Movement ecology of migratory bats in response to an ecological barrier

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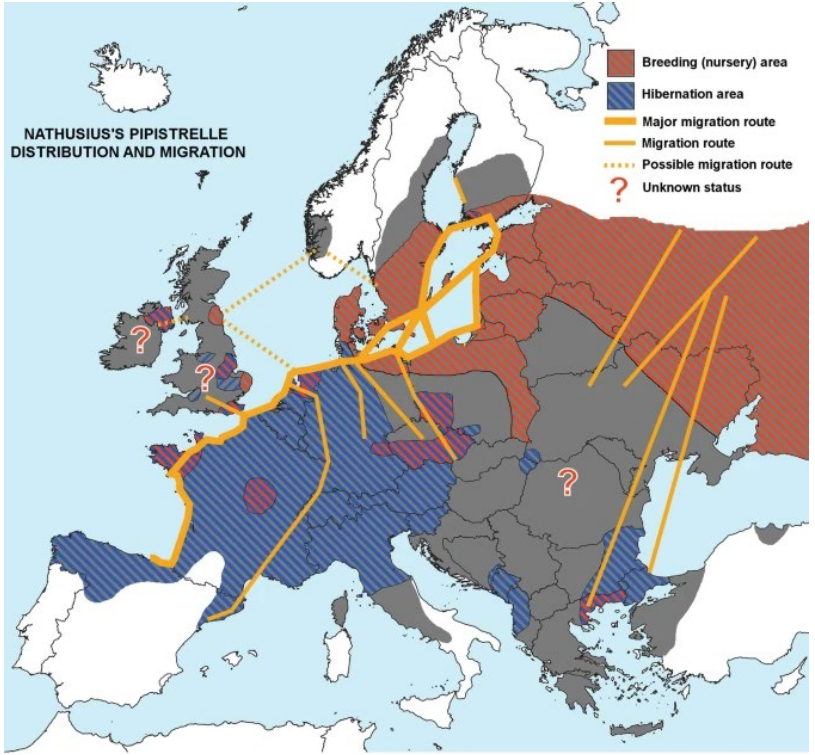
Introduction

- Several bat species perform seasonal movements
- How barriers like the open sea affect bat migratory movements is still poorly known
- Major gaps in our knowledge are:
  - Route selection across ecological barriers
  - Timing of migration
  - Overall migration speed
  - Behavioral response to wind conditions during migratory flights

Case study Nathusius' pipistrelle *Pipistrellus nathusii*

- Small bat of 6-10 g
- Long-distance (partial) migrant
- Main breeding areas in NE Europe
- Winters in S and W Europe, incl. UK
- Migration over land and over sea
- Mating occurs in autumn along the migration routes
- Males generally occupy western parts of the species' range



Russ 2023

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Study area & tagging results

