Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Finding and measuring the invisible diversity

Steve Coulson

Appreciated that invertebrates have a key role in ecosystems

- Soil nutrient cycling,
- decomposition,
- pollinating,
- prey for vertebrates,
- herbivory,
- blood feeding (hence economic importance) etc.,
- intrinsic fascination.

P. polaris Karsten
Sund NHMO

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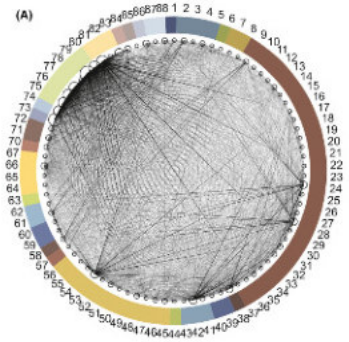

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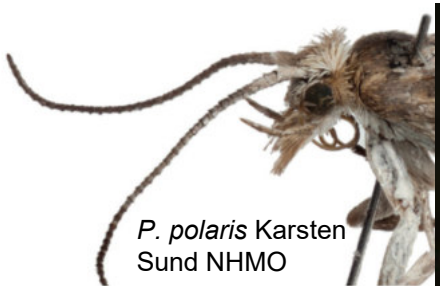

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Sund NHMO

Appreciated that invertebrates key role in ecosystem

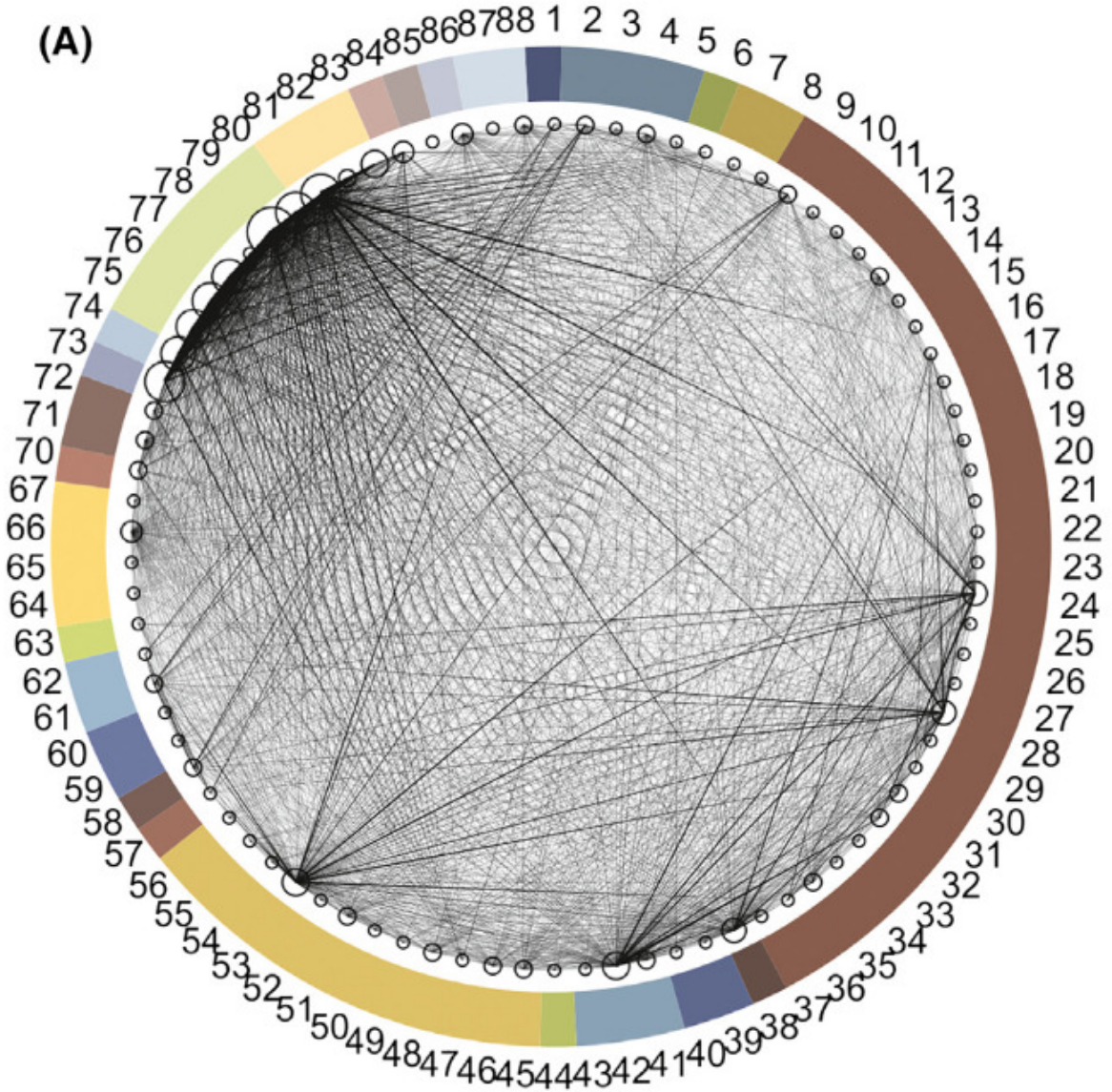
- Diverse (10% soil fauna species described, André *et al.* 2002 *Oikos*)

