NATS 1550 – ANIMAL MIGRATION FINAL EXAM

Lecture #3 – Classifying Diversity
September 10th, 2012

Biodiversity
- Modern classification began in the mid-1700s (Linnaeus: Father of Classification)
- System that named/classified; a categorization of species
- Evolution → Darwin

2 Key Contributions:

1) Ranked Classification
- This system ultimately established 7 categories → all hierarchical (ranked)
- Every species is associated with a name in every rank
- There are more recent additions: Domains and Life
- Ex. 7 categories for the Monarch Butterflies (Danaus Plexippus)
  1) **Kingdom:** Animalia (Animals)
  2) **Phylum:** Arthropoda (Animals with jointed legs)
  3) **Class:** Insecta (6 legged arthapods)
  4) **Order:** Lepidoptera (butterlies/ moths)
  5) **Family:** Nymphalidae (brush-footed butterflies)
  6) **Genus:** Danaus (genus name, italics + caps)
  7) **Species:** plexippus (genus name, italics + lower case 'p')

2) 2-Part (binomial) names for all species

Relatedness or Resemblance?
- Topologists: originally created in current forms (immutable/ pre-evolution) → Resembles
- Evolutionists: mutable/ changeable, name reflects evolutionary history → related
- Phylogeny: evolutionary history (*phyle* – tribe, *genesis* – creation)

Lecture #6 – Downside of Wintering in the Tropics
September 17th, 2012

*** Studying Organism: American Restart**
- Long distance, obligate, complete, nocturnal, Neotropical (new world, Central America)
- Ontario, wintertime:
  a) Wet, mangrove forests → male dominant
  b) Dry, second-growth scrub → female dominant
  - Exhibits: sexual habitat segregation ; Males dominant females – takes better territory
- Does it matter? Yes, 2 evidence to prove:
  1) Early part of winter, there are displacements where 1 bird take another's property
     - Males dominants the female's mangrove territory
  2) **Methods of Studying Migration:** **Technique #1: Removal Experiments**
     A) Does the territory get replaced? **B)** How fast does it get replaced? **C)** Replaced by a lower status bird, (female, younger) or a higher status bird (male, older)?

- Experimented on: Jamaican 'black mangrove' and 'dry scrub' habitants
- Following the removal of the birds (from both habitat):
    1) Within 2 days, new or neighbouring birds were 'moving in'
    2) Territory replacement, more rapid/complete in mangrove
    3) Overall pattern: mangroves preferred by both sexes
    4) Males (esp. older) dominant females and younger males
- Birds that lived in the scrubs have: more mass loss and lower annual survival rates

Technique #2: Isotope Analysis

- Deuterium: hydrogen that is twice as heavy, also have a neutron (+1P, 1E)
- Amount of heavy H in water varies geographically
- Carbon 12 and Carbon 13 (6P, 7N)
    a) Mangroves:
        - Plants in moister habitats have less carbon-13
        - Insects that eat the plants in these moist habitats have less C-13
        - Redstarts eat the insects → a 'fingerprint' in their blood
        - Their C-13 levels are relatively LOW – lasts 6-8 weeks
    b) Scrubs:
        - Plants in drier habitats have more C-13→ insects that eat it have more C-13
        - Redstarts eat the insects → 'fingerprint' ; C-13 levels relatively HIGH – lasts 6-8 weeks
- Method: capture the birds when they first return (1 week) back in Ontario to breed
    - Take their blood samples and measure the levels of C-13

Technique #3: Mist Netting

- Passive mist netting: no bait, uses sex/ breeding
- Active mist netting: uses bait
- The bait: 1) Food for seed eaters, not insect eaters

2) **Technique #4: Song Playback**

- To get blood – mist net by song playback; using Redstart song + stuffed bird

Redstarts returning to Ontario from tropics:

- Males: winter habitat quality influences when they come back
    - Earliest returning birds wintered in the moistest, most preferred sites
    - Return earlier = higher success rate of reproductively; if young – higher survival
- Females: returned at same rate – regardless of winter conditions
    - However, females wintered in higher quality habitats are able to nest earlier
    - Nest earlier = have average of 2 more young per summer

Lecture #7 – Cost of Migration

September 19th, 2012

- Organisms can die during breeding periods, or winter periods
    - Spring (northbound) migration; fall (southbound) migration

Black-Throated Blue Warbler

- Obligate, complete, nocturnal, long-distance, Neotropical

- Study their mortality rate: breeding and winter → stationary periods

1) **Summer Research:**
    - 15 summers, use mist nets to increase capture → male (by song), female (nets near nests)
    - **Technique #5: Mark-recapture or Mark-re-sight Methods**
        - Individuals captured, distinctively marked, later recaptured/ sighted
        - Determines: fidelity (faithfulness) to site, survivorship, population sizes, etc.
    - **Site Fidelity:** return to same area for breeding each year → calculates annual survival
    - Determines survivorship over the years and within a summer:
        - Annual Survival: confirmed identity
        - Summer Survival
2) **Winter Research:**
    - 14 winters – same methods + call notes (notes that make birds curious)
    - Mark-re-sight Methods: determine survivorship over years & within a winter:
        - Annual Survival: re-sighted
        - Winter Survival