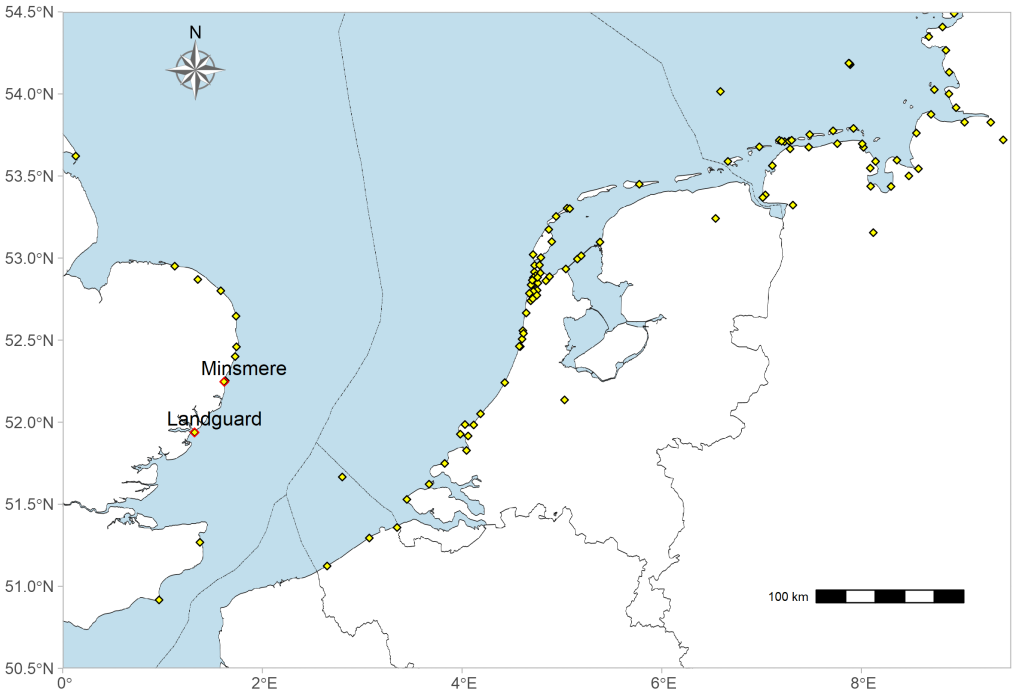

Photo Karina Stienstra

	2021	2022	Total
Female	17	22	39
Male	3	2	5
Total	20	24	44

1 predated and 2 tags found detached

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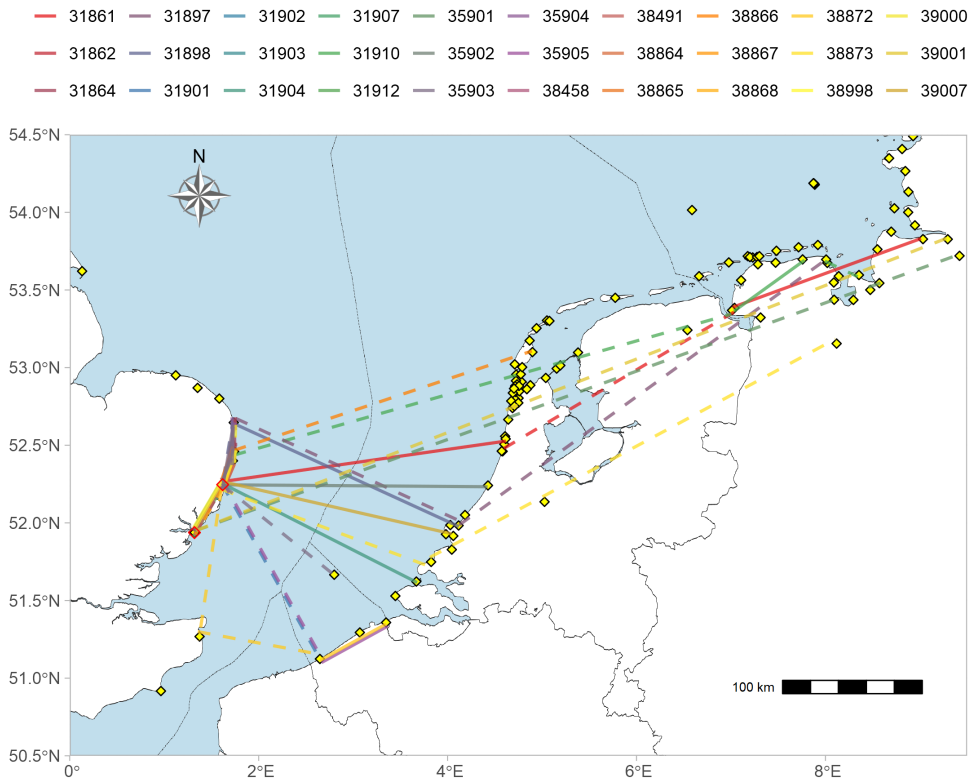
Movements in spring

- 41 detected at tagging location
- 30 elsewhere, of which 15 on the European mainland
- Up-and-down movements along the east coast of the UK
- Crossings over sea in a generally ESE direction and detours to reduce the travel over sea
- Routing adjustments to NE after reaching the European mainland



Lagerveld et al 2024

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Timing of migration & migration speed

Last detection in the UK:

- Females on average 10 May (n= 37) and males on average 4 June (n=4)
- Highly significant difference (t = -5.2307, df = 39, p-value = 6.033e-06)
- Sex-dependent timing in spring

Overall migration speed of females (n=5):

- On average 61 km/day including UK stopover and on average 88 km/day after their last detection in the UK
- Appears to be higher compared to autumn (cf Pētersons 2004, Bach et al 2022)

Single night migratory flights over sea

- Departures on average 69 min (range 40–114 min) after sunset
- Arrivals in the Netherlands on average 204 min (range 129–250 min) before sunrise
- Duration of the crossing on average 224 min (range 170–301 min)
- Distance of the crossing on average 180 km (range 157 to 205 km)

