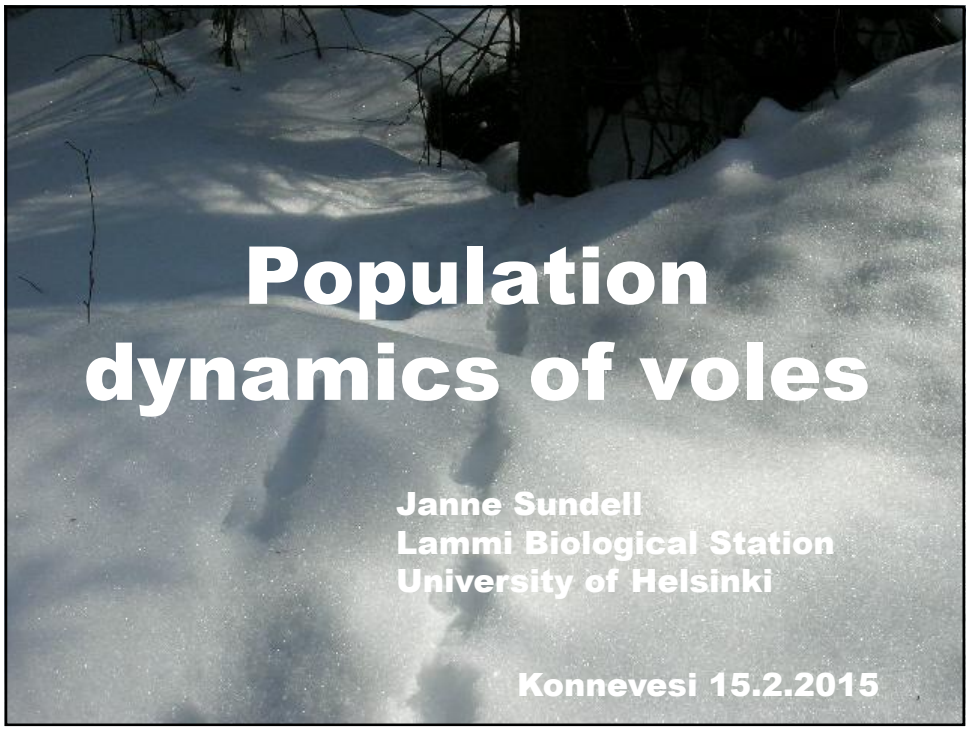


Population dynamics of voles

Janne Sundell
Lammi Biological Station
University of Helsinki

Konnevesi 15.2.2015

Outline

- Introduction: Northern voles
- Monitoring methods
- Introduction: cycles
- Overview of hypotheses

Voles

- Subfamily; Arvicoline rodents
- Appr. 70 species living in northern hemisphere
- Includes species like muskrats and lemmings
- Common, exhibit wide variation in abundance
- Some, mainly northern populations, cyclic
- Important part of the community
  - Common and numerous
  - Effect on vegetation
  - Support large number of predators
- Important to us
  - Pests in forestry and agriculture
  - Vectors of many diseases

Voles of northern Europe

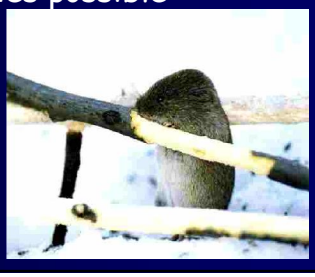
- Two species of lemmings (Lemmus, Myopus)
- Four species of 'field voles' (Microtus)
- Three species of 'forest voles' (Myodes)
- Water vole
- Muskrat

