In many bird species, both members of a pair incubate
- Generally, both parents share this equally, switching at frequent intervals, although the female most often incubates through the night
- Members of a pair may perform a “greeting ceremony” when they exchange duties at the nest



Incubation

- In many other bird species, only one parent incubates
- In ducks, geese, hummingbirds, most owls, and many passerines, the female usually incubates
- Male geese and owls defend or gather food for the female while she incubates
- Only the male incubates the eggs in polyandrous species



Hatching

- 🐦 In preparation for hatching, bird embryos develop an *egg tooth*, a short pointed structure on the tip of the upper beak, which the hatching bird uses to break through the eggshell (it absorbs calcium from the shell)



Fig. 11.42 Egg tooth. To break out of their shells, most bird embryos develop an egg tooth on the tip of the upper beak, visible on this newly hatched Masked Lapwing (*Vanellus miles*). The egg tooth reabsorbs or rubs off within a few days of hatching. (Photograph by Kell Nielsen.)

Hatching

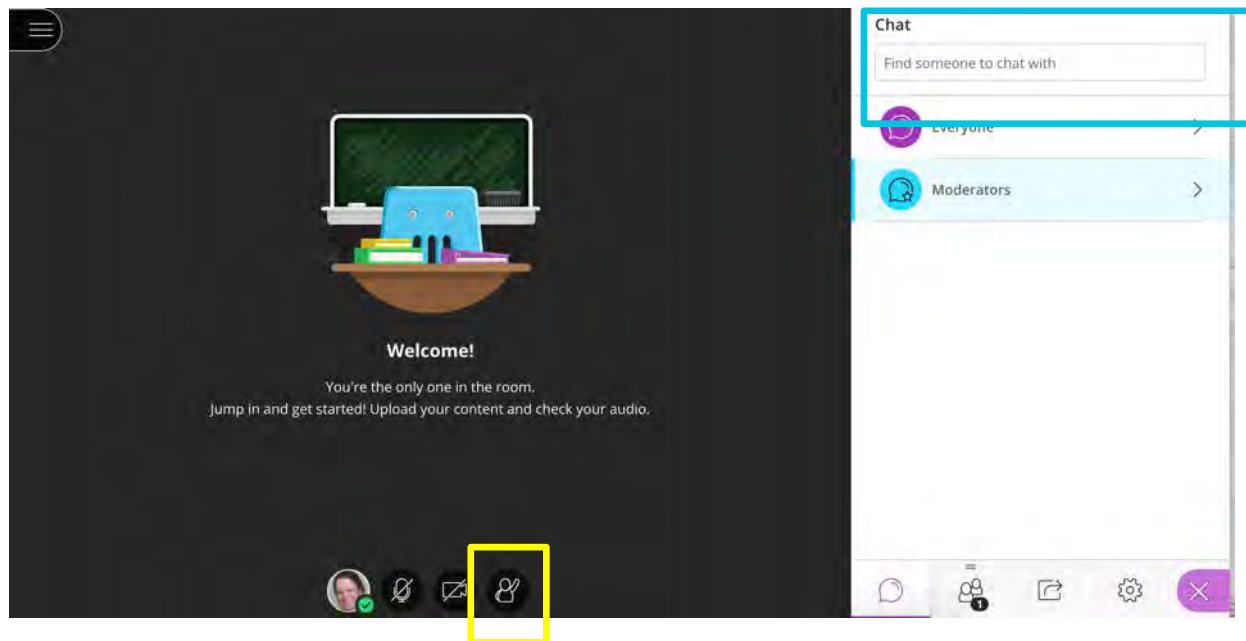
- 🐦 Newly hatched birds vary widely in their readiness for life outside the egg
- 🐦 *Altricial* chicks hatch naked or with sparse down, with no ability to generate heat for thermoregulation, and totally dependent on parents for food
- 🐦 *Precocial* chicks are already well feathered with down when they hatch, with substantial powers of thermoregulation and locomotion, and a considerable degree of independence from the parents for feeding



Fig. 11.44 Altricial versus precocial chicks. (A) Altricial chicks like this Tree Swallow (*Tachycineta bicolor*) hatch at an early stage of development and are highly dependent on their parents for warmth, protection, and food. (B) Precocial chicks like this Spotted Sandpiper (*Actitis macularia*) hatch at a later stage of development that allows them to walk and forage within hours or days of hatching. (Photographs by: A, Chris Gates; B, Navjot Singh.)