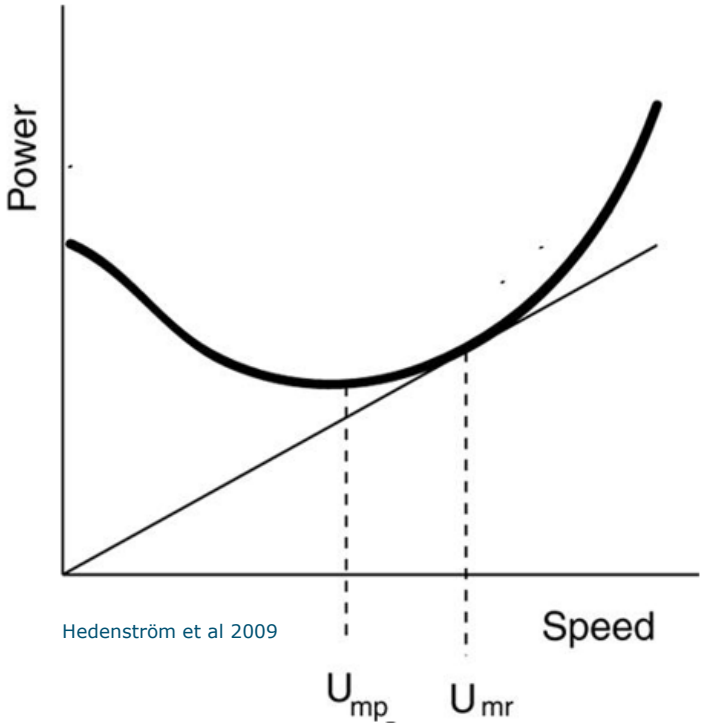
Speed calculations

Flapping flight power curve (Pennycuick 1975)

- U mp: minimum power velocity
- U mr: maximum range velocity

Characteristic airspeeds Nathusius' pipistrelle based on wind tunnel measurements (Troxell et al 2019):

- U mp = 5.8 +/- 1.0 m/s
- U mr = 7.5 +/- 1.1 m/s

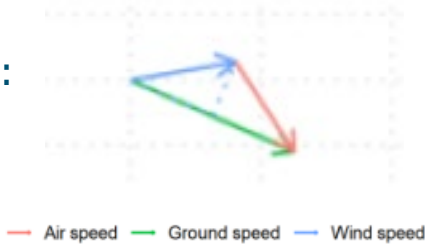


Hedenström et al 2009

Speed calculations

Knowns from bird migration

- Maximum possible angle between Airspeed and Windspeed:
  α max = arcsin (U air/U wind) (Alerstam 1978)
- Full wind drift during nocturnal flights over sea (Alerstam 1979):
  U ground = U wind + U air



Assumptions

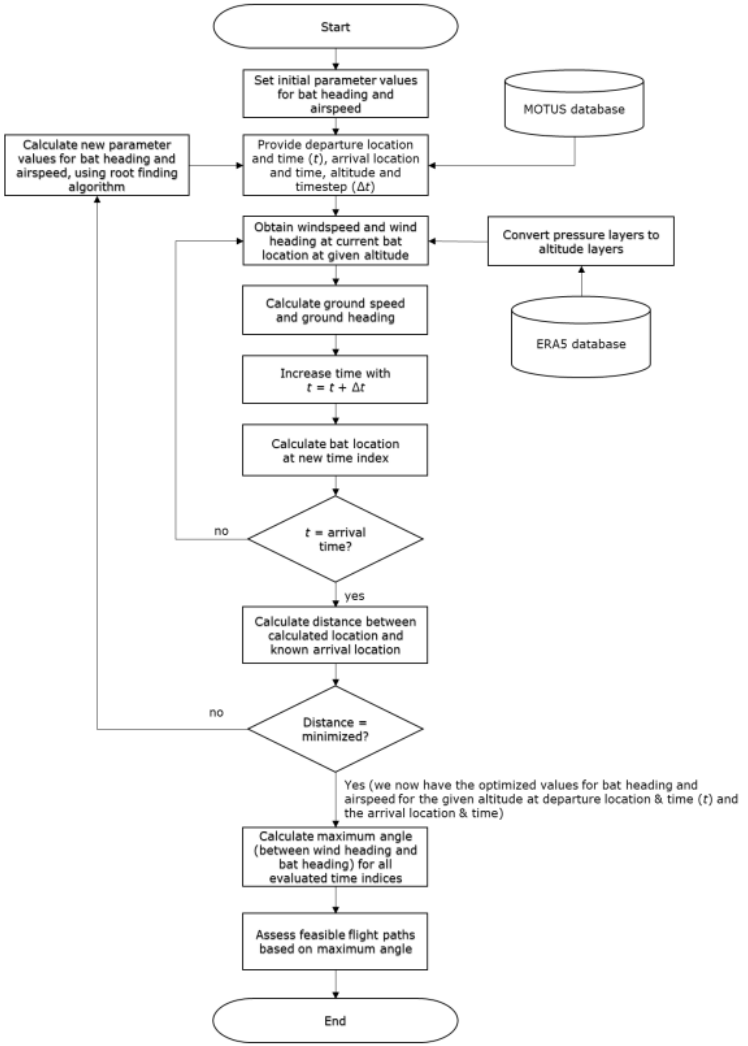
- Fixed bat heading
- Constant airspeed and altitude

