

A photograph of a forest floor covered in dry leaves and pine needles. Numerous monarch butterflies are scattered across the ground, some resting and others in flight. In the background, a dense forest of tall evergreen trees stands under a bright sky. The text is overlaid on the center of the image.

And Don't Forget the Invertebrates – Small Bodies, Massive Migrations

Andrada Opris, Sarah Scott-Marshall and James Williams
JNCC International Advice Team



Decision 15.233

- **Decision directed to:** Scientific Council
- The Scientific Council is requested, subject to the availability of resources, to: a) review the list of species in the Annex to Resolution 14.20 (Rev.COP15) in advance of COP16 and make proposals for any revisions; **b) produce a report, or reports, that identify how CMS may support the conservation of migratory invertebrate species, by i. considering which families or genera of invertebrates contain species that would meet the CMS definition of migratory; ii. identifying species that would meet the criteria within the Guidelines for Preparing and Assessing Proposals for the Amendment of CMS Appendices (Resolution 13.7 (Rev. COP15)); c) develop equivalent lists for other taxonomic groups including freshwater fish, based on the list of Migratory Freshwater Fishes that meet the criteria for listing on CMS contained in Annex 3 of document UNEP/CMS/COP15/Doc.25.6.1/Rev.1, marine fish and mammals.**



Beyond Fur and Feathers

Does a vertebrate bias leave invertebrates behind?

- Round-trip journey where a single individual travels between a breeding location to non-breeding location?
- Vertebrate-centric view impacts international legislation

CMS definition

Under the Convention Text of the CMS, a "**migratory species**" is defined as the entire population or any geographically separate part of the population of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries.

Beyond Fur and Feathers

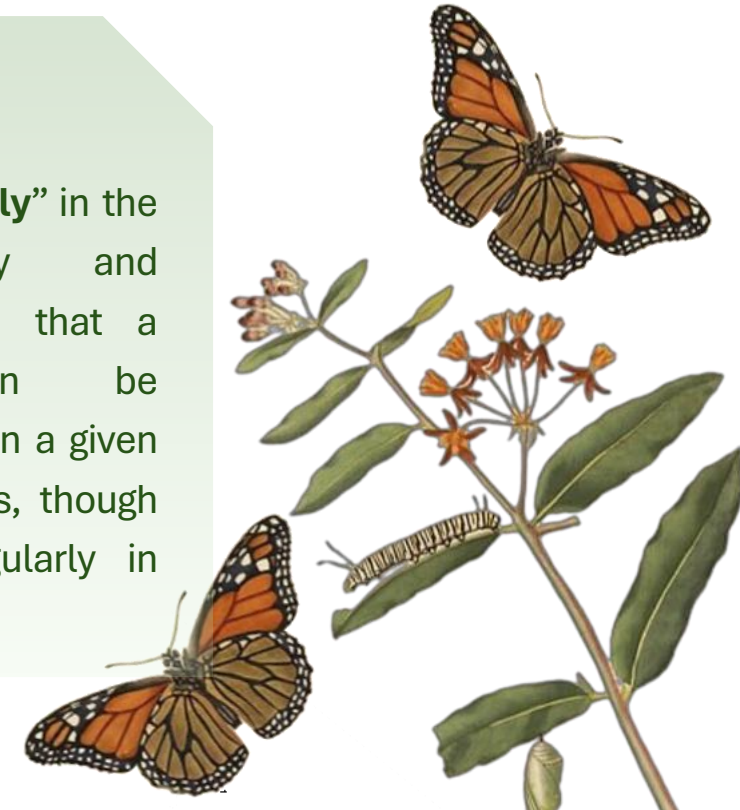


- Most animal migrants = invertebrates
- CMS protects over 650 vertebrates and 1 invertebrate: the **Monarch Butterfly** (*Danaus plexippus*) – Appendix II since 1979.
- IUCN Red Lists cover **9,706 species** of invertebrates (63% DD)
- ... still **1.25-1.7 million described species** out of 5-30 million expected to be described

CMS interpretation

The word “**cyclically**” in the phrase “cyclically and predictably” relates to a cycle of any nature, such as astronomical (circadian, annual etc.), life or climatic, and of any frequency.