Voles of northern Europe

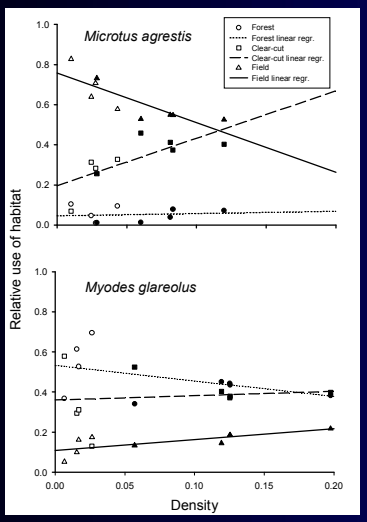
- Two most common ones are:
  - The bank vole (Myodes glareolus)
    - Common, almost everywhere in Finland
    - Mainly granivorous
    - Habitat generalist living mainly in forests
    - Females territorial –limits density

Voles of northern Europe

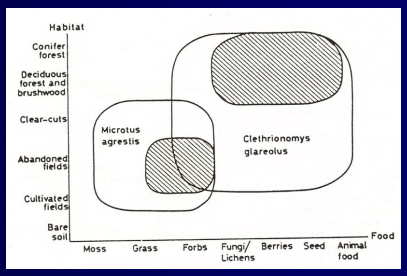
- The field vole (Microtus agrestis)
  - Common, almost everywhere in Finland
  - Mainly herbivorous
  - Lives mainly in fields and meadows
  - Young females live and breed close to their mothers – high densities possible



Voles of northern Europe



Sundell et al. 2012 JAE



Henttonen & Hansson 1984

Voles of northern Europe

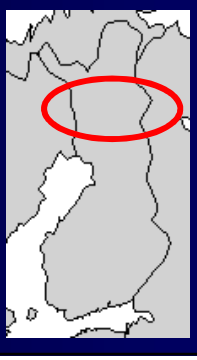
- The bank vole is partly replaced by the grey-sided vole (M. rufocanus) and the red vole (M. rutilus) in the north
- The sibling vole (M. levis) locally abundant e.g. western Finland

Voles of northern Europe

- The field vole is partly replaced by the root vole (M. oeconomus) in the north

Voles of northern Europe

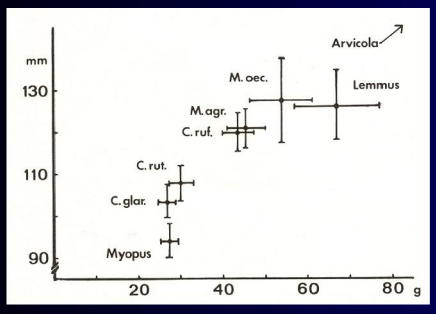
- Due to species' distribution the most vole species rich area in Finland is Lapland
  - Nine species
  - Why?



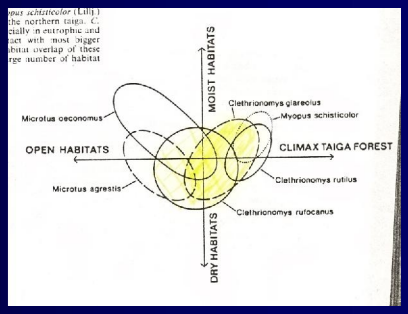
Relationship between vole species

- Generally larger species dominate smaller species
- Competition 'severe' during population highs
  - Dynamics generally synchronous
    - Competition leads to slightly asynchronous dynamics?
    - Habitat selection reduces competition:
      - Wood lemming; old growth forests
      - Norwegian lemming; tundra
      - Muskrat and water vole; wet habitats

Relationship between vole species



Henttonen et al. 1977



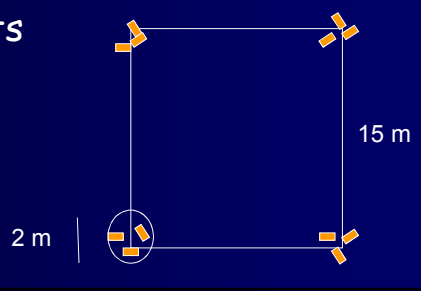
Henttonen & Hansson 1984

Vole monitoring

- Necessary for study of dynamics
- In Finland Finnish Forest Research Institute monitors vole populations with biannually in +20 sites
- Additionally, some amateur ornithologists and researchers monitor voles (<10 sites)

