

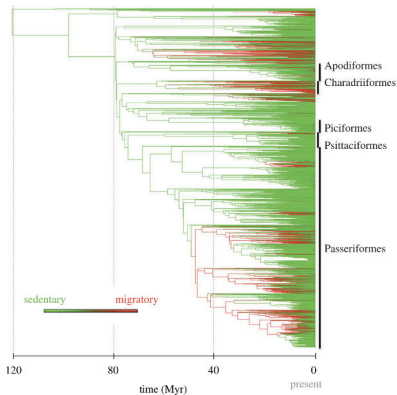


Migration

Dr. Ethan Linck
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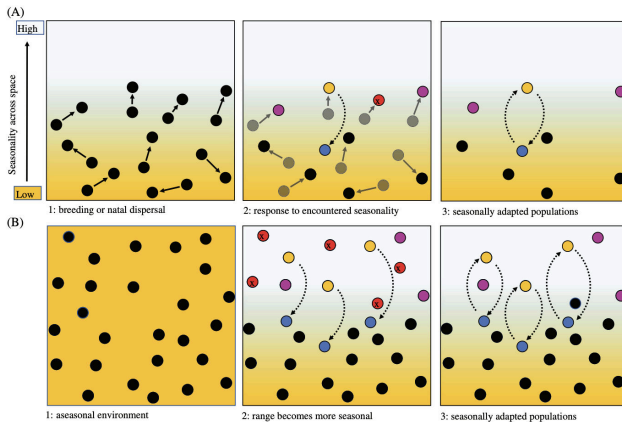
Migration

- ▶ 1817 bird species are migratory (~18%)
- ▶ Repeated evolution of migratory behavior: predictable seasonal movement across latitude, longitude, elevation
- ▶ c.f. **irruptive** movements (unpredictable search for resources)



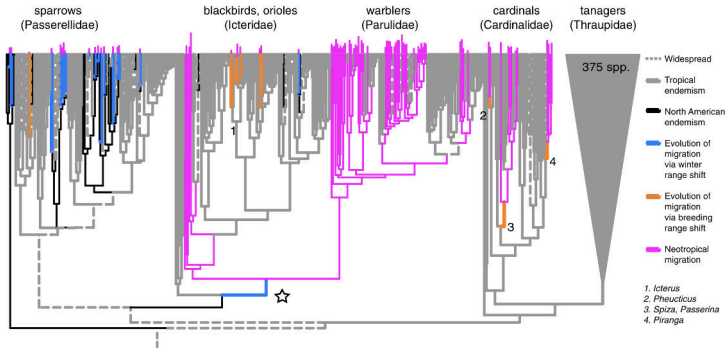
Migration

- ▶ H_1 : Migration is adaptation to reduced competition for breeding sites
- ▶ H_2 : Migration is adaptation to seasonality



Which hypothesis is supported in neotropical migrants?

blue means a lineage with a winter range shift; orange means a lineage with a breeding range shift; pink are lineages that are current neotropical migrants

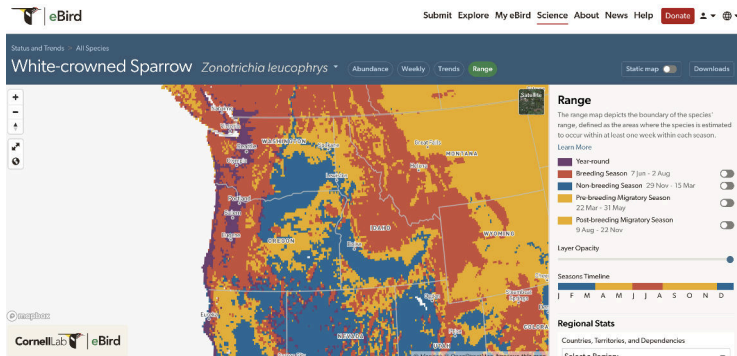


(Winger et al. 2014)

- a) H_1 : adaptation to reduced competition for breeding sites
- b) H_2 : adaptation to seasonality