2 Sites: New Hampshire vs. Jamaica

- New Hampshire: Males territorial, mid-May to mid-Sept (4 months)
- Jamaica: both sexes maintain territories, Oct – March (6 months)
- Summer Results: in N.Hamp – low mortality of adults
    - Monthly/ Summer survival 99% for both sexes
- Winter Results: Jamaica – low mortality rates
    - Monthly survival of 98% for both sexes → winter survival 93%
- Annual survivorship considerably lower – migration is dangerous
- Monthly survivorship during migration: 80%
    - Chances are: 80% birds alive on Sept. 15 alive on Oct. 15
    - 85%+ annual mort. during migration → 15x higher than mort. of 2 stationary periods

Conclusion:

- Migration is comes with a cost
- Has rewards – otherwise migrants would die out, residents survive
    - Ex. European Blackbirds – facultative migrants (not obligate)
        - As they grow older, stop migrating, adopt residency – reducing risks of migration

Lecture #9 - Technique #6 – Satellite Telemetry

- Argos System
    1) Transmitters – programmed to send signal to satellites – periodic intervals
    2) Polar orbiting satellites – picks up signals and stores/ relays info back to earth
    3) 40+ antennas located around globe – collects data from satellites
    4) Processing centers – collect all data, process + distribute to users
        - 2 global centers: France, Washington
    5) Users around the world receive data
        - Biological data published in scientific journals

Lecture #12 – Into the Sea – Diadromy

Diadromy:
- Fish migration between freshwater and saltwater
- Occur at predictable life cycle stages
- Usually obligate, with a specific destination and purpose
- Fish need to have internal systems that cope with the change in salt content
- *Dia* means "through" and *dromous* means "running"
- About 250 species worldwide
- Wide variation in patterns
    - Angfuilliade: Eels
    - Salmonidae: Salmon
    - Osmeridae: Smelts

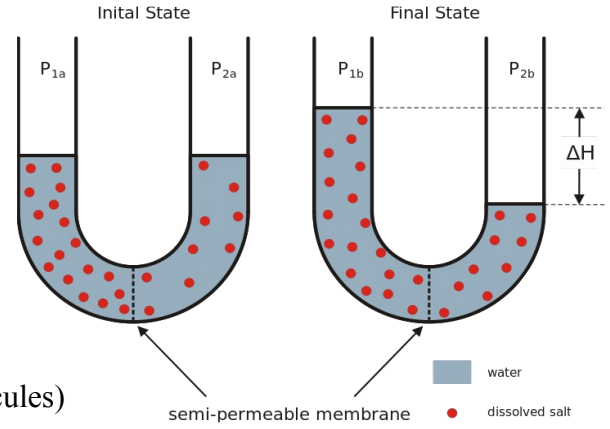
Euryhaline
- *Eury* means 'wide' and *haline* means 'salty'
- Euryhaline fish can cope with changes in salt content of water, but they are not necessarily migratory
- Diadromous migrants are all euryhalic but not all euryhalic fish are migrants

- Non-migratory euryhalic fish often occupy tide pools (variable amounts of salt) – where salt concentrations vary with evaporation, precipitation, and fresh water drainage
- They often occupy estuaries (variable amounts of salt) where large river meet the sea

- Euryhaline freshwater species can access other watersheds this way

Diadromous: truly migratory fish that migrate between the sea and freshwater – 2 main patterns:
1) Anadromous: Diadromous fish that spend most of their non-reproductive life in the oceans and migrate to freshwater to breed (ana means 'up') → Salmons
2) Catadromous: Diadromous fish that spend most of their non-reproductive life in freshwater and migrate to saltwater to breed (cata means 'down') → Eels

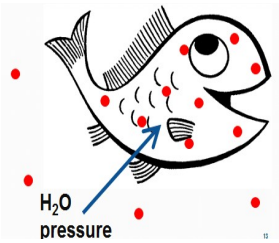
Challenge for Diadromous and other Euryhaline fish:
- What to do about salt?
- There are many salts, but the familiar one and most common oceanic one = sodium chloride
- Sodium (Na+) and Chloride (Cl-)
- Called ions because they have charges
    - things with charges are reactive – bodies have to have systems to cope with ions
    - in water – sodium chloride exists as separate sodium and chloride ions



Osmosis
- Movement of solvent molecules (usually water molecules)

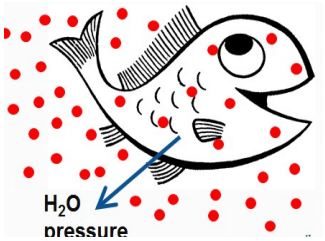
- Across membranes (cell membranes in fish)
- Into a region of higher concentration of solute (ions of salt)
- Stops when solute concentration (ions) are equal on both sides

Freshwater fish:



- Have to have cells in gills/mouth to collect the salts (Na+, Cl-)
- Kidneys also resorb salts (Na+ and Cl-) while making urine
- Freshwater fish make huge amount of very dilute urine (shed water)
- Process takes energy
- Water comes in with dilute amounts of salt (Na+ and Cl-)
  - fish "grabs" Na+ by trading for H+ ions
  - Fish "grabs" Cl- by trading CO3 (carbonate ions)

