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Functional and numerical responses of predators to a fluctuating lemming population

Insights from a long term study in High Arctic Greenland

Cornerstones of the approaches

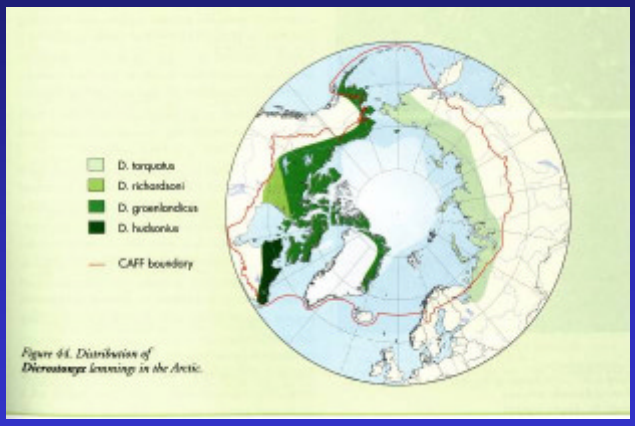
Baseline surveys generating ecological time series
- Long term study
- Observations at the community level

High arctic community (N-E Greenland)
- Simplest vertebrate community
- Little influenced by men
- Better observation conditions

High Arctic Habitats

The collared lemming

A circumpolar small rodent species

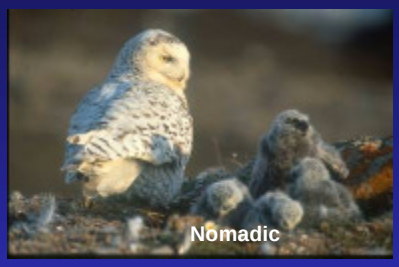


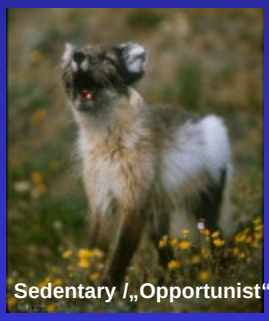
In Greenland, its range is limited to the North-East

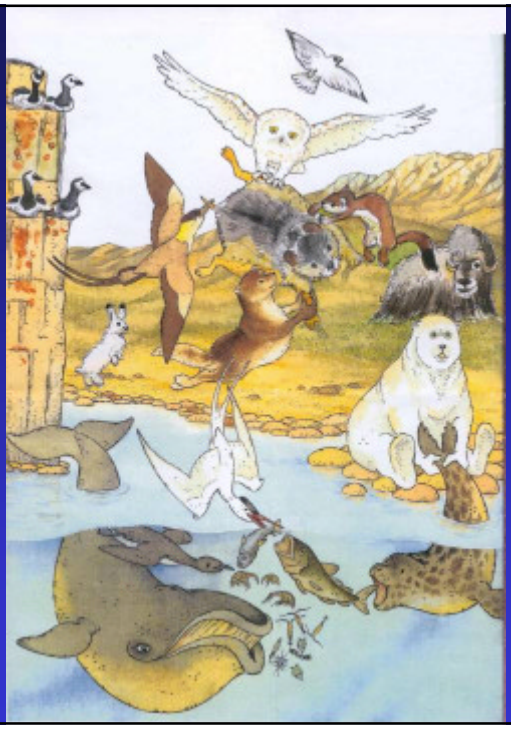
Best adapted to high arctic conditions

- Occurs up to 83.40 latitude North in Greenland!
- Adaptations to snow cover is their forte
  - Thermic protection
  - Shelter against most predators
- Winter reproduction with high demographic potential
  - Ability to produce several consecutive litters
  - Processes at work in the subnivean environment still poorly known
- Compared to Lemmus
  - Prefers drier habitats
  - Occurs generally at lower densities than lemmus

Coexisting predators whose life traits impose different strategies to use lemmings as prey







Main surveys
(on a long-term basis)

- Assessment of characteristics and dynamics of the lemming population
- Numerical responses of the predators
- Functional responses of the predators

Comprehensive census of the winter nests

- Census on 1500 ha (including 1000 ha covered with vegetation)
- Numerous data:
  - Location
  - Size
  - Isolated or part of group
  - Reproduction
  - Predation

Life trapping of lemmings in summer

- Life trapping, marking Telemetry
- Controls of = 500 lemming-burrows

Monitoring of the predators
Numerical responses

- Presence, breeding attempts and reproductive output
- Long-tailed skuas (1500 ha)
- Snowy owls (7000 ha)
- Fox dens (7000 ha)

Special case: the stoat

- Monitoring of lemming winternests predated by stoats (1988 - 2008)

- Trapping and marking

The functional response of predators

- Assessment of daily predation rate in relation to lemming densities
- Various approaches
  - Round a clock observations
  - Scat and pellet analyses
  - Complementary data from literature