Questions?

- 🐦 Press the raise hand icon (yellow box)
- 🐦 Send your question in the chat box (blue box) in the collaborate panel when I call your name



Avian foraging and competition



Generalists and Specialists

- 🐦 **Birds are either generalists or specialists**
- 🐦 ***Generalists* eat anything; *specialists* specialise**
- 🐦 **Diversity of birds' diet and foraging behaviours is evident in aspects of their anatomy, especially their beaks, feet, wings, and tails, that reflect feeding adaptations**

Diversity of bill shape



GENERALIST



INSECT CATCHING



GRAIN EATING



CONIFEROUS-SEED EATING



SCYTHING



FRUIT EATING



CHISELING



DIP NETTING



SURFACE SKIMMING



NECTAR FEEDING



RAPTORIAL



FILTER FEEDING



AERIAL FISHING



PURSUIT FISHING



SCAVENGING

Diversity of foraging strategies

- 🐦 Different birds also exhibit diverse foraging strategies
- 🐦 Techniques and physical and behavioural adaptations required to catch an insect are quite different to those required for capturing a fish



Adaptations to foraging

- 🐦 **Birds generally have to work at foraging**
- 🐦 **While some plants have easily accessible nectar, fruits, seeds, other plant products are diversely defended**
- 🐦 **Adaptations to feeding must take into account the ecological and evolutionary interactions an individual has with its food**
- 🐦 **Flowers of a particular shape favour the evolution of an appropriately shaped hummingbird bill**

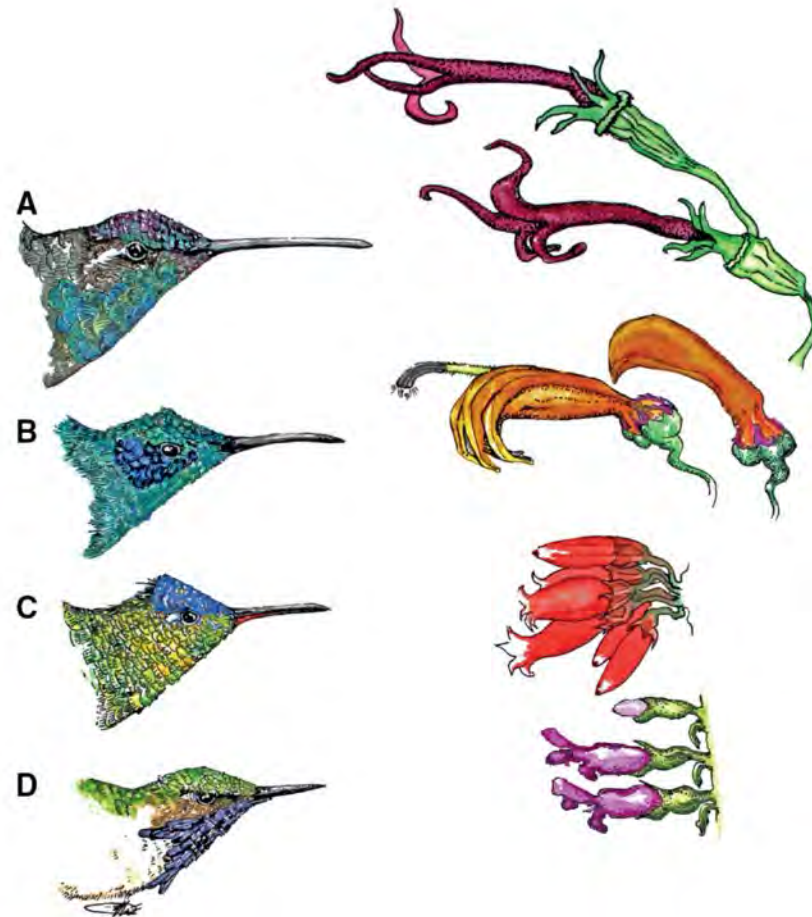


Fig. 8.28 Bill size corresponds to flower shape. The (A) Magnificent Hummingbird (*Eugenes fulgens*), (B) Green Violetear (*Colibri thalassinus*), (C) Fiery-throated Hummingbird (*Panterpe insignis*), and (D) Volcano Hummingbird (*Selasphorus flammula*) coexist in the mountains of Costa Rica, where each species has a bill adapted to different flower sizes and shapes. (Illustration by Alexandra Class Freeman © Cornell Lab of Ornithology, adapted from Wolf et al. 1976.)