Saltwater Fish:



- Have to drink (thereby take in much salt)
- Take steps to retain water and shed salts – esp. through kidney function
- Make very concentrated urine – to shed as little water as possible
- This process takes energy

Salmons are Anadromous:

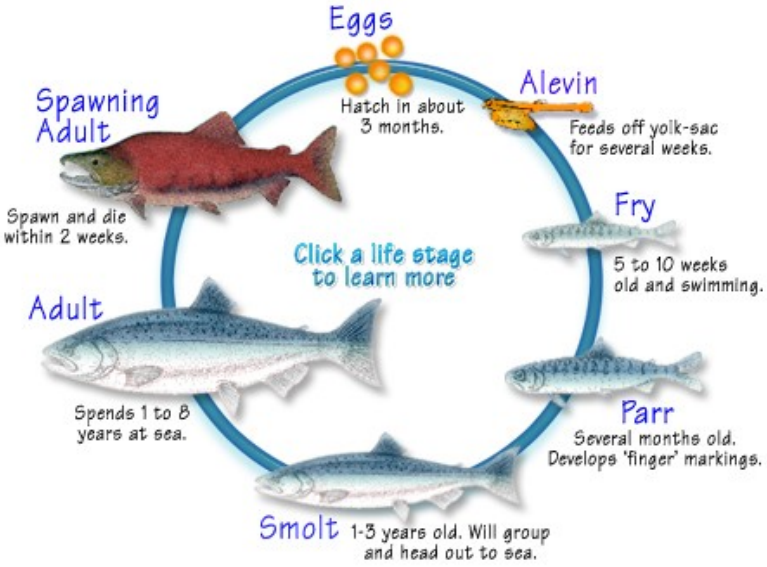
- Moves from salt to fresh water when spawning adult
- Moves from fresh to salt water when a smolt (1-3 years old)

Pacific Coast Salmon:

- 5 species are Anadromous in similar ways
  - Chinook Salmon, Chum Salmon, Coho Salmon, Pink Salmon and Sockeye Salmon
  - They spend most of their life and accomplish most of their growth in North Pacific (found in BC waters) → return to birth river to breed, then immediately die
  - "philopatry"

Salmon Migration – huge significance to humans

- Native peoples
- Current and past economies
- Cultural festivals
- Ex. Adams River – "Salute to the Sockeye" annual festival



Longest Fish Migration

- Yukon River has the longest salmon migration (>3000km)
- Chinook Salmon
- From Bering Sea to upstream of (beyond) Whitehorse

Kokanee Salmon

- Permanently freshwater – land-locked populations (ex. BC's Okanagan Lake)

The Upstream Migration
- Like birds about to cross the Gulf of Mexico – they pack on fact
  - They do not feed while migrating
- Trip upriver takes 3-6 weeks, can be >2400 km and 1200m elevation
- During the trip:
  - Many small falls and rapids must be countered
  - Dams are disastrous in some cases → partial solution: 'fish ladder' construction
  - Reproductive hormones trigger colour change in both sexes and deformation in males
    - Jaws stretch into a hook and back becomes humped

Spawning
- External fertilization takes place in gravel bottoms of well-oxygenated, cool, fresh water
- Adults die very soon after
- **Pacific salmon:** are semelparous (reproduce a single time before it dies)
- **Atlantic Salmon:** similar, but they are iteroparous (reproduces more than once before it dies)
  - Natural, freshwater population in Lake Ontario
  - Breeding "migration" included major run up the GTA's Credit River
  - **Extirpated** - species that no longer exists in one area exists in another still

Ecosystem View of Salmon Migration
- Salmon are packages of "rare" materials
- High energy molecules and relatively rare nutrients is in high densities inside their bodies compared to the environment outside
  - Adult salmon gain more than 95% of their final weight while in the ocean
- Salmon are nutrient conveyor belt

Stable Isotopes help us again
- Carbon-12 and C-13
- Nitrogen-14 and N-15
- Oceans are richer in the heavier isotopes (C-13 and N-15) than are freshwater systems
- Therefore, salmons (that have stopped eating since returning to freshwater) are enriched in heavier isotopes
- MDNs are higher in C-13 and N-15m → find them in bodies of organisms
- Salmon creek vs. salmon-less creek
  - Measurement is of the heavier isotopes – normally more abundant in oceans
  - For both carbon and nitrogen – higher values for creek with salmon
- Evidence of nutrient deficit in freshwater systems of Pacific Northwest
  - Because since 1900s, pacific salmons have disappeared 40% in Canada

Escapement
- Fish that avoid being harvested before they get to the spawning areas
- Economic goal: enough to produce a new generation
- Ecological goal (ignored): enough to also maintain the flow of nutrients back into mountain watersheds
- **Marine-derived-nutrients (MDN):** decomposing bodies of fish → eaten by bears + others

    - MDN distributed in their droppings
- 6-7% of historic nutrient levels

From Lecture #13: Technique #8: PSAT

- Pop-up Satellite Archival Tags
- For aquatic organisms
- At a pre-determined time, tag is released from animal and floats
- Logged data is sent to satellite

- Adult eels captured/ tagged in freshwater in 2006
    - Satellite Transmissions received 14/22 tagged eels
    - Some tags were released too early, some traveled as far as 1300 km
    - Go in a Southwest direction → 14km a day average
    - Too slow → possibly slowed down from tag? Or will later increase speed in the west?
- Daily Vertical "migrations" – deep during the day → to avoid predators?