The word “**predictably**” in the phrase “cyclically and predictably” implies that a phenomenon can be anticipated to recur in a given set of circumstances, though not necessarily regularly in time.



Why care?

Ecosystem function: services (and disservices)

Nutrient cycling

- 2,000-5,000 metric tons of insect migrant biomass moves annually between Africa and Europe = 7x songbird migrant biomass annually
- Aquatic larval stages help facilitate waste recycling
- Pulses of prey for migrating birds

Pollinating services

- Migrating hoverflies pollinate 52% major food crops
- US\$300 billion/year in pollination services
- Plant gene flow between isolated populations, food security

Natural pest control

- Aphid feeders = 10% of all migrant flies
- Dragonflies = top larval predators of mosquitoes, midges

Disservices

- Major pests of crops and livestock
- Vectors of disease: Japanese encephalitis, malaria
- Pest and disease forecasting = internationally coordinated strategies



How do we study insect migrations?

- Monitoring methods are fundamental to building the evidence base needed to identify, characterize, and assess insect migration
- Robust evidence is needed to inform conservation policy and management

Evidence needed for CMS consideration	Methods that can address gaps
Repeated occurrence	systematic trapping, observations, citizen science
Directional movement	visual observations, radar
Individual movement between sites	mark–recapture, telemetry
Long-distance movement	radar, atmospheric modelling
Population origin/connectivity	genetics, isotope analysis
Timing/periodicity	long-term monitoring
Scale of migration	abundance counts, radar, aerial trapping
Distinguishing migration from vagrancy/dispersal	combination of the above



Tagged monarch butterfly (*Danaus plexippus*).
© Elert S. Oxford (2008). CC BY 2.0.



Mangrove darner (*Coryphaeschna viriditas*).
© Dave Clermont (2013). CC BY-SA 4.0



What makes insect migration biologically distinctive?

Migrant and resident phenotypes

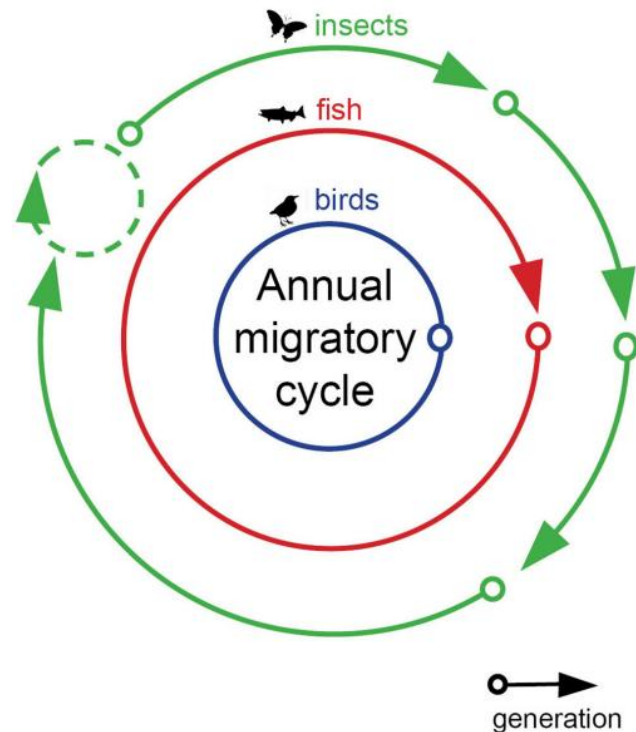
- Unlike vertebrates, most insects undergo **partial migration** = some individuals remain residents while others migrate
- Both strategies are regulated genetically, besides proximate cues (photoperiod, temperature, food, etc.)

The globe skimmer (*Pantala flavescens*).
© Robert Eede (2018). CC BY-NC-SA 2.0.



The globe skimmer (*Pantala flavescens*).
© Robert Eede (2018). CC BY-NC-SA 2.0.

What makes insect migration biologically distinctive?