- Relatively few studies (”*it can be said that essentially all organisms are insects*” May 1988 *Science*)

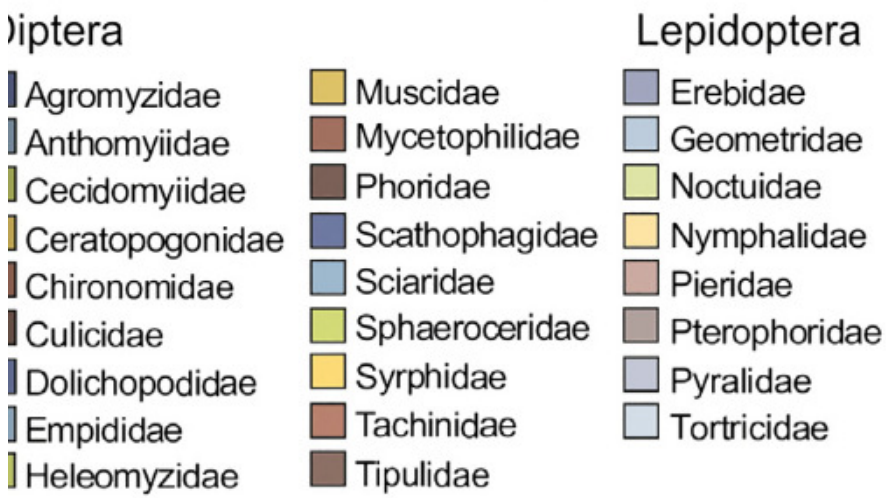
Percentage of representation of different taxa over a ten year period in *Journal of Animal Ecology*.

Wilkinson 1998 *Oikos*

	1987	1992	1997
Birds	23	29	32
Other vertebrates	31	25	29
Invertebrates	41	39	29
Protists	0	0	1
No main taxa	5	7	9



- Wirta *et al*. 2015 Ecol and Evol.



re 4. Qualitative generalized overlap diagrams showing shared predators among dipteran and lepidopteran prey potential for indirect interactions. In each panel, the small circles on the perimeter represent prey species (num lies are identified by colors on the surrounding circle. Each line connecting two prey species (small circles) repr ed among the respective prey species, thus revealing the potential for indirect interactions among the species linkec is proportional to how many times this prey species was detected among the predators, with the strength of th y times a predator species was found to use the two prey species. Different panels represent different predatc bined, (B) birds, (C) spiders, and (D) lepidopteran parasitoids.

But

- Arctic invertebrate biodiversity poorly known (Hodkinson CAFF 2013, Gillespie *et al.* in prep)
- lack of focus on the invertebrate community (lack of charismatic and iconic species?)
- Invertebrates have short generation times & rapid population fluctuations
- Respond rapidly to environmental drivers (temperature, precipitation, phenology)
- Natural population cycles and complex trophic interactions
- Challenging to resolve drivers without long term data sets

Required

- Assess biodiversity
  - Comprehensive inventories
  - Updated revisions, updated taxonomies, assessment of community change
  - Sample collection from as yet unstudied regions

- Coordinated monitoring and reporting

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- Comprehensive inventories
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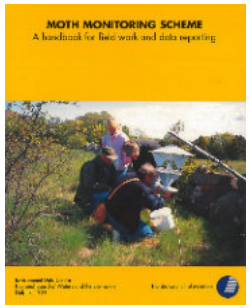
Coordinated monitoring and reporting

- Greenland Ecosystem Monitoring BioBasis
- Iceland Moth Monitoring



Solutions?

