

ARTICLE

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Stochastic simulations reveal few green wave surfing populations among spring migrating herbivorous waterfowl

Xin Wang^{1,2}, Lei Cao^{1,3}, Anthony D. Fox⁴, Richard Fuller⁵, Larry Griffin⁶, Carl Mitchell⁶, Yunlin Zhao⁷, Oun-Kyong Moon⁸, David Cabot⁹, Zhenggang Xu⁷, Nyambayar Batbayar¹⁰, Andrea Kölzsch^{11,12,13}, Henk P. van der Jeugd^{14,15}, Jesper Madsen⁴, Liding Chen^{1,3} & Ran Nathan²

Tracking seasonally changing resources is regarded as a widespread proximate mechanism underpinning animal migration. Migrating herbivores, for example, are hypothesized to track seasonal foliage dynamics over large spatial scales. Previous investigations of this green wave hypothesis involved few species and limited geographical extent, and used conventional correlation that cannot disentangle alternative correlated effects. Here, we introduce stochastic simulations to test this hypothesis using 222 individual spring migration episodes of 14 populations of ten species of geese, swans and dabbling ducks throughout Europe, East Asia, and North America. We find that the green wave cannot be considered a ubiquitous driver of herbivorous waterfowl spring migration, as it explains observed migration patterns of only a few grazing populations in specific regions. We suggest that ecological barriers and particularly human disturbance likely constrain the capacity of herbivorous waterfowl to track the green wave in some regions, highlighting key challenges in conserving migratory birds.

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¹² Group of Mathematical Modelling, Institute for Chemistry and Biology of the Marine Environment, Carl von Ossietzky University Oldenburg, Carl-von-Ossietzky-Straße 9-11, 26111 Oldenburg, Germany. ¹³ Institute for Wetlands and Waterbird Research e.V. (IWWR), Am Steigbügel 3, 27283 Verden(Aller), Germany. ¹⁴ Vogeltrekstation—Dutch Centre for Avian Migration and Demography (NIOO-KNAW), Wageningen 6708 PB, The Netherlands. ¹⁵ Sovon Dutch Centre for Field Ornithology, PO Box 65216503 GA Nijmegen, The Netherlands. Correspondence and requests for materials should be addressed to L.C. (email: leicao@rcees.ac.cn) or to R.N. (email: ran.nathan@mail.huji.ac.il)



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Phylogenetic tree of the genus *Anas* based on mitochondrial cytb sequences. The tree shows relationships between various species, with bootstrap values indicated at the nodes. The species names are: Dataset, *Branta leucopsis*, *Anser albifrons*, *Cygnus cygnus*, *Cygnus columbianus*, *Anser cygnoides*, *Anser fabalis*, *Anser serrirostris*, *Anser brachyrhynchus*, *Anser albifrons flavirostris*, *Anas platyrhynchos*, and *Anas acuta*.

Figure 1 is a scatter plot titled "Method evaluation". The x-axis is labeled "Iteration" and ranges from 0 to 100. The y-axis is labeled "Percentage of correct results" and ranges from 0% to 100%. There are two data series: "fi" (fitted) and "m" (method). The "fi" series shows a rapid increase in accuracy, reaching nearly 100% by iteration 10. The "m" series shows a much slower increase, reaching approximately 80% by iteration 100.

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1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes the need for transparency and accountability in financial reporting.

2. The second part of the document outlines the various methods and techniques used to collect and analyze data. It includes a detailed description of the experimental procedures and the statistical analysis performed.

3. The third part of the document presents the results of the study. It includes a series of tables and graphs that illustrate the findings of the research. The data shows a clear trend in the relationship between the variables studied.

4. The fourth part of the document discusses the implications of the findings and provides recommendations for future research. It suggests that further studies should be conducted to explore the underlying mechanisms of the observed phenomena.

5. The fifth part of the document concludes the study and summarizes the key findings. It reiterates the importance of the research and the need for continued investigation in this field.

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