Multiple generation cycles

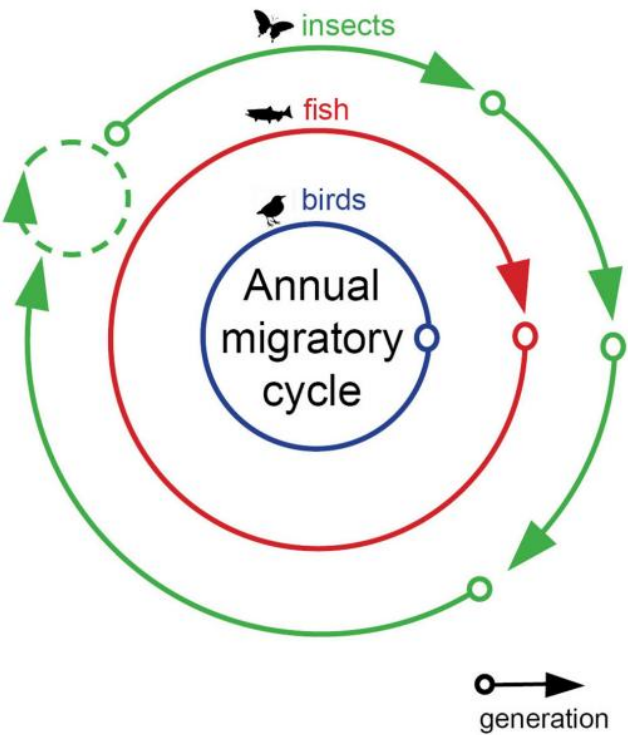
- Unlike vertebrates, most insects fulfill that migratory cycle over multiple generations
- **Longest insect migration:** wandering glider dragonfly (*Pantala flavescens*)
- 4 generations to complete 17,000 km round-trip between India and East Africa

Satterfield, D. A., Sillett, T. S., Chapman, J. W., Altizer, S., & Marra, P. P. (2020). Seasonal insect migrations: massive, influential, and overlooked. *Frontiers in Ecology and the Environment*, 18(6), 335–344. <https://doi.org/10.1002/fee.2217>



The globe skimmer (*Pantala flavescens*).
© Robert Eede (2018). CC BY-NC-SA 2.0.

What makes insect migration biologically distinctive?



Trait	Globe Skimmer Dragonfly (<i>Pantala flavescens</i>)	Bar-tailed Godwit (<i>Limosa lapponica</i>)
Single generation distance	~6,000 km (up to 3,500 km over open ocean)	11,000–13,500 km non-stop (Godwit)
Relative distance	~133 million body lengths	~33 million body lengths
Life expectancy	Weeks - months	Years - decades
Migration experience	First-time, one-way trip	Learned routes + genetic programming, return trips

Satterfield, D. A., Sillett, T. S., Chapman, J. W., Altizer, S., & Marra, P. P. (2020). Seasonal insect migrations: massive, influential, and overlooked. *Frontiers in Ecology and the Environment*, 18(6), 335–344. <https://doi.org/10.1002/fee.2217>

How does invertebrate migration occur?



Robber crab (*Birgus latro*). © David Stanley (2016). CC BY 2.0.

