Orientation and Navigation

How birds find their way

I. Introduction

- Most difficult problem
- Must know
  - Where it is
  - Direction of goal

Two terms often misused

Orientation
Navigation

Orientation – identify compass heading and following it

Navigation – knowing where you are, where you want to go, and then using the appropriate orientation to get there

Birds utilize suite of environmental cues to solve orientation problems

No evidence that they utilize one sole source

- Not all sources of orientation are equally successful
- Not all sources are equally available

- True navigation requires bicoordinate grid system by which you identify both
  - Location of where you are
  - Location of where you want to go
- Currently do not know what this system is for birds

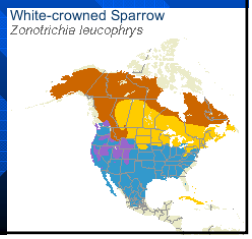
II. Displacement Experiments

Bird captured, banded and then released at different geographic locations

A. Mewaldt's Work

Worked on White-crowned Sparrows
100's moved 2900km

From San Jose, CA (wintering grounds) to Louisiana



- Following winter

15 recovered in San Jose

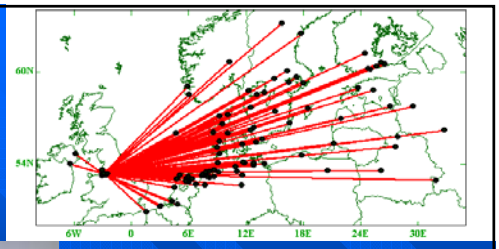
- These, + additional birds transported to Maryland and released

- Many returned to San Jose
- Among these – 6 who had been displaced to Louisiana the year before!!

B. Perdeck's Work

Captured 15,000 European Starlings in Netherlands

Released them in different locations (Switerland, and Spain)



Naturally migrate WSW to winter in British Isles

1. Experiment 1

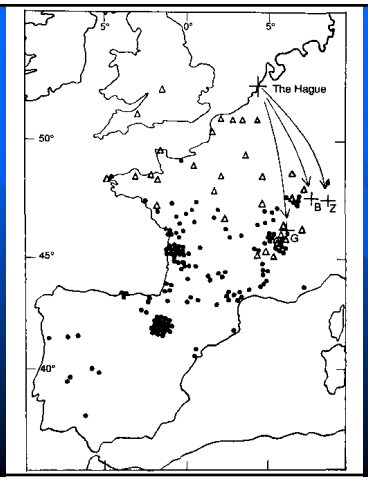
11,000 birds captured in Netherlands transported to sites in Swizterland (Berne, Geneva, and Zurich)

~ 750 km SSE of Hague

- Adults compensated for displacement

Made correction and headed toward traditional wintering sites

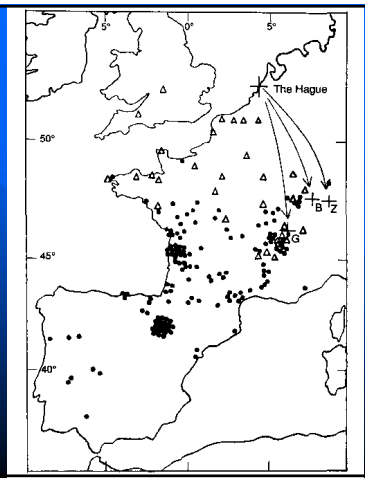
- Even though they had never been to Switzerland before!



- Juveniles did not recognize they had been displaced
- Continued to fly in WSE heading

(correct heading for wintering in British Isles from Netherlands)

Which took them to Spain



- Adults could navigate
- Juveniles could not

but they could orient

2. Experiment # 2

- 3600 starlings transported to Barcelona, Spain
- Again adults could navigate but juveniles could not
- Measured average distance of travel

- Avg distance similar to avg distance from Hague to normal wintering grounds
- Concluded – Juveniles know what direction and how far to fly but adults having been on wintering ground learned coordinates and could navigate back there