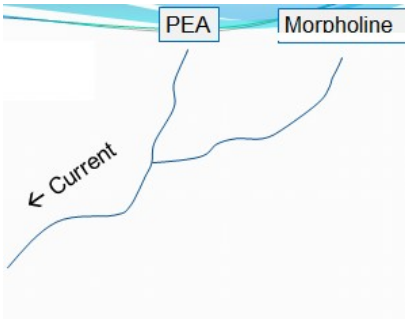
Lecture #14 – Salmon Homing

How do salmon find their home river?

- All species of Pacific Salmon famous for their ability to return to their 'natal' river to spawn
- To get there – travel through ocean, lake, river, and stream
- Each has own orientation clues + requires special sensory abilities
- Despite challenge, philopatry is strong, most indiv. return to natal river, even tributary system
- Prior to seaward journey, young smolts learn – imprinted the odours associated with natal site
    - Return journey – adult salmon ready to breed use odours to **'home'**

Olfactory (Odour) Hypothesis

1) Streams differ in chemical characteristics that are stable over time
2) Salmon can distinguish these differences
3) Salmon learn the chemical characteristics of their natal system prior to/ during their seaward migration – remember it, respond to it when they are adults



Technique #9 – Lab Manipulations

- To test the Olfactory Hypothesis
- Exposed juvenile Coho Salmon to one of two synthetic chemical
- Result: able to attract salmon into the unfamiliar streams that had one of chemical's scent during spawning migration 1.5 yrs. later

Chinook Salmon

- Introduced during 1901-07
- Current Pacific Salmon rivers of New Zealand's South Island
- In North America – populations from different rivers genetically distinct
- New Zealand – 30 generations have resulted in genetically distinct populations in diff. river systems → fish 'home' as in North America
- Microevolution
- Study: harvest breeding fish from different rivers – determine differences, release them, look at traits and survival rates of returning fish

- Different populations have become suited genetically to rivers they occupy

Lecture #16 – Genes and Migration

Migration Patterns are changing:

Ex #1: American Goldfinch

- Challenge: getting enough food – bird houses
- Graph: over the course of 40 years, population is stable
- Number of birds staying behind are increasing
- Partial migrants – some staying behind, most migrate
- Microevolution – if the genes changed
  - Goldfinches were always partial (incomplete), and facultative migrants
  - Might be behavioural response to changed conditions
  - Not necessarily a change in genes → mild/short winter, increased bird feeders

Ex #2: Blackcap Research

- Genetics over 50 years – slight changes
- Physical and behavioural changes related to migration
- Map: traditional pattern of migration for the studied German population
- 2 traits: broad beak for winter fruit-eating, long wing for longer distance migration
- After WWII, British started putting out more bird feeders
  - Few Blackcaps migrated north (`by accident`) thrived rather, not killed off
- 2 migrating pops. less likely to breed together when they re-meet in spring, Germany
  - Overwinter in British return to Germany earlier than those that go to Portugal – advantage to over-winter in Britain
  - Two populations in the same place, partly reproductively isolated
  - After 30 generations, British population physically different: shorter wings and narrower beaks (shorter migration + different food?)

Genetic Structure: genetic differences between different migratory populations

Ex #3: Willow Warbler

- European populations winter in West Africa, Siberian populations in South America
- Not different species but genetic differences between the populations

- Long haul migrants, most common bird throughout breeding range
- Wintering grounds: any country with trees
- Spring: Europe, Asia in April-May
  - Male establish nesting territories, compete for mate → sing
  - Rapid breeder, average 4-8 youth in 26-28 days
  - Ready to migrate south in late July-August
- Different Journeys: many are banded each year → data pools

- Arrive in Africa between Sept – Dec
- Flight Strategies:
    - Small birds, fast refuelling capacity – use their daytime stops to feed, nights to fly
    - Timing of migration varies – sex and age
    - Youth migrate before adults which catch up later s
        - Youth have smaller wings, rounder profile – less efficient for long distances
        - In spring, males return first – look for territory for potential mate

Lecture #17 – Instinct and Learning in Migration

- **Ethology:** scientific study of animal behaviour (*ethos* – custom, *logos* – knowledge)
- **Adaptation:** genetically-based trait conferring an advantage to the individual
    - Spreading or maintained by natural selection
- **Instinct:** a behaviour pattern that develops and promotes an adaptive response to a stimulus (a trigger) from the first stimulation
- **Learning:** a durable and beneficial behaviour pattern traceable to experience
- **Imprinting:** a form of learning – exposure to certain key stimuli early in life forms an association with the stimulating object
- **Proximate Cause:** an immediate, underlying cause based on the operation of internal mechanisms possessed by an indiv. → a trigger for behaviour
- **Ultimate Cause:** the evolutionary/ historical reason why something is the way it is
    - Benefit of the behaviour