Speed calculations

Calculation of airspeed and heading

using a root finding algorithm (Brent 1973)

for a selection of altitudes between 10 – 3000 m.



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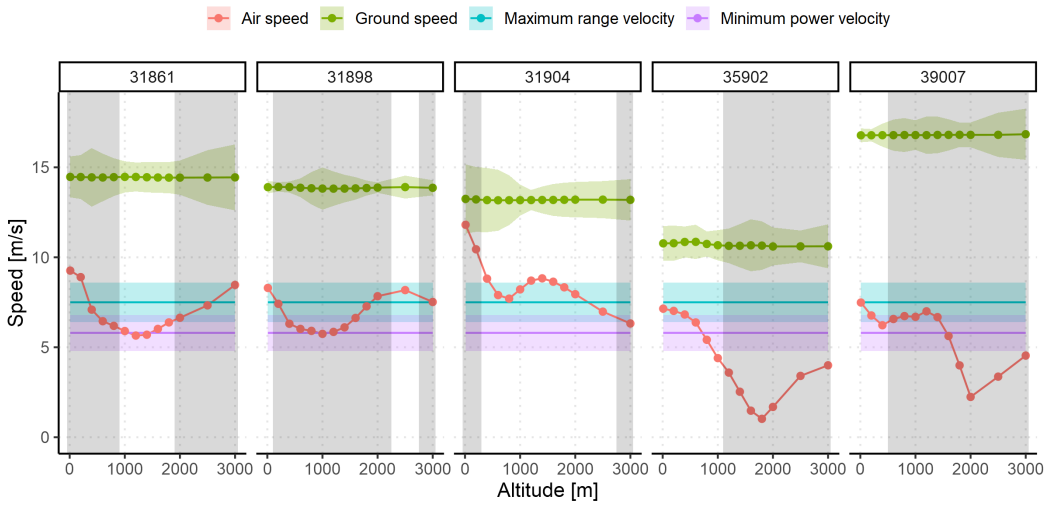
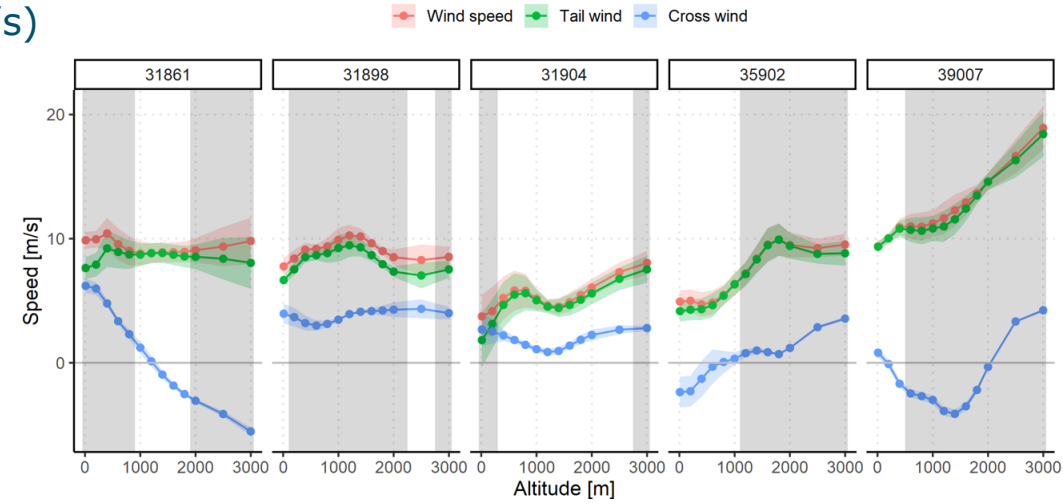
Speed calculations

