LIGGINS INSTITUTE
THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

NATIONAL RESEARCH CENTRE FOR GROWTH AND DEVELOPMENT

LENScience Senior Biology Seminar Series

Animal Navigation: Magnetic Sense

Questions and Discussion

Pre-seminar School Discussion

During the year you have learnt about how animal and plant behaviour is often linked to information from the biotic and abiotic environment. In particular you have studied the biological orientation behaviours of taxes, kinesis, homing and migration in which behaviour is linked to an ability to sense information from the abiotic environment. The journeys that animals make in both migration and homing are amazing. From the multi-generational migration of the Monarch Butterflies to the annual migrations of whales in through the southern oceans, each journey brings enormous challenge and expenditure of energy - yet overall is beneficial to the species.

Here in New Zealand we are familiar with the migratory birds such as the Kūaka or Bar-tailed Godwit with its international migration between New Zealand and Alaska, as well as species such as the Ngutuparore or Wrybill which migrate within New Zealand.

Fig 1: Kūaka-Bar Tailed Godwit. Miranda, New Zealand Image: J Bay

Understanding **how** and **why** animals make these journeys has challenged scientists for many years. The energy expenditure and risk associated with migration is enormous. Yet we know that in a biological system this behaviour would not have evolved unless the **advantage outweighed the risk.** Understanding of **how** animals navigate these journeys involves looking into the sensory perception of each species. One of the most fascinating is magnetic sense, known to be used by bacteria, as well as animals from insects through to the vertebra group. This tells us that it is a sense that evolved very early.

This seminar will encourage you to explore what is known about magnetic sense and how scientists go about finding out more about how animals detect, process and use information about the Earth's magnetic field.

Pre-seminar review questions:

1. Define the terms taxes, kinesis, homing and migration and explain the difference between homing and migration.
2. A range of sensory receptors are used by animals in orientation responses (taxes, kineses, homing and migration). Make a list of the main sensory receptors used, and link each to an example E.g. Audioreceptors - Navigation in bats and whales
3. Orientation behaviour such as migration is often triggered by an **environmental cue**. Describe the potential environmental cue that would trigger the beginning of the annual migration of the Kūaka or Bar-tailed Godwit from Alaska to New Zealand.
4. Magnetic sense allows animals to make of the ability to sense variation in the earth's magnetic field in navigation. Before the seminar, make sure you understand the Earth's magnetic field is and how it is created.

Challenge Questions

1. **Using information from the seminar, explain how scientists believe animals detect magnetic fields and outline the evidence that suggests that this ability is used in navigation.**
2. **Animal navigation involves both timing and orientation behaviours in response to environmental cues. Discuss the relationship between timing and orientation in homing and migration behaviours.**
3. For an environmental cue to be of use to an animal in navigation, the cue must be:
    - consistent,
    - vary systematically in space to provide information about specific points on the Earth's surface,
    - be stable over time
    - provide enough accuracy to allow the animal to reach its specific goal destination.

    Using named examples, discuss the adaptive advantage of the ability to use magnetic sense in comparison to other environmental cues.

Level 3 Achievement Standards linking to this seminar:

AS 90716 Describe animal behaviour and plant responses in relation to environmental factors

Key Concepts from Level 3 Biology that link to this seminar:

Below are selected objectives from the Y13 biology programme that link to this seminar. THESE ARE NOT A FULL LIST OF THE CONCEPTS IN YOUR COURSE**. You should review the bolded concepts before the seminar.**

- Distinguish between intraspecific and interspecific responses in animals and the relationship between these responses and ecological niche.
- **Distinguish between innate and learned behaviour.**
- Recognise and explain the purpose of the following types of intraspecific interactions: Fighting; territoriality; hierarchies; group formation; courtship and breeding; parental care.
- Recognise and explain the purpose of the following interspecific interactions: predator – prey; obtaining food; defensive behaviour; mutualism; commensalism.
- **Describe ways in which animals sense or detect environmental stimuli. To include photoreceptors, thermoreceptors, mechanoreceptors, chemoreceptors, auditory receptors, detection of electrical and magnetic fields.**
- **Describe the following biological orientation responses in animals – taxes, kineses, homing, migration including the triggers for these responses.**
- **Describe how the following environmental clues are used by animals for homing and migration: visual clues, solar navigation, magnetic fields, star navigation, chemical navigation, sound – sonar navigation.**
- **Define what a biological timing response is and give examples of timing responses.**
- **Define the following terms: Biological clock; circadian rhythm; circatidal rhythm; circannual rhythm, ciralunar rhythm.**
- Define and recognise the following daily cycles: Diurnal; nocturnal; crepuscular; arrhythmic.
- Analyse data to define the period of a biological rhythm; effect of a phase shift; free running period.
- Define the terms entrainment; zeitgeber, endogenous rhythm and exogenous rhythm.