Manipulative Experiments

- Recent Journal Paper: "evidence for a navigational map stretching across the US in a songbird"
- Earlier studies used banding birds and site fidelity
- Ex. White-crowned Sparrows were tracked between their migration grounds

Technique #10 – Translocation Experiments

- Update with fancier technology
- Showed that there is both instinctive components to migration and a learning component
- Ex. White-crowned Sparrows that were trapped during fall (south) were flown to the east
    - Released with radio tags for tracking
    - Results: told us about the learning in migration (difference between the youth/adults)
    - The adults went towards the 'right' wintering grounds in California
    - Youths went towards the 'wrong' wintering grounds in Florida
- Implications:
    - Youths travelling using instinct: they 'know' they should head south
        - So they went south to Florida, rather than California
    - Adults are travelling with experience → know to fly more westerly than southerly
        - They know they are 'supposed to' arrive in California rather than Florida
- This technique still does not tell us how the adults are adjusting; know they've been displaced

Technique #11 – Hybridization Experiments

- Ex. 2 similar European birds both breed in north-central Europe
    - 2 important differences about their migration:

        - Black Redstarts are 'tougher' short-distance migrants; spend winter in southern Europe, rather than Africa → they depart much later in the fall as a result
        - Common Redstarts are long-distance migrants; winters in Africa, depart earlier
    - Using hybridization:
        - Black Redstarts x Common Redstarts = Hybrids
        - Genetic complement of the hybrids = 50:50 , Black Redstarts: Common Redstarts
        - So if their migrations are genetically determined, the hybrids should exhibit traits from both the parent species
- Test to see when they were interested in migrating
- ***Zugunruhe*** – German word for migratory restlessness
    - Birds that exhibit *zugunruhe* at twilight during migration periods vs. when they are in top condition during migration periods s
    - Results: 1) They leave much later for typical short-distance migrants
      2) Migrates for shorter period, consistent with shorter distance
    - Hybrids showed a 'hybrid pattern' → starts midway between the other 2, lasts midway

Technique #12 – Emlen Funnel

- **Genetic Range Structure:** Genetic differences between diff. migratory pop. of same species
- Ex. Willow Warbler: the European populations instinctively travel to West Africa, the Siberian populations travel to South Africa
    - They are not different species, but have genetic differences, influencing where they go
- Evidence that migration is at least partly instinctive:
    - **Brood Parasites** – a bird that lays its eggs in the nest of another bird species
        - No parent-chick relationship
        - Host: the foster parent that unwittingly accepts the parasite's egg and raises it
        - Ex. Brown-headed Cowbird – incomplete migrant, indivs. head south for winter → No parent-offspring relationships
- Sometimes instinct can be a restraint in migration
    - Ex. Northern Wheatear migrates from arctic Canada to Africa; Why?
        - There are probably better strategies for coping with seasonal changes
        - But, their reason: they follow their instinct
        - Or, the Tropical Ancestral Home Theory – they are an Old World bird species
        - Though they breed in Canada's arctic, they originate from group in Asia/ Africa
        - **Ultimate reason:** species from the Old World from a few thousand years ago → returns instinctively to spend winter in ancestral wintering areas of Africa
    - Some New World birds breed in Asia now → ex. the Gray-cheeked Thrush

Imprinting

- Form of learning, exposure to certain key stimuli early in life – associate with stimulating object
- Some birds get taught how to migrate (ex. cranes) → some migrate as families
- Ex. Whooping Cranes (endangered species), are bred in captivity
    - Have to be imprinted – taught to migrate so they can be successful in the wild

Lecture #18: Migration – Rhythms and Clocks

- How does the instinct operate?

- Ex. Crab breeding is synchronized by the moon → during lunar cycles, following onset of monsoons, there is a 4-5 day period (last quarter of cycle) where mating happens
- What influences these timings? Birds have clocks?
    - Behaviour motivated by hormones → diff. behaviour under diff. circumstances
    - Hormones are signals used to trigger migration too
- Recall causes (ex. pain):
    - **Proximate Causes:** immediate (ex. you lift your hand from hot object to avoid pain)
        - Ex. birds migrate because their hormones change
        - Multiple causes (ex. for migration → change in levels of hormones)
    - **Ultimate Causes:** deeper (ex. lift your hand so it won't be burnt)
        - Ex. birds migrate because it is a strategy that preserves them + their genes
- Bodies use pain (proximate) to achieve a goal (preservation)
    - Therefore, a bird uses hormones (proximate) to achieve a goal (preservation)

Photoperiod – "the amount of light per day" (ex. per 24 hours)
- *Zeitgeiber* (time giver/ synchronizer)
    - Main factor for bird migration → other factors: temp., lunar cycles, time since nesting
        - All are thought to refine migrant's sense of timing
        - However, the main clock-setting signal is 'photoperiod'
- Photoperiod organizes many activities each year: reproductive timing, migration, moult
    - Birds receive light → their hormonal systems respond to light levels
    - Photoperiod caused by the interplay of: angle of Earth tilt, Earth's position in relations to the sun, and Latitude (distance from equator)
    - Ex. Summer Solstice, Fall Equinox, Winter Solstice, Spring Equinox