C. Ruppell's Experiment

Hooded Crows displaced

- No correction by either adults or juveniles

D. Displacement with Caged Migrants

Can use Zugunruhe – don't need to mark and recapture birds

Barred Warbler – long distance migrant from Europe to Horn of Africa

Birds displaced eastward

Compensated for displacement

Orientation of Zugunruhe was toward proper wintering range

III. Cues used for Orientation

A. Topography

Only useful when covering familiar ground

Yg birds could learn if migrating in family groups (Cranes, Geese, Swans)

May be useful in locating familiar stopover points

- Evidence landmarks directly used for orientation – follow coastlines, and peninsulas

B. Celestial - Solar

- Gustav Kramer's research on starlings
  - Birds orient on sunny day but not cloudy day
  - Used mirrors to deflect sun 90° to left
    - Changed heading accordingly

Thus, use angle of sun

- Similar "Sun Compass" identified for
  - Penguins
  - Pigeons
  - Other passeriformes
  - Waterfowl

Does sun provide not only orientation but also bicoordinate navigational system?

Does it provide a map as well as a compass?

- Homing pigeons well known to return to loft after being displaced
- Also known to orient by using angle of sun

Keeton's Experiment

- Keeton clock-shifted Homing Pigeons
  - Gradually changed light regime so that they were 6hrs out of phase of local time
  - 6 hrs = 90° of longitude
- If sun used for navigation how does clock-shift affect their behavior

9am where is sun

But your clock says 3pm.

SO…

You are long way from home -
West of where you ought to be
To return you must fly
East!!!

But if birds do not use the sun as bicoordinate system (use something else) then they should return to home loft

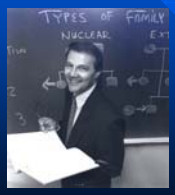
So…

Found their way back to the home loft!!!

Do not use sun for navigation but just for orientation

C. Celestial - Stellar

Emlen's Planetarium Experiments



- Projected constellations on ceiling (reversed direction)

- Birds reversed their orientation
- Also clear –
  - do not use single star
  - Use only the northern portion of the sky

- 2nd Group of Experiments

Kept young birds from seeing night sky

Couldn't orient properly during Zugunruhe

- Stars only provide orientation information not bicoordinate navigation

D. Geomagnetism

Clear from radar observations that birds migrate when its overcast

Also migrate within cloud decks

In work with pigeons interesting phenomenon noticed

Under cloudy skies birds not affected

So… using time-independent orientation mechanism

- If attach magnets to legs of Homing Pigeons

They have difficult time orienting

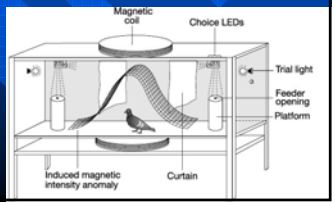
But eventually find home loft

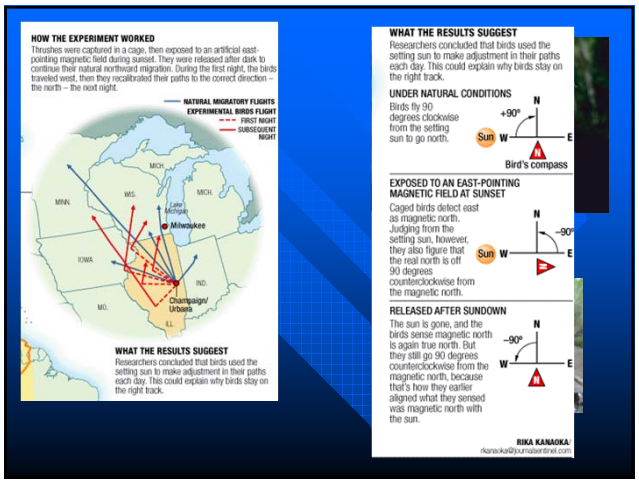
Either disorientation short-lived or able to compensate

- North – south orientation based on earth's magnetic field around for long time but…

No previous evidence

Experiments demonstrated birds can respond to artificial magnetic fields





- Iron-containing magnetite crystals have been found in pigeons in connective tissue between skull and brain