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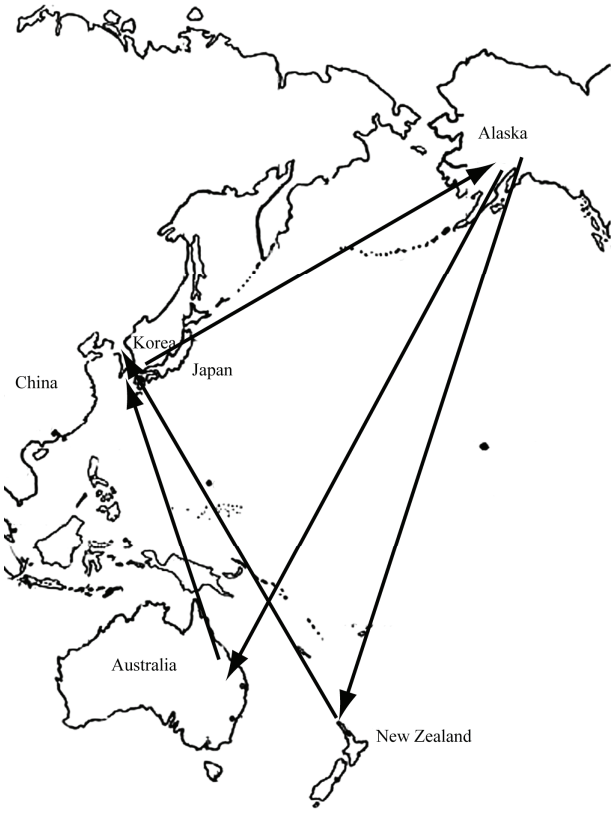
A reminder of the 2006 Scholarship Question (NZQA 2006).
http://www.nzqa.govt.nz/scholarship/subjects/resources.html

Question One:

The bar-tailed godwit, *Limosa lapponica baueri*, or kuaka, is a wading shorebird seen on marshy estuaries and wetlands during the New Zealand summer. Populations of this species embark on some of the longest migrations known amongst migratory animals.

Bar-tailed godwits breed in Alaska, spending the non-breeding season in New Zealand and eastern Australia (see map opposite). The journey from New Zealand to Alaska – a distance of up to 13 000 km – is completed in two stages. It begins in March, when the birds fly to South Korea, Japan or China. Here, they spend some time on feeding grounds (called staging sites) that may be shared with other migratory species, before leaving for Alaska in May. The birds return to New Zealand in September and October, taking a direct, non-stop route over the Pacific Ocean – a flight of approximately 11 000 km that takes 6 – 10 days. This southward migration begins about one month earlier than that of other migratory species.

Before each migration begins, flocks of godwits congregate at leaving sites and feed continuously. At the time of departure, up to 45% of their body weight is fat. Adult birds accumulate more fat than juveniles. The timing of the migratory flights coincides with weather systems, in both northern and southern hemispheres, that generate favourable tail winds.



Migratory routes of bar-tailed godwits throughout the Pacific Ocean.

Discuss the biological concepts associated with the migration of the **bar-tailed godwit**. In your discussion, consider:

- the biological mechanisms involved in the preparation for, and during the migration
- the benefits and risks of migration to the birds
- how this behaviour may have evolved.

Key terms

Abiotic
Biological Clock
Biological Orientation
Biotic
Environmental Cue
Homing
Innate Behaviour
Kinesis
Learned Behaviour
Magnetic Anomaly
Magnetic Field
Magnetic topography
Migration
Model Animal
Navigation
Sensory Receptor
Taxes