Search and recognition

- 🐦 Food-searching process often involves scanning substrates such as leaves, tree trunks and the ground
- 🐦 Some birds use a “*sit and wait*” strategy to capture prey that moves infrequently



Search and recognition

Home Episodes Clips News Helping winter wildlife

Winter
watch
BBC



Phil Hayne

<https://www.bbc.co.uk/programmes/p05w5mm4>

Search and recognition

- 🐦 **Other birds, such as thrushes have an acute sense of hearing to detect underground animals**
- 🐦 **Woodpeckers listen for wood-boring insects**
- 🐦 **Although most birds have a poorly developed sense of smell, some birds do use olfaction to find food**
- 🐦 **Some seabirds search over large ocean areas, and once they discover a smell, move upwind to find its source**
- 🐦 **Nostrils at the very tip of the beak, capable of detecting scents at concentration of only a few parts per million**



Fig. 8.12 Olfaction in foraging. (A) Bonin Petrels (*Pterodroma hypoleuca*)—like many petrels, shearwaters, and albatrosses—use their keen sense of smell to locate prey on the ocean surface. (B) King Vultures (*Sarcamphus papa*), along with most New World vultures, use olfaction to locate carrion when foraging in forested habitats. (C) Great Spotted Kiwis (*Apteryx haastii*) and other kiwi species are nocturnal foragers, employing smell to locate earthworms and other prey underground. (Photographs by: A, Chandler S. Robbins; B, E. J. Peiker; C, Sharon Richards.)



*A few species of
birds use tools
to extract prey*

Fig. 8.20 Foraging extraction tool. Woodpecker Finches (*Camarhynchus pallidus*) use small twigs or spines to extract grubs from decaying wood. These birds carefully choose twigs depending on the dimension of the cavity and may reuse a preferred tool several times. (Photograph by Susan B. Wright.)

Populations and individuals

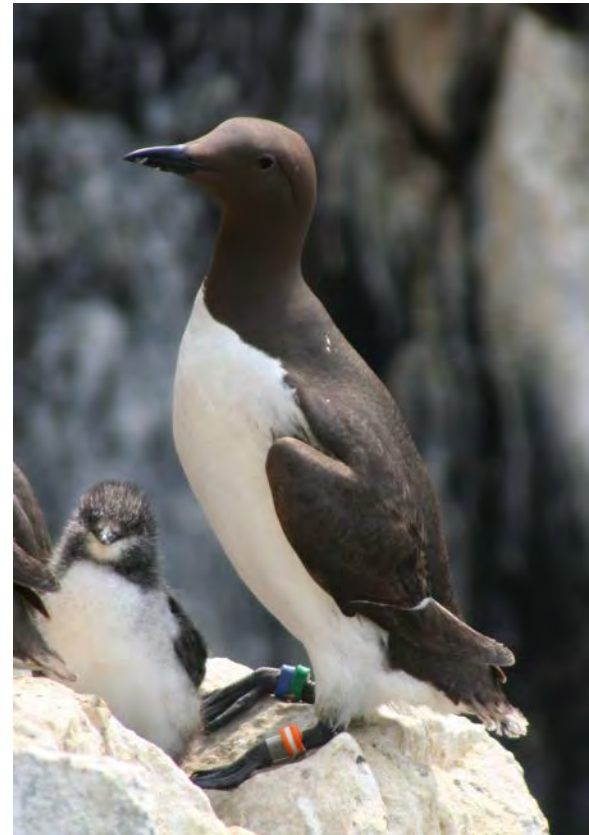


Population ecology

- Population ecologists study features that describe the *demography* of a population
- survivorship* - the proportion of birds that survive from one year to the next
- fecundity* - the number of offspring produced each year
- dispersal patterns* - rates of immigration/emigration
- age structure* - proportion of juveniles versus adult birds and the ages of those adults
- sex ratio* - ratio of males to females

Population ecology

- 🐦 To understand which *demographic* trait is driving a population to increase or decrease, population ecologists must be able *identify* and study *individuals* across many years
- 🐦 Catch and ring birds
- 🐦 Colour rings and unique metal BTO ring



Population ecology

- 🐦 **Demographic data require many years of detailed study (Isle of May long term study has been going since 1973)**