- Calculated airspeeds match with Ump and Umr !
- Reduction airspeed during tailwinds and increasing with crosswinds
- Departures with average tailwind of 5.9 m/s at 10 m asl (range 1.8–9.3 m/s)
- Groundspeed up to 16.8 m/s (60.5 km/h) on average 2.2 times (range 1.7–2.7) higher than airspeed
- Non-stop crossings





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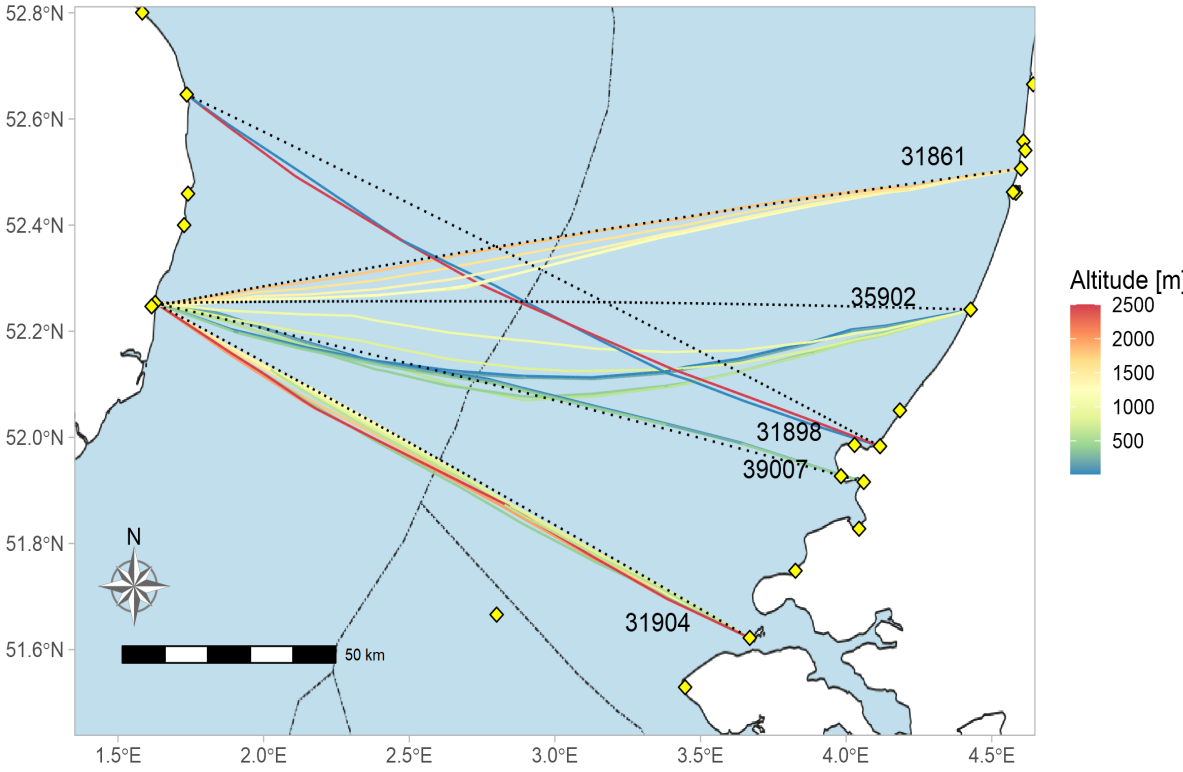
Flight path and altitude

- Wind conditions determine the altitudinal range
- At least two flights > 400 and >800 m
- Optimal wind support: flight altitudes of about 400, 800, 1200, 2500 and 2500 m
- First optimum: flight altitudes of about 10, 400, 800, 1000 and 1200 m



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Summary & Conclusions

- Barrier effects affect routing decisions, including avoidance of the open sea and reducing the extent of the overseas crossing.
- The migration timeframe depends -also in spring- on the sex of the animal
- The overall speed of migration in spring may be higher compared to autumn
- Our estimated airspeeds correspond well with the characteristic airspeeds measured in a wind tunnel
- Bats use wind adaptively to reduce airspeed when flying under tailwind and increase airspeed when flying under crosswind conditions.

