Navigation and orientation

- Two major phenomena
  - Latitudinal migration
  - Homing behavior

Homing behavior

- Displacement experiments have shown the remarkable orientation and navigation abilities of birds

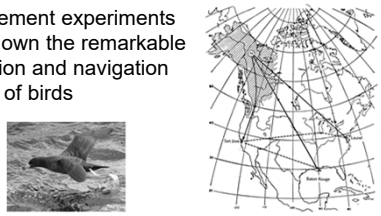


Table 14–1 Abilities of Birds to Return to the Site of Capture after Transport to a Distant, Unfamiliar Release Site

Species	Number of Birds	Distance (km)	Return (%)	Speed (km/day)
Leach's Storm-Petrel	61	250–870	67	56
Manx Shearwater	42	491–768	90	370
Laysan Albatross	11	3083–7630	82	370
Northern Gannet	18	394	63	185
Herring Gull	109	396–1615	90	112
Common Tern	44	422–748	43	231
Barn Swallow	21	444–574	52	278
European Starling	68	370–815	46	46

(From Griffin 1974)

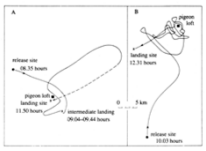
Navigation requires…….?

Navigation requires a map and a compass

- Map and compass information are derived from:
  - Topographic features and other visual landmarks
  - The position of the stars
  - The angle of the sun in the sky
  - Olfactory information
  - Geomagnetic information
  - Polarized light

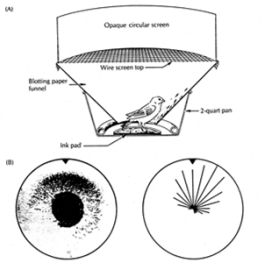
Topographic features

- Evidence of use is ambiguous
  - Birds concentrate along flyways that follow mountains and rivers
  - Radar shows many nocturnal migrants do not use topographic features
  - Homing in visually impaired pigeons

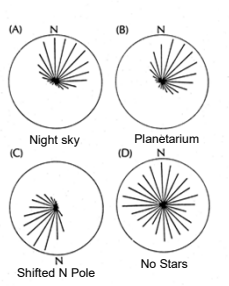


Celestial navigation

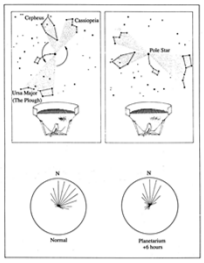
- Emlen funnels measured *zugunruhe* in response to celestial clues in a planetarium



- Experimental evidence that birds orient to stars in the night sky

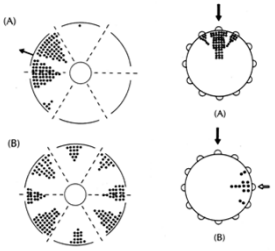


- Most species show no evidence that an internal clock is used in celestial navigation



Sun-compass navigation

- Zugunruhe of Starlings in Emlen funnels shows that birds use sun position for orientation
- Clock shift experiments show that some birds use a precise internal clock in combination with the angle of the sun



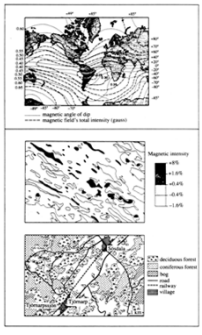
Clock Shift Experiment

- Birds are trained to orient North to get food reward.
- Remember: at 6 AM the sun is in the eastern sky, at noon it is in the southern sky, and at 6 PM it is in the western sky.
- Where is the sun in the sky when the bird first sees it?
- What time does the bird think it is?
- When bird faces the sun, what direction does it think it is facing?
- How should bird orient using the direction of the sun to find north?
  - e.g. if bird's clock is 6 hrs. slow, then 6 AM bird time is noon sun time. When bird faces the sun at noon, its internal clock says it is 6 AM. Therefore the bird assumes it is facing East and it rotates 90 degrees counter clockwise to orient north. It actually is orienting East.

Olfactory navigation

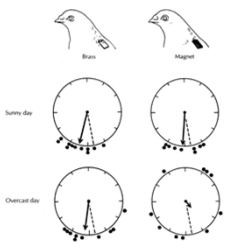
- Well developed in Procellariiformes
  - Dimethyl sulfide, a gas given off by phytoplankton may be clue
- Pigeons show reduced homing when smell is blocked
- Starlings use smell to find nesting material that inhibits parasites

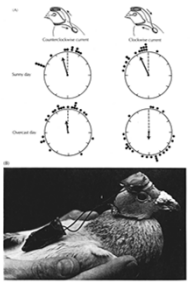
Geomagnetic orientation



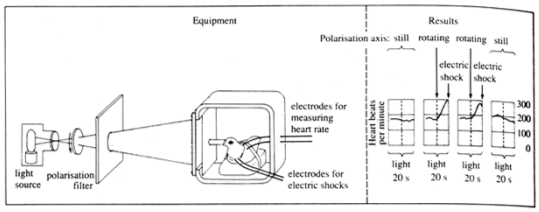
Wiltschko's showed birds shift their orientation in response to changing magnetic fields

Magnets disrupt geomagnetic orientation



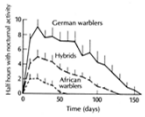


Polarized light may be used for orientation



Genetic components of navigation

- Peter Berthold (1988) created hybrids of migratory German Blackcap Warblers and non-migratory African Blackcaps
  - Zugunruhe of hybrids was intermediate
  - Migration patterns also intermediate

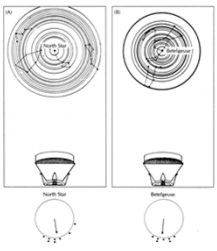


Learned components of navigation

- Perdeck (1967) showed that adult birds can reorient using prior experience
- Juvenile birds practice simple directional orientation

Baby Indigo Buntings learn the night sky

- If young birds not exposed to stars during first month of life they do not show celestial orientation
- Young birds can be trained to orient on novel star maps



Summary

- Orientation and navigation uses genetic and learned components
- A map, compass, and internal clock are used
- Multiple cues:
  - Sun
  - Stars
  - Magnetic fields
  - Odors
  - Landmarks
  - Polarized light
- Systems are redundant
  - Use varies with age and with conditions