Seabird studies



Bird conservation



Bird conservation



Species Dashboard

Total species
10,988

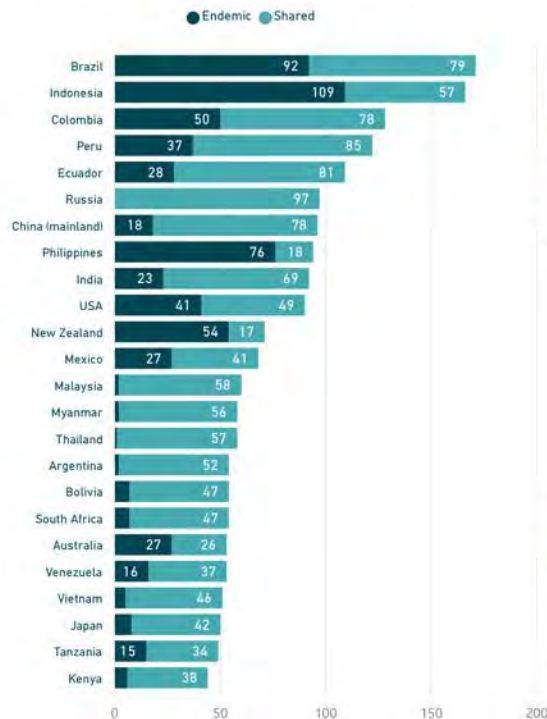
Globally threatened species
1,486

Dashboard guide ?

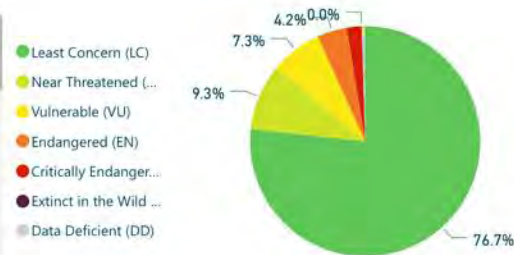
Reset all filters ↶

Region: All
 Country: All
 Family: All
 Extant/Extinct: Extant
 Ecosystem: All
 Species Type: All

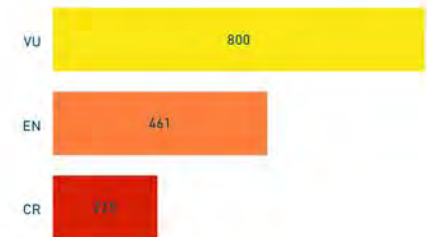
Globally threatened species by country



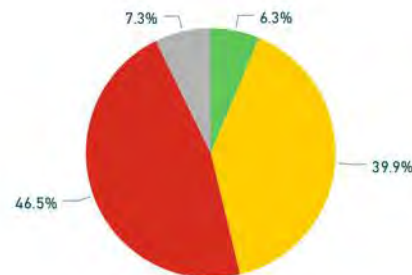
IUCN Red List Categories



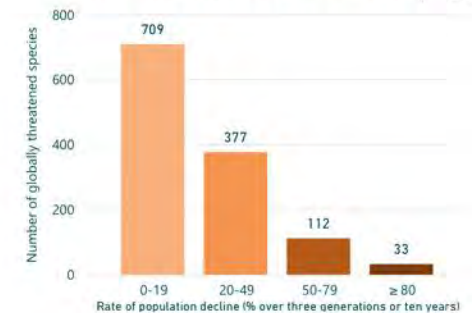
Number of globally threatened species



Direction of global population trend



Trends for declining globally threatened species



Major threats to bird populations



Habitat fragmentation



Introduced predators

- 🐦 Introduction of new predators into habitats previously lacking them represents a huge threat to birds
- 🐦 Rats, cats, mice, mongooses, stoats and ferrets are the most widespread and notorious



Climate change

- 🐦 Climate change increasingly is implicated as a threat to bird populations around the world
- 🐦 Northward-shifting distributions - birds are breeding and migrating further north
- 🐦 Progressively earlier spring arrivals and nesting dates among northern hemisphere birds
- 🐦 Concern - may become increasingly difficult to find suitable breeding grounds, more exhausted from longer migrations, may become out of sync with their prey

Conservation solutions

- 🐦 **Above all, *maintaining suitable habitat* is the essential requirement for the successful conservation of any species, community or ecosystem**
- 🐦 **Conservation solutions are complex - need to balance the needs of both humans and the natural world**
- 🐦 **Many conservation projects require lots of time and effort by many volunteers**
- 🐦 **Protection needs to be implemented globally - birds move across country boundaries with different laws**



Fig. 15.43 Mauritius Kestrel (*Falco punctatus*). This species recovered from the brink of extinction in the mid-1970s thanks to the timely intervention of biologists. Eggs were removed and raised in a captive-breeding program, while parents raised their own replacement clutches in the wild. The population today is healthy and at carrying capacity in remaining forest habitats. (Photograph by Sam Cartwright.)