Partial Migration

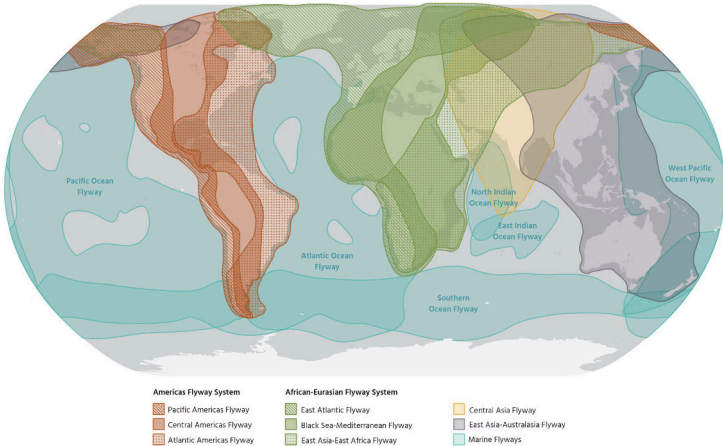
- ▶ Common: Found in (e.g.) 32-44% of Australian species
- ▶ Tradeoffs: Energetic costs of overwintering versus migrating vary across space



(eBird)

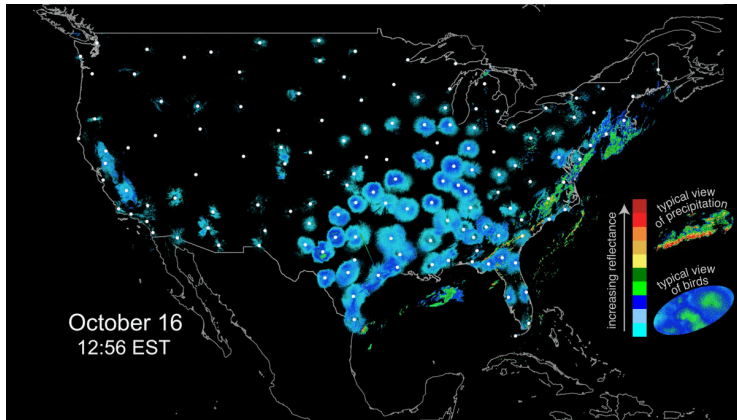
Flyways

- ▶ **Flyways** are corridors where many species migrate
- ▶ can include **stopover sites** (think freezeout lake)



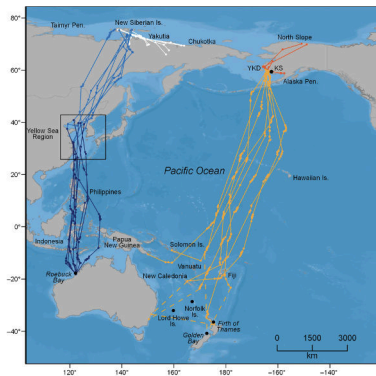
Radar ornithology

- ▶ radar can detect birds as well as weather events
- ▶ confused WWII era operators, who called them “angels”
- ▶ filtering out weather and other signals leaves us with migration forecasts!



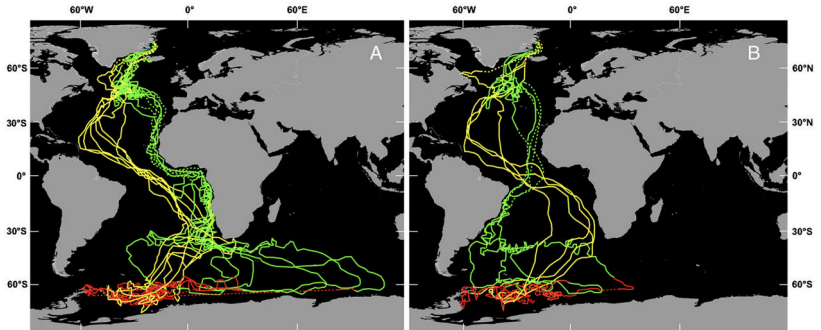
Direct tracking technology

- ▶ **geolocators** track daylight to log precise location of birds
- ▶ **radio telemetry** tracks birds from ground-based towers / hand-held devices
- ▶ **satellite tags** use GPS satellites