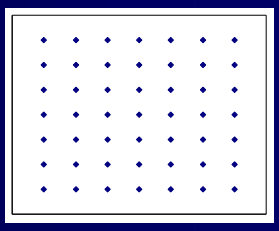
Vole monitoring: methods

- Snaptraps
- Systemically
  - Density index
- E.g. Small Quadrat Method, trap lines
  - Ind./100 trap nights



Vole monitoring: methods

- Live trapping
- Systemically in small area; a grid
  - Density estimates (CMR)
- Additional data on many variables; survival, behaviour
- Does not remove ind. from pop.
- Too laborious for large areas

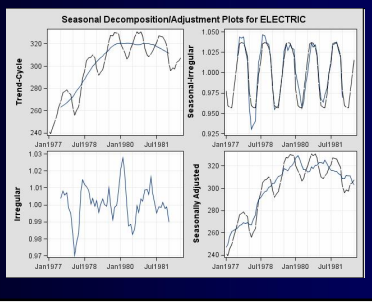


Vole monitoring: methods

- Indirect methods
  - Tracks
    - Snow
    - Foraging
    - Burrows, nests
    - Pellet counts
  - Predator abundance/breeding success
  - Predator diet
- Only abundance indices

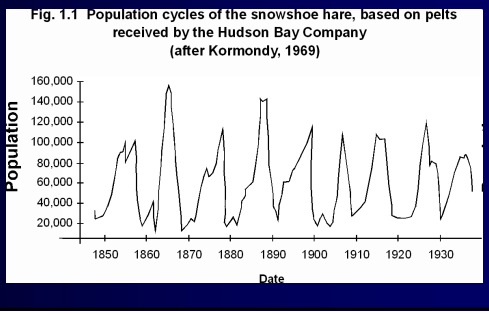
Vole monitoring: time series

- Regular monitoring yields time series of abundance = population dynamics
- Lots of statistical tools to detect density dependence, periodicity, trends, synchrony etc.



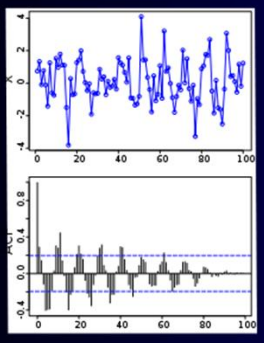
Population cycles

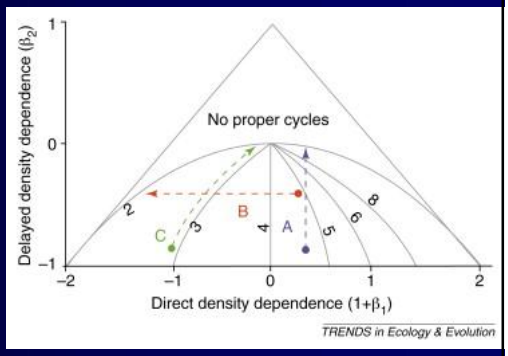
- 'Regular' multiannual fluctuations, not seasonal fluctuations
  - Period: cycle length
  - Amplitude: difference between min and max density



Population cycles

- Density dependence: delayed vs. direct
  - 2nd order autoregressive model: $x_t=\beta_0+\beta_1 x_{t-1}+\beta_2 x_{t-2}+\varepsilon t$
  - Royama triangle
- Autocorrelation functions (ACF)

