Evidence for 'magnetic' true navigation in a migratory songbird

Florian Packmor

Dmitry Kishkinev **1**2

Nikita Chernetsov **28**

Richard A. Holland







1



Bird migration:

Amazing journeys requiring great navigational accuracy...



PRIFYSGOL BANGOR



'True navigation' in birds:

<u>Commonly defined as:</u> Ability to return to a known destination from unfamiliar sites using locally available cues

'Map and compass' concept: 'True navigation' involves two steps...



'Map step':



'Compass step':

Determining the own position with respect to the destination

Determining the direction towards this destination





'True navigation' in birds:

<u>Commonly defined as:</u> Ability to return to a known destination from unfamiliar sites using locally available cues

'Map and compass' concept: 'True navigation' involves two steps...



'Map step':



('Compass step':

Determining the own position with respect to the destination

Determining the direction towards this destination

→ Compass systems:

- Geomagnetic compass
- Celestial compasses (stars & sun)





'True navigation' in birds:

<u>Commonly defined as:</u> Ability to return to a known destination from unfamiliar sites using locally available cues

'Map and compass' concept: 'True navigation' involves two steps...



Determining the own position with respect to the destination

Determining the direction towards this destination

→ Compass systems:

- Geomagnetic compass
- Celestial compasses (stars & sun)



Magnetic map hypothesis:

Cues derived from the geomagnetic field:

- Total magnetic field intensity [nT]
- Magnetic inclination [°]
 (dip angle between magnetic field lines and the horizon)
- Magnetic declination [°]
 (angle between geographic and magnetic North)





ANGO

Magnetic map hypothesis:

Cues derived from the geomagnetic field:

- <u>Total magnetic field intensity</u> [nT]
- Magnetic inclination [°]
 (dip angle between magnetic field lines and the horizon)
- Magnetic declination [°]
 (angle between geographic and magnetic North)





ANGO



Cues derived from the geomagnetic field:

- **Total magnetic field intensity** [nT]
- Magnetic inclination [°]
 (dip angle between magnetic field lines and the horizon)
- Magnetic declination [°]
 (angle between geographic and magnetic North)







B A N G O R

Magnetic map hypothesis:

Cues derived from the geomagnetic field:

- **Total magnetic field intensity** [nT]

0

- Magnetic inclination [°]
 (dip angle between magnetic field lines and the horizon)
- Magnetic declination [°]
 (angle between geographic and magnetic North)





B A N G O R



Testing the **magnetic map hypothesis:**

→ 'Magnetic' or 'virtual' displacements

Orientation tests ('Emlen funnels') during exposure to altered magnetic conditions encountered elsewhere on the globe



Adapted from Mouritsen 2015

→ Response similar to a physical displacement to the simulated site

Reed Warbler Acrocephalus scirpaceus







Testing the **magnetic map hypothesis:**

- → Virtual displacement by a counter-clockwise rotation of the magnetic field by 8.5°
- Magnetic declination
 changed!
- → Response as expected for physical displacement to the simulated site...
- → But only in experienced (adult) birds!!!



ORIENTATION IN THE NATURAL MAGNETIC FIELD (Rybachy)



Chernetsov et al. 2017

Hypotheses:

- → Migratory birds use different cues derived from the geomagnetic field to determine their own position for long-distance navigation.
- → Migratory birds are capable of true navigation when exposed to geomagnetic cues of unfamiliar magnitude.





Methods...



Field site: Lake Neusiedl

- Shallow steppe lake surrounded by large reed beds
- Location: NW edge of the Pannonian Basin

→ Biologische Station Neusiedler See

(Illmitz, Austria)





Methods...



Field site: Lake Neusiedl

- Shallow steppe lake surrounded by large reed beds
- Location: NW edge of the Pannonian Basin

→ Biologische Station Neusiedler See (Illmitz, Austria)

 → Bird ringing project (July-October)
 <u>Study species</u>: *Eurasian reed warbler* (most abundant songbird in the reed beds)





Experimental procedures: Orientation tests (*Emlen funnels*)

- Birds kept in outdoor aviaries (with access to geomagnetic and celestial cues)
- **<u>Orientation tests</u>**: \rightarrow Inside a magnetic coil setup \rightarrow *virtual displacement*
 - \rightarrow Under the open starry sky (access to celestial cues)



ANGO



Natural migratory direction and distribution:

(Eurasian reed warblers from Lake Neusiedl)

Ring recoveries:

- Autumn (same CY)
- ♥ Autumn (later CY)
- Δ Spring (later CY)

Distribution:

passage

Breeding distribution
 Wintering distribution
 Potential migratory





Experiment 1:

Orientation tests in **'natural magnetic field'** [NMF] and **'declination changed magnetic field'** [dCMF]

- → Magnetic field rotated by +10°
- → Total intensity and magnetic inclination unchanged!
 - → Conflicting geographic information!







Experiment 1:

Orientation tests in **'natural magnetic field'** [NMF] and **'declination changed magnetic field'** [dCMF]

- → Magnetic field rotated by +10°
- → Total intensity and magnetic inclination unchanged!
 - → Conflicting geographic information!



NMF (Illmitz)







Experiment 1:

Orientation tests in **'natural** magnetic field' [NMF] and 'declination changed magnetic field' [dCMF]

- → Magnetic field rotated by +10°
- → Total intensity and magnetic inclination unchanged!
 - → Conflicting geographic information!
- → No significant change in the birds' orientation!







Experiment 2:

Orientation tests in **'natural** magnetic field' [NMF] and **'changed magnetic field'** [CMF]

- \rightarrow Total intensity + 6,570 nT
- \rightarrow Magnetic inclination +9°
- \rightarrow Magnetic declination +10°



Resembling natural magnetic field near Neftekamsk (Russia)







Experiment 2:

Orientation tests in **'natural** magnetic field' [NMF] and **'changed magnetic field'** [CMF]

- \rightarrow Total intensity + 6,570 nT
- \rightarrow Magnetic inclination +9°
- \rightarrow Magnetic declination +10°



Resembling natural magnetic field near Neftekamsk (Russia)



NMF (Illmitz)







Experiment 2:

Orientation tests in **'natural** magnetic field' [NMF] and **'changed magnetic field'** [CMF]

- \rightarrow Total intensity + 6,570 nT
- \rightarrow Magnetic inclination +9°
- \rightarrow Magnetic declination +10°



Resembling natural magnetic field near Neftekamsk (Russia)

→ Significant change in the birds' orientation!

Consistent with a compensatory response after a displacement to the simulated site!





Conclusions:

- → At least some migratory birds seem to use several different cues derived from the geomagnetic field for geographic positioning and navigation.
- → The same birds are able to interpret such cues and adjust their migratory directions accordingly, even if these are of unfamiliar magnitude.



Acknowledgements...



F. Bittermann, G. Hafner, R. Haider, C. Jöhl,P. Kishkinev, B. Kofler, I. Maggini, H. Mouritsen,R. Schalli, S. Szűcs, W. Vogl, H. Winkler &T. Zechmeister



Funded by...







Russian Science Foundation

PRIFYSGOL BANGOR



Pre-migratory movements and timing of initial migratory departures in adult and juvenile Sedge Warblers (Acrocephalus schoenobaenus) Funded by:





BANGOR