Migratory distances

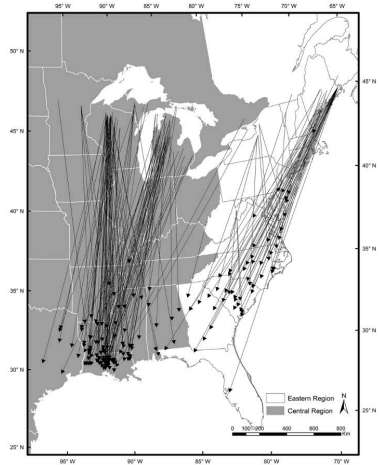
- ▶ up to 96,000 km (59,000 mi) round trips for Arctic Terns
- ▶ up to 13,559 km (8425 mi) *nonstop* for Bar-tailed Godwits



(Egevang et al. 2010)

Studying connectivity: bird banding

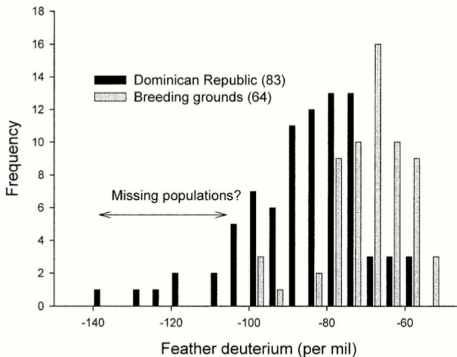
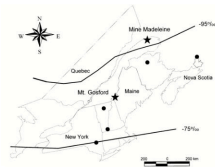
- ▶ Metal rings with unique codes attached to netted birds
- ▶ Long-term program by USGS (soon to be cut?)



(USGS; Moore & Krementz 2017)

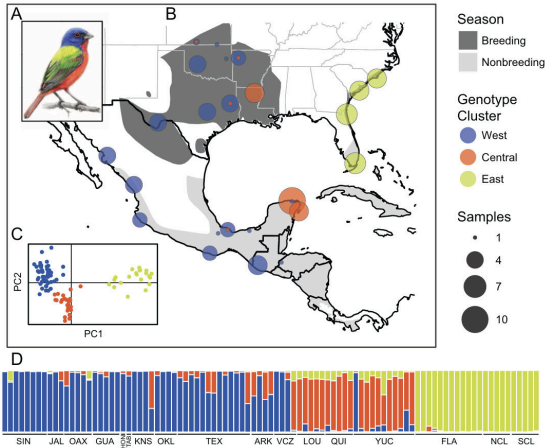
Stable isotopes

- ▶ deuterium (^2H) is a variant (“isotope”) of hydrogen with same number of protons but different number of neutrons
- ▶ ratio of deuterium to hydrogen varies in precipitation—and thus feathers—across latitude and altitude
- ▶ can link breeding and wintering ranges



Population genetics

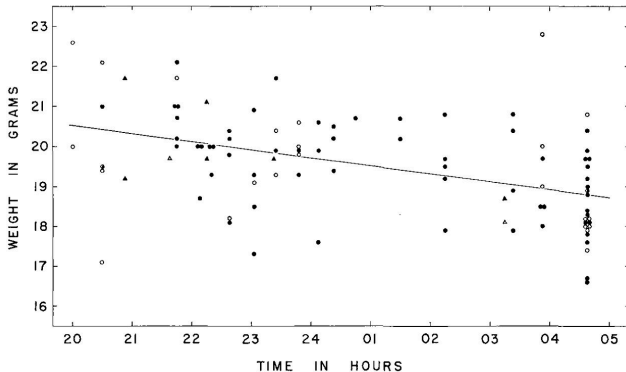
- connectivity can also be detected by similar DNA sequences / allele frequencies in wintering and breeding populations



(Battey et al. 2018)

Migration is costly

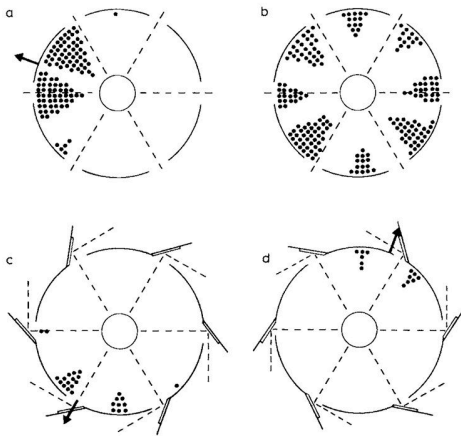
- ▶ Birds burn fat, carbohydrates, protein
- ▶ Ovenbirds lose 0.2g body weight / hour while migrating (16-20g total weight)