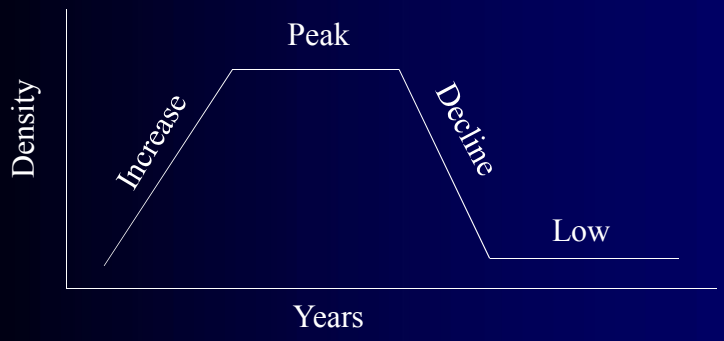




Ims et al. 2008 TREE

Population cycles

- Divided into different phases

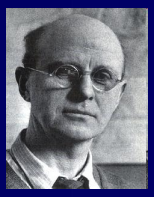


Vole cycles: brief history

- The Bible and historical writings on periodic mass occurrences
- Collett 1911-1912: Norges pattedyr; fluctuations of lemmings and other mammals
- Hewitt 1921: fluctuations of wildlife in Canada

Vole cycles: brief history

- Elton 1924: Periodic fluctuations in numbers of animals: their causes and effects
- Elton 1942: Voles, mice and lemmings: problems in population dynamics
- Oxford: Bureau of Animal Population
- 1960-1980; dispute on cycles, different schools
- Hundreds of papers and more than 20 reviews

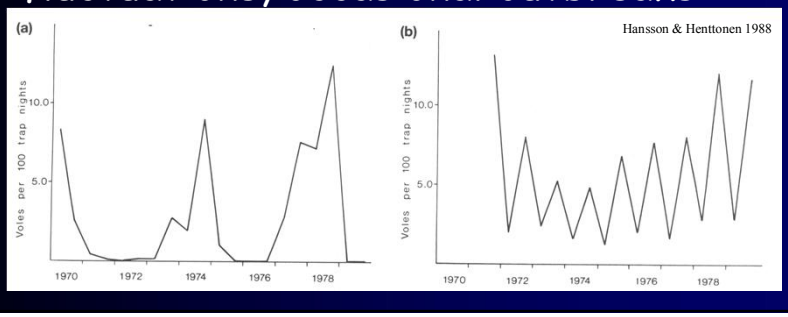


Nature of northern vole cycles

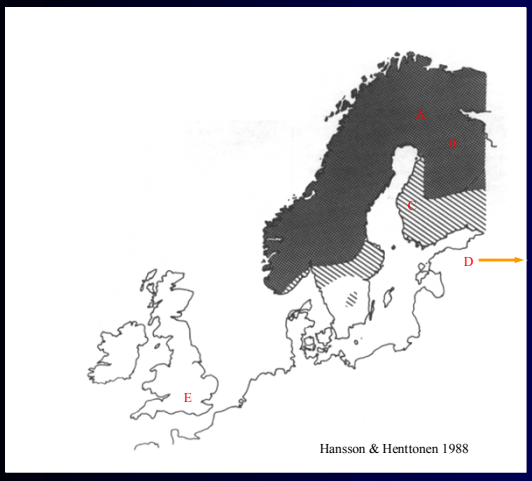
- 3-5 year population cycles in voles
  - Gradient in cycle length and amplitude
- Large-scale spatial synchrony
- Temporal synchrony between many species
- Phase-related changes in life history characteristics
- Summer declines
- Winter breeding

Cycle length

- Gradient in cycle length: 4-5 years in northern and 3-4 years in southern Finland, more south mainly seasonal fluctuations, occasional outbreaks