Pioneering Work in the 1920s – by William Rowan
- He manipulated the amount of light captive Juncos (birds) experienced
- Mimicked the amount of light they receive during spring in winter → measured their response
- Circannual Rhythms in birds
    - More sophisticated → measure not only gonad size, but moulting of feathers

Instinctive "Endogenous" Clock
- Gets 're-set' by photoperiod
- Annual growth and shrinking of the gonads (12 years study) → 12 hours dark, 12 hours light
- A 'drift' in the pattern; without the photoperiod changes, clock loses its accuracy

Pineal Gland
- Found in all vertebrates – a small endocrine gland in vertebrate brain
- Produces melatonin – hormone that affects daily (circadian) and seasonal (circannual) rhythms
    - Melatonin is stimulated by darkness and inhibited by light
    - Light received by the eye is not just for visual information
- Ex. human hormones → human brain → pineal gland → daily/seasonal rhythms; same for birds

Many Migrants use Photoperiod
- Ex. Atlantic Salmon – exposed to reciprocal photoperiod
    - Decreasing day length in the spring, increasing day length in summer
    - Showered poor growth and low efficiency of food conversion after transfer to seawater

    - Seaward migration of smolts occur naturally under conditions of low light intensity → level of melatonin in the system is high
- Photoperiod affects males/females on different schedules
    - In spring, migration is **protandrous** (males first) → due to territorial roles
    - For many species, in fall, migration is **protogynous** (females first)
    - Protandry may be related to the distances the diff. sexes have to go
- Males winter further north because:
    - They are bigger and can cope with colder conditions?
    - They are territorial sex, and there is a 'race' back to the breeding grounds in spring?
    - Tested this with Kestrel birds, where females are bigger
        - Showed that males still wintered further north → therefore, size is not main factor
- It is logical for birds to time their nesting with the peak of available food?
    - Some species' migration schedule is set by internal clock even + food does not affect
- Did the caterpillar peak advance? Yes → is it happening sooner in spring
- Ex. Eleanora's Falcon nest along the Mediterranean Coast in the fall
    - They like to eat small birds and their nesting schedule is set to make the most of the songbird migration (adults + youth birds) passing through

Lecture #19 – Migration and Navigation

- One of the first manipulations done was: translocation experiments
- Navigation: star compass, sun compass, magnetic fields, smell, experience, and landmarks
- **Planetarium Studies** → Emlen Boxes – not just *zugunruhe*, but orientation too
    - Their *zugunruhe* is orientated by stars in a planetarium → using the North Star as key
- Young birds must be exposed to the night sky to imprint on it
    - Youths travel farthest spend most time being 'restless' in the night sky
        1) They can be imprinted to a 'wrong' sky
        2) Longest distance birds spend most time being active in the dark

Learning and Stars
- Young buntings exposed to natural sky use the stars for orientation
- The stars 'rotate around the North Star'
- In a planetarium, others exposed to artificial rotation around Betelgeuse → they adopt this as the North Star and consistently orient from it

The Sun
- Ex. during spring, captive Starlings are kept in cages – is oriented northwest if have solar cue
    - With no solar cue (overcast days), they were not oriented
- Also influenced their orientation by using mirrors → give false impression the sun was in a position 90 degrees from where it really was
    - With the sun to the south, they preferred to head northeast
    - With mirrors employed, they could be induced to go northwest or southeast
    - Ex. Monarch Butterflies react this way

Clock Shifting and Navigation
- Starlings were trained to get food in particular directions → 'clock-shifted' 6 hours

    - So when it is noon, they think it is 6am → captivity light patterns are 6 hours late
    - Then, they use sun to set their sense of direction, 90 degree off in their navigation
- To fly west in early evening (sun is to the west) → you head towards the sun
- To fly west at noon (when sun is to the south) → fly with the sun to your left
- If you are clock-shifted (6 hours) and it is early evening (you think it's noon) → you fly north

- **Different cues conflict?** Sun as compass and Earth's magnetic field?
    - Ex. use a bar magnet to interfere (as a disruptor) with a pigeon's ability to return home on a cloudy day → results: brass bar control does not affect ability
    - Therefore, the solar orientation has priority over magnetic
    - The solar information prevails
        - If sun is out, it doesn't matter what the earth's magnetic field says
        - If it is cloudy, then birds will resort to magnetic field, but then (with disruptor), they cannot navigate
    - Counter-clockwise current mimics magnetic field
    - Clockwise current reverses the magnetic field → south 'feels like' north
    - If it is sunny, the current (magnetic field) makes no difference → sun prevails
    - If it is cloudy, birds use magnetic fields, and if clockwise, head 180 degree off course