(Hussell 1969)

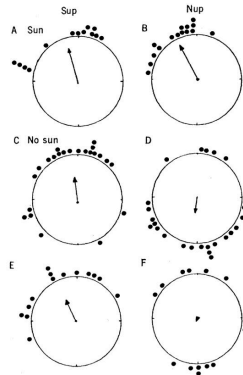
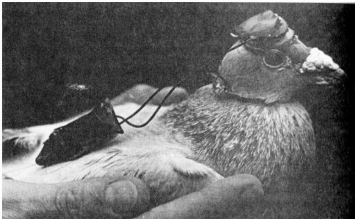
Navigation cues: sun

- ▶ Starlings change orientation during zugunruhe if sunlight is manipulated experimentally



Migration cues: magnetic field

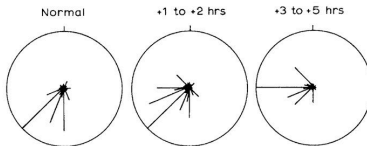
- ▶ Reversing the direction of an artificial magnetic field around a pigeon's head causes them to reverse their orientation on overcast days



(Walcott & Green 1974)

Migration cues: stars

- ▶ Advancing the position of planetarium stars leads to orientation changes in nocturnal migrants



(*Sylvia atricapilla*; Emlen 1975)

Lecture Exam Review

- ▶ Wednesday, October 21st
- ▶ 50 points on feathers and flight, physiology, senses, vocalizations, annual cycles, and migration
- ▶ No lab content that wasn't also covered in lecture
- ▶ Question types: multiple choice, multiple select, true / false, fill-in-the-blanks, short answer
- ▶ Format: Canvas quiz, closed book. Bring a laptop or tablet.
- ▶ **Anything covered in lecture is fair game**

Feathers

- ▶ Identify feather types, tracts / apteria, major structures
- ▶ Name feather macromolecule
- ▶ Order feather developmental stages
- ▶ Describe the major hypothesis for feather evolution
- ▶ Match colors with pigment type or structural color / iridescence
- ▶ Describe fitness consequences of molt
- ▶ Contrast resident versus migrant molt patterns

Flight

- ▶ Explain how birds generate Bernoulli and Newtonian lift
- ▶ Define different types of drag
- ▶ Explain relationship between flight power, airspeed, and energetic cost
- ▶ Contrast thermal and dynamic soaring
- ▶ Identify major flight muscles and bones
- ▶ Predict ecology from wing aspect ratio and wing loading

Physiology

- ▶ Relate bird body temperature to other vertebrates
- ▶ Describe respiratory system adaptations for flight
- ▶ Contrast basal metabolic rate, active metabolic rate, and metabolic scope
- ▶ Define thermoneutral zone
- ▶ Predict impact of summer plumage on BMR in winter
- ▶ Contrast nocturnal hypothermia, torpor and hibernation
- ▶ Describe adaptations to cope with hyperthermia
- ▶ Contrast mammalian and avian treatment of nitrogenous waste
- ▶ Explain importance of nasal salt glands

Senses

- ▶ Describe avian eye anatomy
- ▶ Contrast avian and human vision
- ▶ Explain cause and consequences of tetrahedral color space
- ▶ Explain how eye position, field of vision, and ecology relate
- ▶ Contrast avian and mammal ear anatomy
- ▶ Name organs responsible for tactile sensation
- ▶ Contrast avian and mammalian taste
- ▶ Describe basis and origin for carbohydrate taste in hummingbirds
- ▶ Link avian brain anatomy with intelligence
- ▶ Describe evidence for avian intelligence