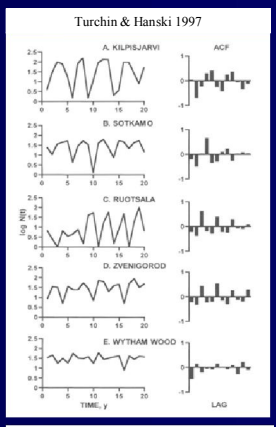


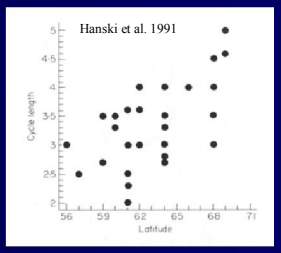
Cycle length

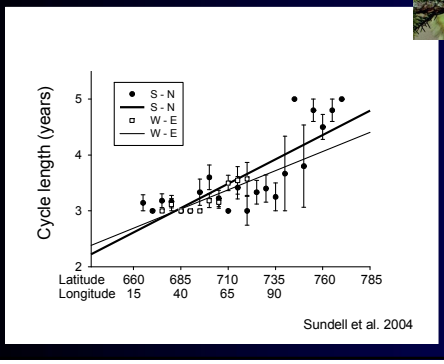


Hansson & Henttonen 1988

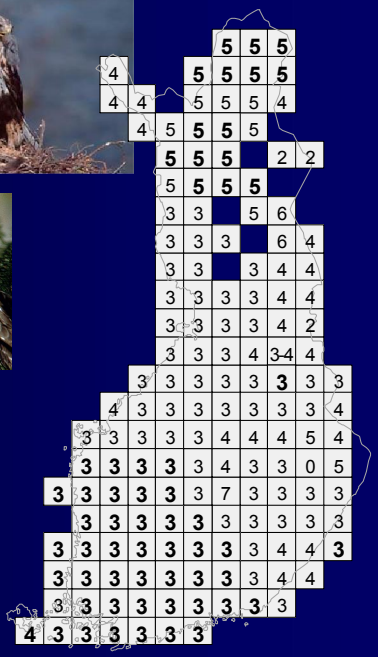
Turchin & Hanski 1997



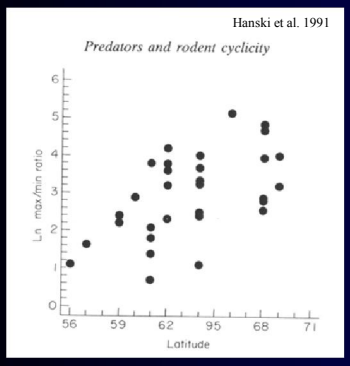




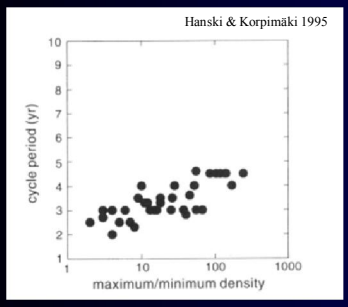
Sundell et al. 2004



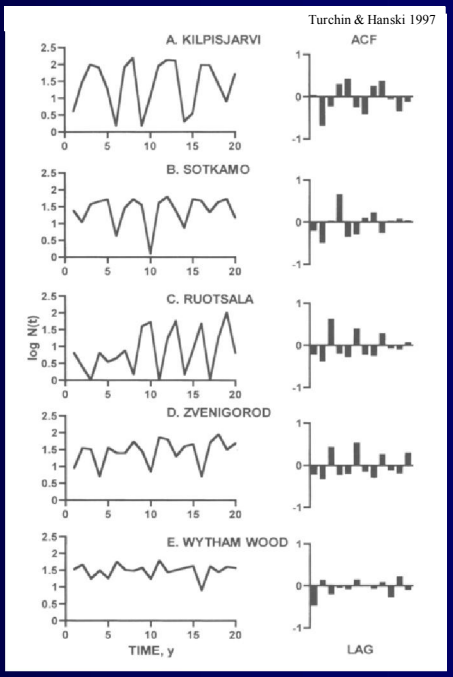
Hanski et al. 1991