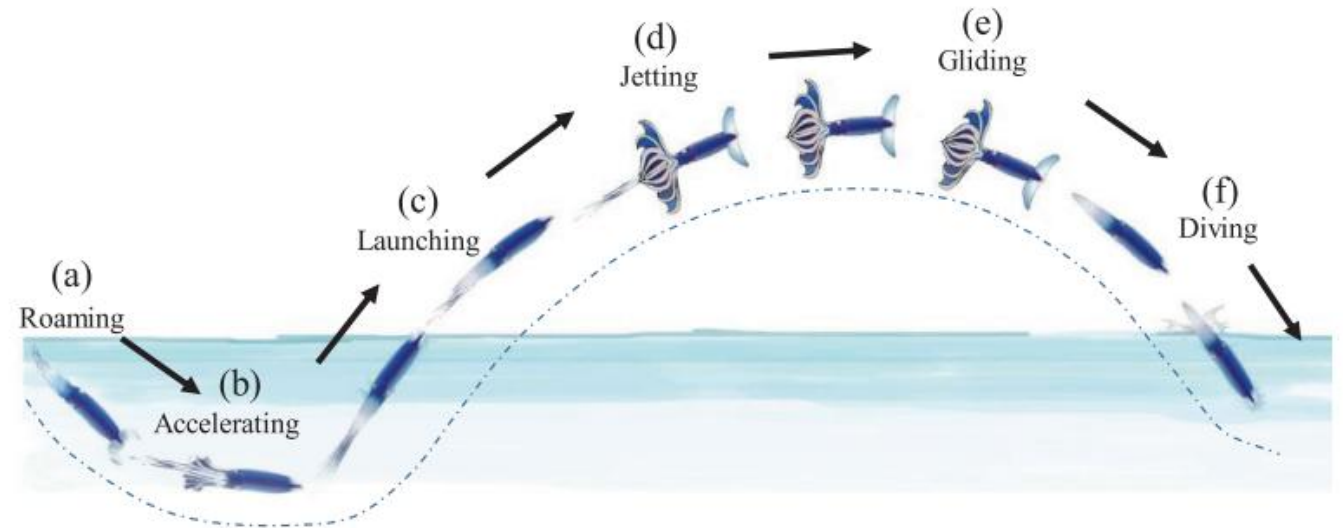


Nautilus (*Nautilus pompilius*). © Itkovian (2009). CC BY-NC-SA 2.0.

- **Drift in ocean currents** – passive vs active migration
- **Zooplankton grow up** – when do they become active rather than drifting?
- **Vertical migrations** – do these cross international borders?
- **Active migration** in Humboldt Squid (*Dosidicus gigas*), via Jet propulsion



Loggerhead turtle (*Caretta caretta*). (c) Florida Fish and Wildlife (2005). CC BY-ND 2.0



Hou, T., Yang, X., Wang, T. M., & Fan, Y. (2020). Locomotor transition: how squid jet from water to air. *Bioinspiration & Biomimetics*, 15(3), 036001. <https://doi.org/10.1088/1748-3190/ab784b>

Where are we looking?

From isolated records...
...to migration hotspots

- Once upon a time in the **Pyrenean Pass of Bujaruelo**
... “the most remarkable migrants of all”.
- 1 million insects migrate annually



Karpaz peninsula (Cyprus)