Vocalizations

- ▶ Contrast avian larynx and syrinx
- ▶ Describe link between syrinx anatomy and vocal ability
- ▶ Explain the aspects of songs captured by amplitude and frequency
- ▶ Interpret spectrograms (e.g., which labeled section is louder / higher?)
- ▶ Name anatomical features responsible for harmonics, self-duetting, post-source modulation
- ▶ Explain impact of ecology on post-source modulation
- ▶ Evaluate evidence for acoustic adaptation hypothesis
- ▶ Name taxa that are vocal learners
- ▶ Recall phases of song learning and apply to mimicry / learning from “tutors”

Annual Cycles

- ▶ Contrast resident and migratory life cycles
- ▶ Explain link between food availability, molt, and migration
- ▶ Name environmental cues that mediate annual cycles
- ▶ Define circadian and circannual rhythms
- ▶ Define zeitgebers and explain why they are necessary
- ▶ Explain the phenomenon of phenological mismatches

Migration

- ▶ Contrast hypotheses for evolution of seasonal migration
- ▶ Explain factors leading to partial migration
- ▶ Define flyways and stopover sites
- ▶ Evaluate pros and cons of different migration tracking methods
- ▶ Explain genetic and stable isotope evidence for migratory connectivity
- ▶ Describe energy sources for migration
- ▶ Describe evidence for navigation by the sun, magnetic fields, and stars

References

- ▶ Title slide species: *Acrocephalus taiti*, *Heteroxolmis dominicana*, *Momotus bahamensis*, *Poecile montanus*
- ▶ Rolland, J., Jiguet, F., Jønsson, K. A., Condamine, F. L., & Morlon, H. (2014). Settling down of seasonal migrants promotes bird diversification. *Proceedings of the Royal Society B: Biological Sciences*, 281(1784), 20140473.
- ▶ Winger, B. M., Auteri, G. G., Pegan, T. M., & Weeks, B. C. (2019). A long winter for the Red Queen: rethinking the evolution of seasonal migration. *Biological Reviews*, 94(3), 737-752.
- ▶ Winger, B. M., Barker, F. K., & Ree, R. H. (2014). Temperate origins of long-distance seasonal migration in New World songbirds. *Proceedings of the National Academy of Sciences*, 111(33), 12115-12120.

References

- ▶ Egevang, C., Stenhouse, I. J., Phillips, R. A., Petersen, A., Fox, J. W., & Silk, J. R. (2010). Tracking of Arctic terns *Sterna paradisaea* reveals longest animal migration. *Proceedings of the National Academy of Sciences*, 107(5), 2078-2081.
- ▶ Conklin, J. R., & Battley, P. F. (2010). Attachment of geolocators to bar-tailed godwits: a tibia-mounted method with no survival effects or loss of units. *Wader Study Group Bull*, 117(1), 56-58.
- ▶ Battley, P. F., Warnock, N., Tibbitts, T. L., Gill Jr, R. E., Piersma, T., Hassell, C. J., ... & Riegen, A. C. (2012). Contrasting extreme long-distance migration patterns in bar-tailed godwits *Limosa lapponica*. *Journal of Avian Biology*, 43(1), 21-32.
- ▶ Moore, J. D., & Krementz, D. G. (2017). Migratory connectivity of American Woodcock using band return data. *The Journal of Wildlife Management*, 81(6), 1063-1072.

References

- ▶ Hobson, K. A., Aubry, Y., & Wassenaar, L. I. (2004). Migratory connectivity in Bicknell's Thrush: Locating missing populations with hydrogen isotopes. *The Condor*, 106(4), 905-909.
- ▶ Battey, C. J., Linck, E. B., Epperly, K. L., French, C., Slager, D. L., Sykes Jr, P. W., & Klicka, J. (2018). A migratory divide in the Painted Bunting (*Passerina ciris*). *The American Naturalist*, 191(2), 259-268.
- ▶ Hussell, D. J. T. (1969). Weight loss of birds during nocturnal migration. *The Auk*, 75-83.
- ▶ Emlen, S. T., Farner, D. S., & King, J. R. (1975). Migration: orientation and navigation. *Avian biology*, 5, 129-219.
- ▶ Walcott, C., & Green, R. P. (1974). Orientation of homing pigeons altered by a change in the direction of an applied magnetic field. *Science*, 184(4133), 180-182.