Summary & Conclusions

- Departures over sea coincidence with tailwinds, enabling bats to more than double their airspeed, reaching ground speeds of up to 16.8 m/s (60.5 km/h).
- Our analysis suggests that bats select altitudes with favourable wind conditions and that they seek altitudes of several hundred meters, possibly extending up to 2,500 m.
- Low-altitude migration occurs when wind conditions are less favourable.
- The first study to estimate flight altitudes using 2D tracking data

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Thanks for your attention!

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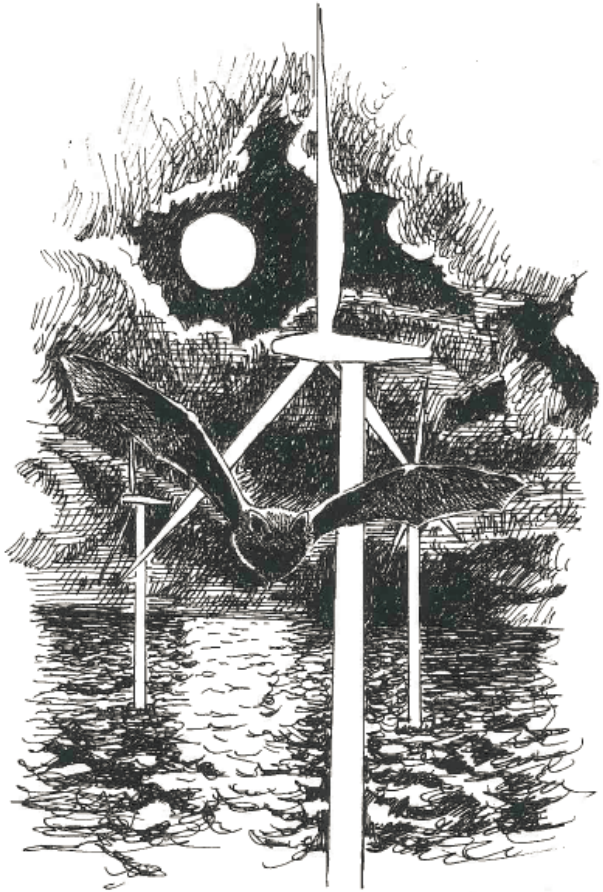

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References

- Alerstam T. A graphical illustration of pseudodrift. Oikos. 1978a;30:409–12. https://doi.org/10.2307/3543492.
- Alerstam T. Wind as selective agent in bird migration. Ornis Scand. 1979;10(1):76–93. https://doi.org/10.2307/3676347.
- Bach P, Voigt CC, Göttsche M, Bach L, Brust V, Hill R, Hüppop O, Lagerveld S, Schmaljohann, Seebens-Hoyer A. Offshore and coastline migration of radio-tagged Nathusius' pipistrelles. Conserv Sci Pract. 2022;4:e12783. https://doi.org/10.1111/csp2.12783.
- Brent RP. An Algorithm with Guaranteed Convergence for Finding a Zero of a Function. Algorithms for Minimization without Derivatives, Englewood Cliffs, NJ: Prentice-Hall, ISBN 0-13-022335-2. 1973.
- Hedenström A, Johansson C, Spedding GR. Bird or bat: Comparing airframe design and flight performance. Bioinspiration & Biomimetics 4(1):015001 (2009). DOI: 10.1088/1748-3182/4/1/015001

References

- Lagerveld, S., de Vries, P., Harris, J. et al. Migratory movements of bats are shaped by barrier effects, sex-biased timing and the adaptive use of winds. Mov Ecol 12, 81 (2024). https://doi.org/10.1186/s40462-024-00520-7
- Pennycuick CJ. Mechanics of flight. In D. S. F., & J. R. K. (Eds.), Avian Biology, Vol. 5 (Vol. Vol 5, Chapter 1:1-75). Academic Press. 1975.
- Russ J. Nathusius's Pipistrelle Pipistrellus nathusii (Keyserling and Blasius, 1839). In: Hackländer K, Zachos FE (eds) Handbook of the Mammals of Europe. Handbook of the Mammals of Europe. Springer, Cham. 2022. https://doi.org/10.1007/978-3-319-65038-8_68-1
- Troxell SA, Holderied MW, Pētersons G, Voigt CC. Nathusius' bats optimize long-distance migration by flying at maximum range speed.
  J. Exp. Biol, 222(4), jeb176396. 2019. https://doi.org/10.1242/jeb.176396
- Pētersons G. Seasonal migrations of north-eastern populations of Nathusius' bat Pipistrellus nathusii (Chiroptera). Myotis. 2004;41–42:29–56.