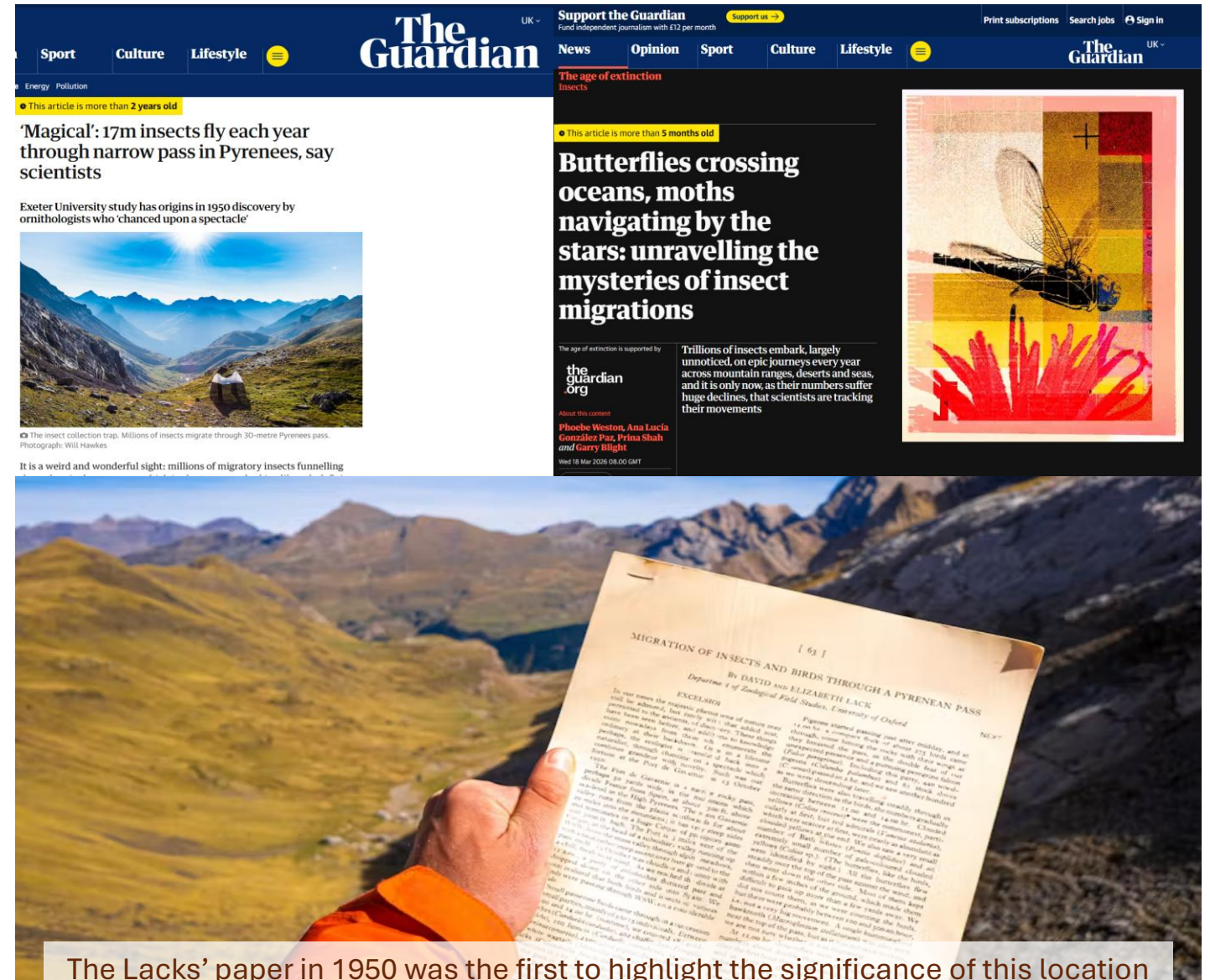
The Levantine Corridor (Israel)



The Maldives

Protect migration bottlenecks

=> umbrella protection for the migratory process itself



The Lacks' paper in 1950 was the first to highlight the significance of this location as a major migratory route for insects. © Will Hawkes. CC BY-ND.



Freshwater pearl mussels (*Margaritifera margaritifera*).
© Joel Berglund (2007). CC BY-SA 3.0.

Host-mediated migration of a threatened ecosystem engineer

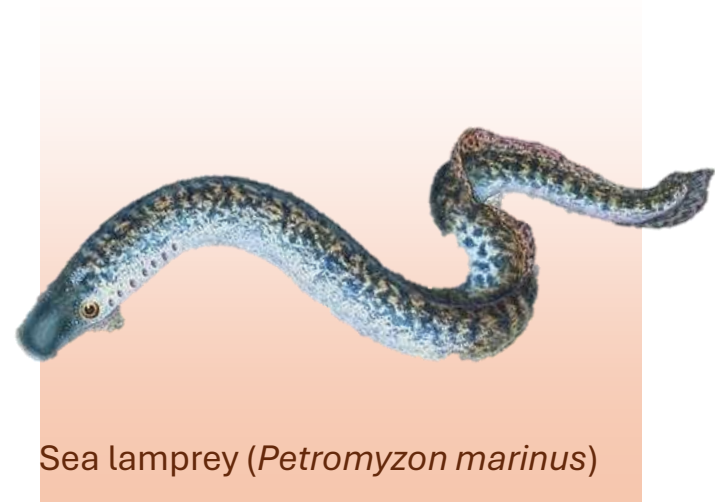
- Endangered species
- EU habitats directive
- Important ecosystem engineer
- Declining population

Larvae rely on migratory fish

- Critically Endangered sister species *Margaritifera auricularia*
- Sea lamprey = regionally invasive in America
- Case-by-case CMS assessment



Atlantic salmon (*Salmo salar*)



Sea lamprey (*Petromyzon marinus*)

Conclusion: the Atlas needs to include invertebrates

Thank you!