E. Wind

Wind has been suggested
Birds are responsive to wind speeds

Can't be only system operating

F. Olfaction

Experiments where olfactory nerves of pigeons are severed

Do not return to loft as well as controls

Also strong odors disrupt homing

G. Multiple Cues

Suggested that birds use hierarchy of cues

1. Celestial – either solar, stellar or both
2. Geophysical
   a. Magnetic cues
3. Landmarks

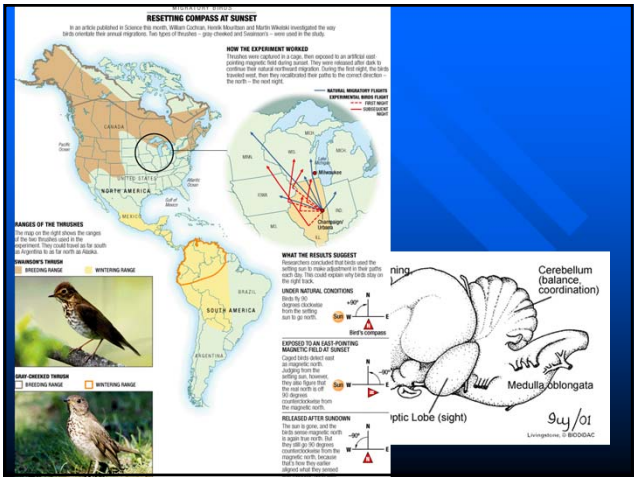
H. Experience

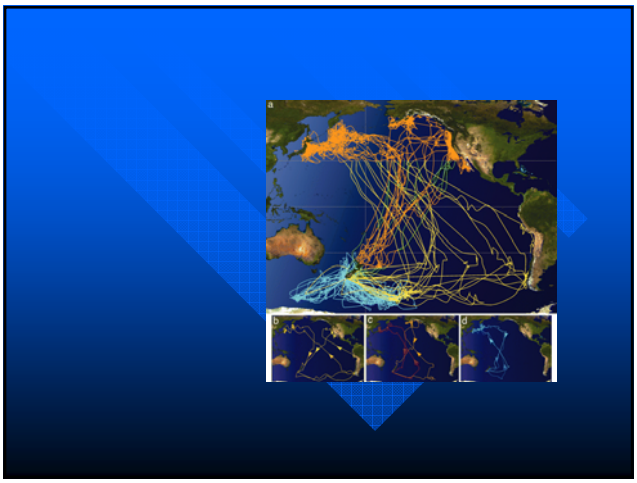
Demonstrated that older birds require less information than young birds

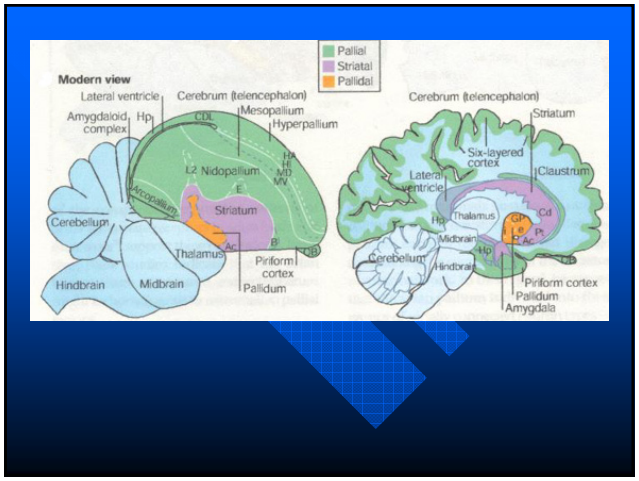
So experiential component as well as innate

IV. Philopatry

STOP






Pallial
Striatal
Pallidal
Modern view
Lateral ventricle
Amygdaloid complex
Hp
Cerebrum (telencephalon)
CDL
Mesopallium
Hyperpallium
L2 Nidopallium
Arcopallium
Striatum
Cerebellum
Thalamus
Ac
Piriform cortex
Pallidum
Hindbrain
Midbrain
Cerebrum (telencephalon)
Striatum
Six-layered cortex
Claustrum
Lateral ventricle
Thalamus
Cd
Midbrain
Hp
Ac
Cerebellum
Hindbrain
Piriform cortex
Pallidum
Amygdala