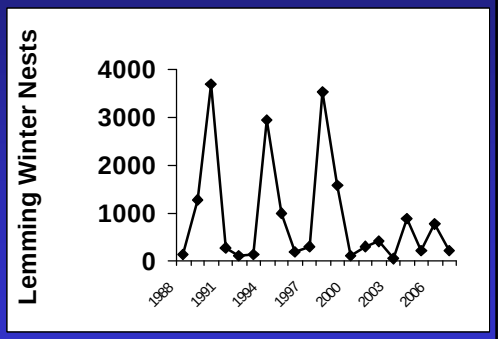
Systematic observations of predators




Results

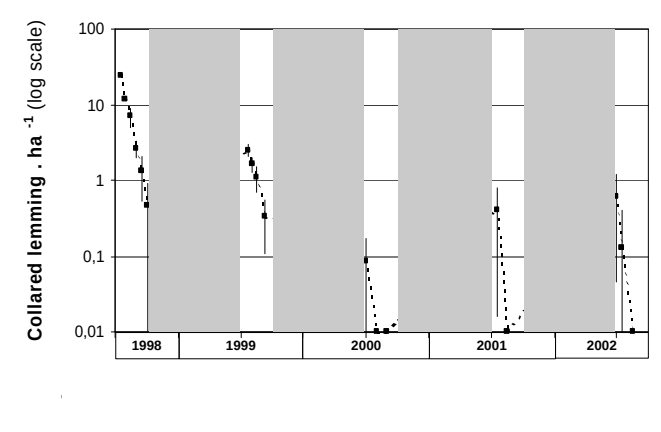
Long-term fluctuations of the lemming population

- Densities 0,1/ha – 25/ha
- Pattern with cycling fluctuations
- But greatly influenced by season
  - „Outbreaks“ leading to peaks in fews winters
  - Summer declines as a rule



Summer declines

The rule in this community !

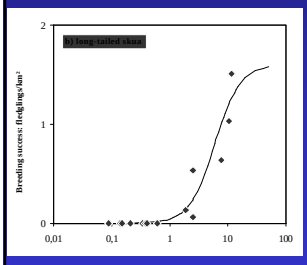


Daily losses: 1 to 4 %

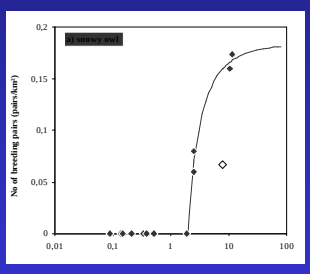
Seasonal reversing of trends !