Hanski & Korpimäki 1995



Turchin & Hanski 1997



Vole cycles

- 3-5 year population cycles in voles
  - Gradient in cycle length and amplitude
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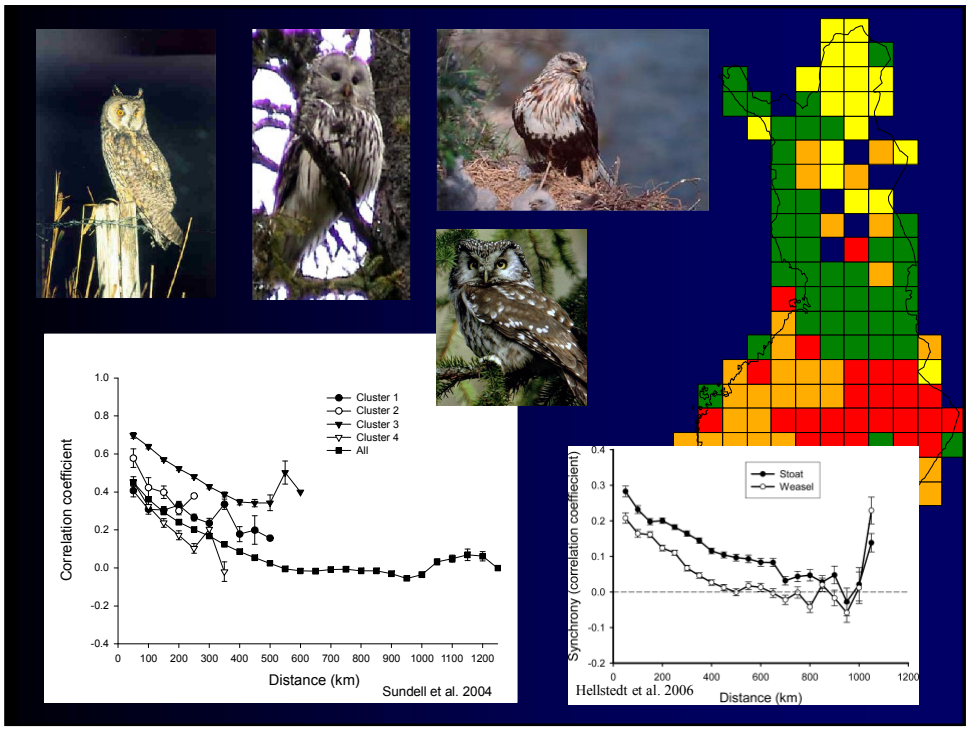
- Winter breeding



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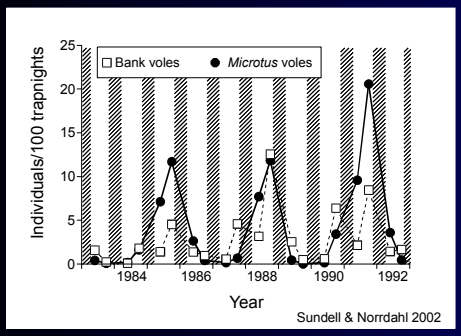
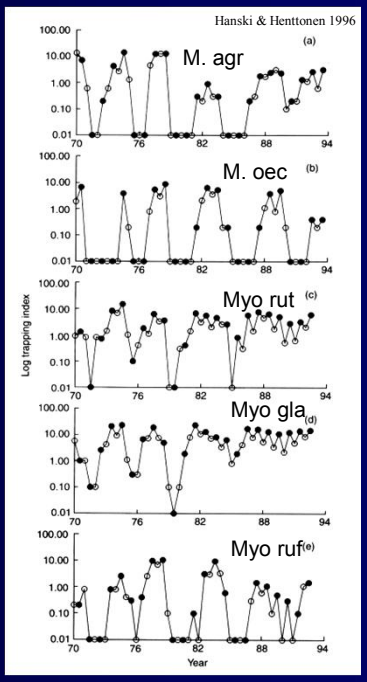
Synchrony between species