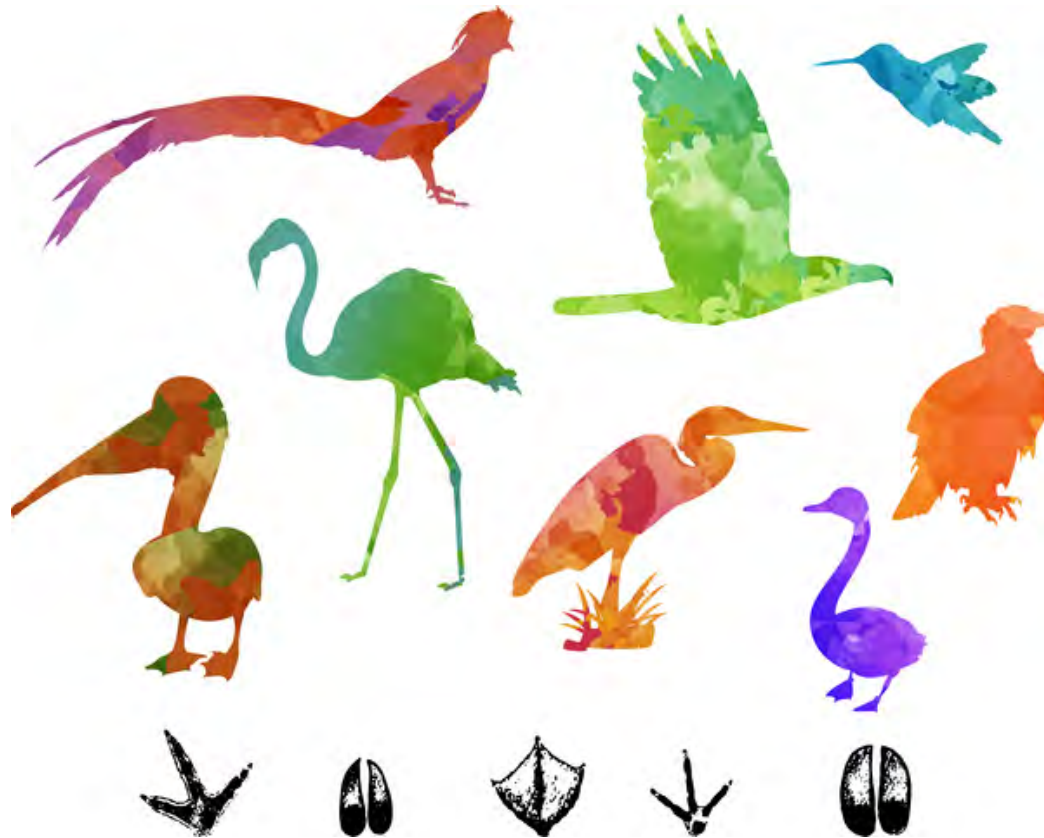
Fig. 15.49 Kakapo (*Strigops habroptila*). A large, flightless, nocturnal parrot, this New Zealand endemic was an easy target of introduced feral cats and was nearly extinct by the late 1970s. In 1989, the Kakapo Recovery Plan moved 65 individuals to several small, virtually predator-free islands. With extensive volunteer efforts and successful captive rearing, current populations include 130 monitored individuals. (Photograph by Stephen Jaquery, Otago Daily Times.)

What each of us can do

- 🐦 **There are so many little things that we can do to help**
- 🐦 **Back garden conservation, citizen science, adopting a place/animal, consumer choice, environmental education, wildlife watching with youngsters, contribute to conservation organisations, *never give up***



Biology of birds



Dr Sue Lewis

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Questions?

- 🐦 Press the raise hand icon (yellow box)
- 🐦 Send your question in the chat box (blue box) in the collaborate panel when I call your name