Smell
- Salmon → smolts imprinted on a chemical in lab tank pursue 'home' by smelling that chemical
- Ex. adult/ youth birds are tracked → young only know to head south, hitting ocean barrier
    - Adults, with experience, have sense of landmarks → head further west to avoid ocean
- Ex. adults tracked with and without scenting
    - Control adults are doing the 'logical thing'; so are birds with magnetic ability disabled
    - However, adults with smell disabled are acting like youths → heading directly south
- Therefore, smell is an important cue for navigation
- Some birds follow landmarks (ex. Golden Eagle migrations follow spine of the Rockies)

Sea Turtles
- Able to detect the Earth's magnetic field
- Reproductive "Strategy" → travel to remote islands with few predators → lay eggs/ hatchlings
- Favourite spot: Ascension Island
- Interfered the magnetic field currents

Lecture #20 – Using Geolocators Instead of Satellite Tags

- Small organisms are tougher to track and they navigate
- Ex. Curlews are large enough to carry satellite tags, but most songbirds are not
- Bristle-thighed Curlew
    - Tags are turned on for 8 hours, then off for 24 hours → save battery
    - When on, they communicate with orbiting satellites
    - August – 4 birds left Alaska and flew non-stop across the Pacific
- Bar-tailed Godwit → a smaller songbird
    - Use **Technique #14 – Geolocator**
        - Geolocators measure light → use the light to determine location

- Geolocators must be place on bird → it doesn't communicate with satellite (or anything else); has a clock, battery and light sensor
- Logs light levels every 10 minutes (or however long it is programmed to) s
- If it cannot retrieve the Geolocator – gets no info
  1. Catch a bird in territory in year 1 → harness him with Geolocator
  2. Year 2 – go back to the same spot, hopefully re-catch the bird → retrieve Geo.

- Songbirds are too small → can only study them through these brief snapshots of radar images or opportunistic recaptures of banded individuals → then studied migrants on ground, refuelling
  - Some studies even involve following radio-tagged songbirds by plane
- Migration rate was 2-6x more rapid in spring than in fall
  - Ex. 9 days in migration flights, 4 days on stopovers (577km/day)
  - Previous studies underestimated their flight performances

Lecture #21 – Migration and Conservation Issues

- Migrants have to move through highly altered world → changed landscapes = challenges

Aquatic/ Marine Migrations

1. River obstructions for Diadromous and other river-migrating species
2. Causeways
3. Tidal energy structures
4. Overexploitation and by-catch

- **Colorado River Fish** → 36 native species, 64% endemic (in no other rivers) → endangered
- Dams are unnatural, prevent migratory and other movements
  - Prevents extensive fish movements and mixing of genes from diff. populations
  - Also: alters temp, turbidity, patterns of spring floods
  - 'Impoundments" stocked with non-native species
- Canadian Rivers - many dams (ex. St. Lawrence River +8000 dams, restrict fresh water)4

- American Eels
  - 2 major dams block ell migration from Lake Ontario → both added eel ladders for upstream eel migrations
  - Unfortunately, eels migrating downstream suffers at least +40% mortality
  - 1980s – 26 000 eels/day → 2002 – 55 eels/day
- Fish-ways (ladder systems) in Ontario
  - They often depend on human assistance
  - Fish-ways = losses to turbine mangling (those going downstream)

Fish movements in the Nile River – altered by human activities
  - Loss of annual silt deposition that made floodplain and delta fertile
  - Influenced patterns of fish migration in Eastern Mediterranean
- **Causeways** can be similar – blocking the Strait caused troubles for migratory fish
  - But: makes feeding rage for birds when fishes are backed up behind causeway

Tidal Energy Threats

- **Macrotidal estuary** – region of collision: migratory marine animal vs tidal power development
- Many commercial important fish travel along coastlines in annual migrations
- Ex. symptoms of turbine damage = direct physical trauma to fish (ex. cut in half)

By-catch

- Organisms caught unintentionally in a fishery → intentions were to target fish/seafood
- Most of the time, includes migratory species (ex. tortoises)
- **By-catch reduction technology** – depends on the willingness of the fishermen
    - Ex. using circle hooks reduces turtle by-catches
- Large fishing crews – willing to use circle hooks in months with high migratory action
    - Only if an economic incentive provided + public acknowledgment of their efforts
- Impact of Taiwanese water longline fisheries → catching seabirds too ☹ (at least 10,000/year)
    - Should regulate/ map out where the birds will be, avoid these areas
- Many of the problems occur in the unregulated High Seas → no one enforcing laws
- **Cetacean by-catches** – mammals (ex. whales, dolphins) → vulnerable because air-breathers

Bird Migration Suffering Modern Challenges

- Generalization, migrant birds declining → annual surveys (winter range, breeding range, etc.)