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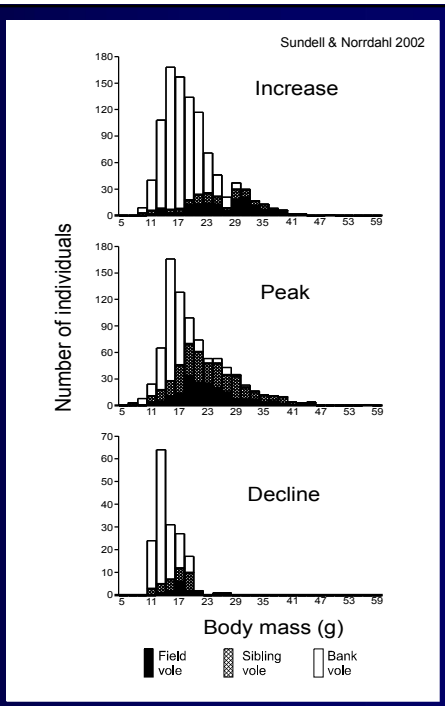
Chitty effect

- Voles are larger in increase and peak phases than in decline (or low) phase
- Phase-dependent changes also in reproduction and survival (proportion of mature voles, breeding season length…)



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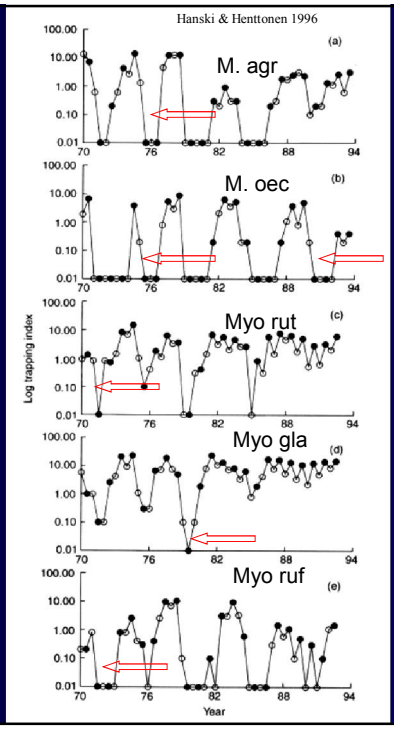
Summer decline

Spring

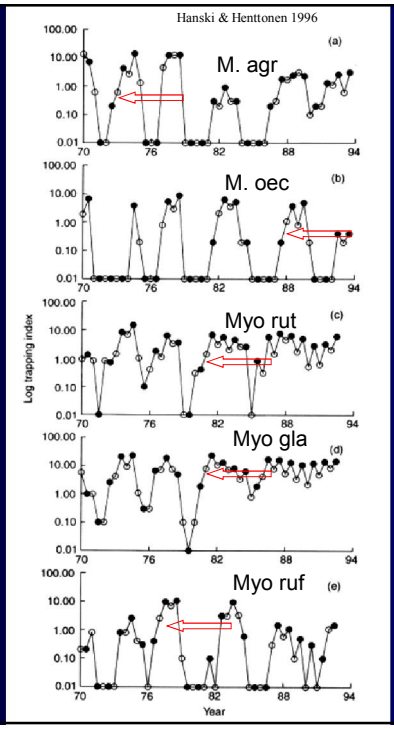
Autumn



Winter breeding

Spring

Autumn



Hypotheses on cycles

Olaus Magnus 1555

Hypotheses on cycles

- Many different hypotheses to explain the phenomenon >20
  - Abiotic factors: weather, sun spots
  - Intrinsic biotic factors: changes in quality of individuals during the cycle, density induced stress
  - Extrinsic biotic factors: food quality/quantity, parasites, diseases and predation
  - Multifactorial hypothesis; necessary and sufficient factors

Take home messages

- Vole populations fluctuate strongly
- Periodic fluctuations, cycles, are common in northern populations
- Characteristics for cycles are:
  - Periodicity of 3-5 years
  - High amplitude
  - Geographical trends in period and amplitude
  - Extensive synchrony over space and species
  - Summer decline and winter breeding

Take home messages

- Explanations for cycles are numerous
- No consensus about factors behind cycles
- You will hear more about some of them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