Numerical response of predators

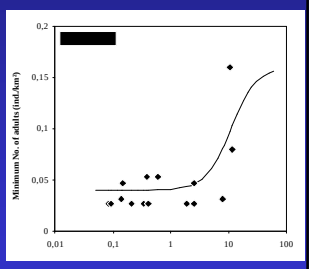
Long-tailed skua



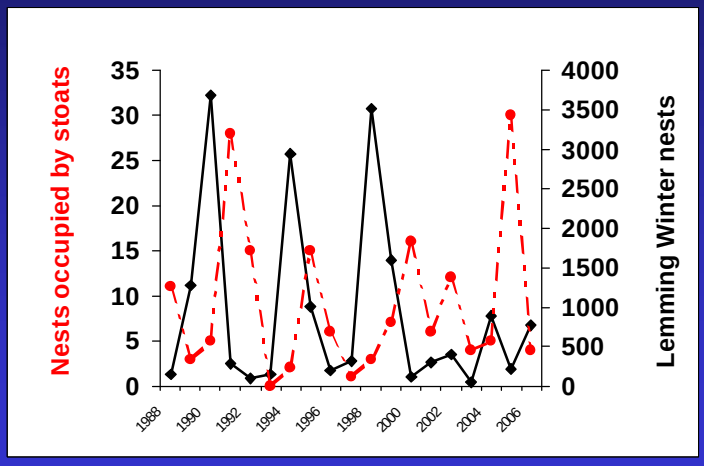
Snowy owl



Arctic Fox



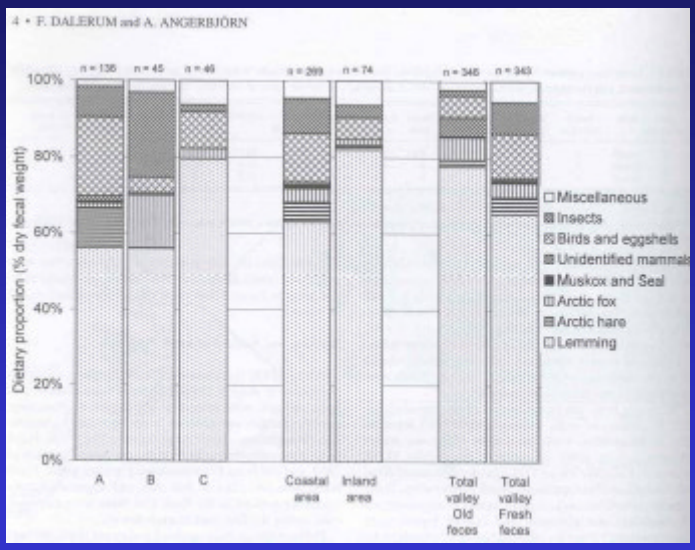
The time lag in the response of stoats



Functional responses

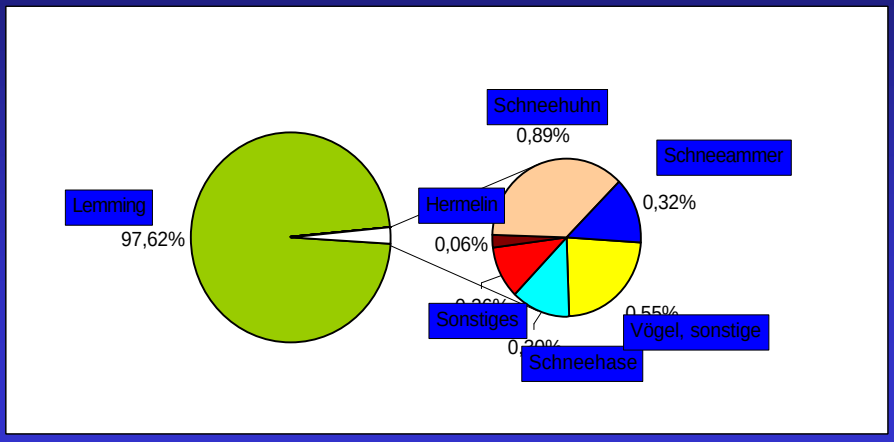
- Snowy owl: DCR = 3,2 – 4,73 lemmings
  (up to 16 lemmings captured by a single pair within 6 hours)
- Long tailed Skua: DCR = 0 – 4,5 lemmings
- Foxes: DCR = 0 – 4 lemmings
  respond faster to an increase in lemming density than do avian predators
- Stoats: DCR = around 2 lemmings

Diet of Arctic foxes as assessed by analysis of scats



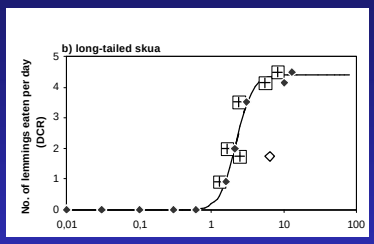
Even in low years, proportion of lemmings remains high

Diet composition of snowy owls as assessed by pellet analyses (n = 5304)

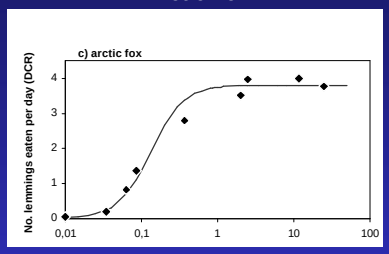


The functional response of predators

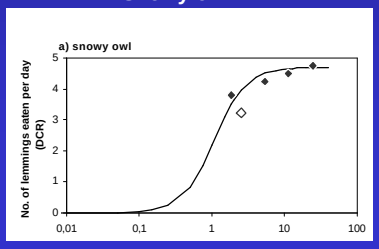
Long-tailed skua



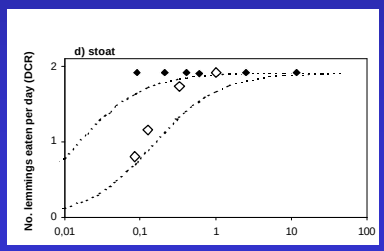
Arctic Fox



Snowy owl



Stoat



Total response and impact of predators on the lemming population

- Heavy variation in predation by more than 100-fold
  > 10 lemmings/km2 taken per day in peak summer
  < 0,1 lemming/km2 taken per day in depression phase
- In peak years. avian predators with greatest impact
  In low years, greater impact by mammalian predators
- When lemming densities are high, the daily predation rate exceeds the intrinsic growth rate of the lemming population
- Telemetry suggesting that more than 90 % of documented mortality is due to predators

Some conclusions

Predation as a key factor in shaping the lemming dynamics

The long term data support the specialist predator hypothesis

- Striking population declines associated with an increase in the overall predation rate

- Stoat predation pressure in winter was delayed density-dependant

Key pending issues

Are patterns (type of response, etc.) observed in Greenland shared by other circumpolar regions?

- Similar habitats and communities
- Communities including Lemmus
- Communities with other predator assemblages (Wrangel, where stoats are missing)

How may climate change affect these communities?

Outlook

Keep up with monitoring effort in our study site

Additional approaches to improve assessment of the responses of the predators

Also greater attention to possible effects of changes in the environmental conditions