Technique #15 – Radar Studies

- **'Radar Angels' –** before WWI, scientists did not know the radar clouds are birds (1950s)
- Documents that migrant bird populations are declining
    - Ex. Radar of Trans-Gulf migration indicates 50% decline from 1965-1987
    - Measuring nights of major flights over Gulf of Mexico (1960s vs. 1980s)
    - A 'cloud' of nocturnal migrants shown in radar studies in 2000

Wind Turbine

- Proposed 700 wind turbines in Lake Erie → however, wind farms proven hazardous to birds
- Ex. Wolfe Island, Lake Ontario – 86 turbine farm → kills +1800 birds/bats in 6 months

Lit Structures

- Proven deadly for bird migrations → attracted to lights
    - Ex. World Trade Centre, Annual Light Show; mid-Sept, height of southbound migration
- Many tall wireless communication towers
- Fatal Light Awareness Program (FLAP) → Toronto-based organization
    - Goal: reduce migration casualties caused by nocturnal collisions with towers/buildings
- Most migrant birds travel at night; if it is cloudy, they may become confused
    - Ex. National Geographic's – 2000 birds that did not survive downtown Toronto

Habitat Changes

- **Desertification** → poor water management and climate change → increases drought
    - Ex. Sahel Desertification → important for Eurasian-born, African-bound migrant birds
    - Ex. White Storks must navigate through the growing Sahara

Risky and Expensive

- Ex. tropics are not universally dense/lush/resource-filled for migrants

- Ex. land with horrible practices: slash and burn agriculture, land-clearing, deforestation
- Some agricultural land may be 'green' but is 'developed' – low in ecological resources
    - Most crops are grown for livestock food (ex. corn grown to feed cattle) or markets
- Ex. Coffee prod. in developing tropical countries, consumed by developed countries
    - In the past – coffee prod. in 'shade' or 'semi-shade' coffee plantations
        - These plantations required other species to live there (feeding, nesting, etc.)
        - Ex. North American birds over-winter in these tropics (shade coffee plantations)
        - The darkest countries suppose most migratory birds in shade coffee plantations
        - Ex. if coffee has a 'Bird Friendly' seal = preserving crucial habitat
    - Modern day: sun coffee → little diversity, low levels of utility for other species
        - Sun coffee is prod. in large open fields
        - However: Indian Coffee – amazing habitat, much like wildlife or bird sanctuaries

- Affects the Altitudinal Migrants → ex. Costa Rica's Resplendent

Sustaining Migration Period Habitats

- Are required because migrants cannot survive if we only protect their breeding habitats (ex. boreal forests) or if we only protect their winter habitat (ex. rainforests)
- Not all stopovers are created equal – ex. Long Point in Lake Erie is 'Important Bird Area'
    - Valued for its stopover habitat
- Urban stopovers are crucial (ex. Toronto's Thompson Park)
- **Connectivity** – geographically spaced needs of migratory species
    - Ex. Canada's Red Knots breed in the tundra → makes the 3 jumps (total)
        - Feast on eggs of Horseshoe Crabs in late May on their trip north
        - Competition/high demand for the eggs → humans use these crabs as bait to catch eels → $2Ms fishery + $6M eel fishery
        - Red Knot survey – 18% of what it used to be → steady decline
    - Ex. American Eel – already in state of decline, to harvest them = other things to decline

- **State of Delaware:**
    - Ex. Red Knots travel as much as 5000 miles non-stop → Delaware Bay is final most critical rest stop → timed their arrival perfectly for spawning of the horseshoe crab
    - The eggs sustain the birds for the remainder of their 2000 mile trip to Artic
    - During their brief stay – the birds can double their body weight!
    - However: cycle is being disrupted – before 100,000 Red Knots arrived for spring stopover, in 2009, only 25,000 visited
    - New Jersey – campaigned + got a moratorium stating that Horseshoe Crabs (Knots' main food source) are to be protected
    - Hopefully, Delaware will follow NJ's example + allow the crab/Knot's pop. to recover
- Another problem related to Connectivity:
    - **Toxins** – pesticides and herbicides have 'smaller' consequences compared to DDT
    - Ex. Population of Bald Eagles, declined due to use of DDT in the 1950s
    - Ex. DDT banned in Canada and USA – steady increase in Bald Eagle + Ospreys pop.
    - 'replacements' are still toxic, just not as 'persistent' → ex. Monocrotophos (insecticide)
        - One of the most toxic pesticides known for birds → +100,000 moralities

- **Artic Chemical Contamination** – even in remote parts of world, migrants find toxins
    - Ex. Ivory Gull pop. decline of 80% in Canada and Norway since 1980s
    - Occurring in remote regions where human impact is 'minimal'
    - However, high levels of PCDs and DDT found in the Gull's eggs
- Ex. male polar bears may even appear female due to effects from toxins

Introgression ("Genetic Pollution")

- Migratory species change their geographic ranges/ habitats
- This may bring 2 species, formerly separated in space, in contact (ex. west/east)
- **Hybridize** - if they are similar, they can interbreed
    - With 2 species – where one overwhelms the other by Introgression
    - Ex. Mallard ducks lived in the western, prairie region of North America avoiding eastern, forest wetlands (that the Black ducks like)
    - Then humans opened up the eastern forest to the Mallards
    - Mallards x Blacks = Hybrids → Hybrids x Mallards = Hybrids of hybrids (3/4 Mallard)
        - Blacks lose potential mates because Mallards more preferable → winning genes
        - Even the Hybrids tend to mate with the Mallards → difficult to find pure Mallard
        - Male Mallards: aggressive reproduction → multiple mates → multiple hybrids