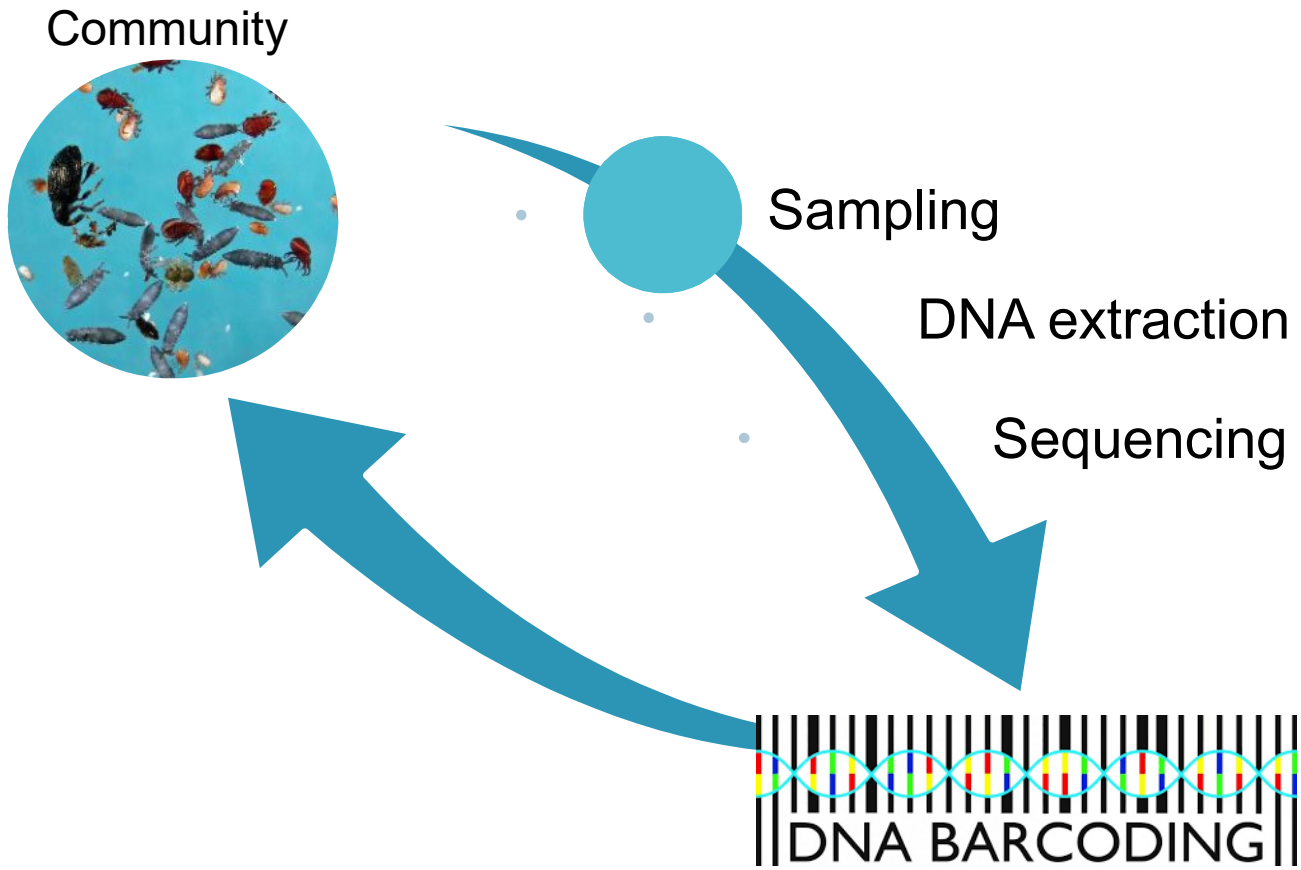
International collaboration & **elevate** importance of invertebrates in Arctic research and environmental assessments

But:-

- Sample collection only part of the problem for ***monitoring***
- resources always likely to be limited.

Can eDNA provide a rapid and cost-effective method for screening large sample sizes?

*e*DNA sequencing for biodiversity monitoring.



eDNA sequencing for biodiversity monitoring.

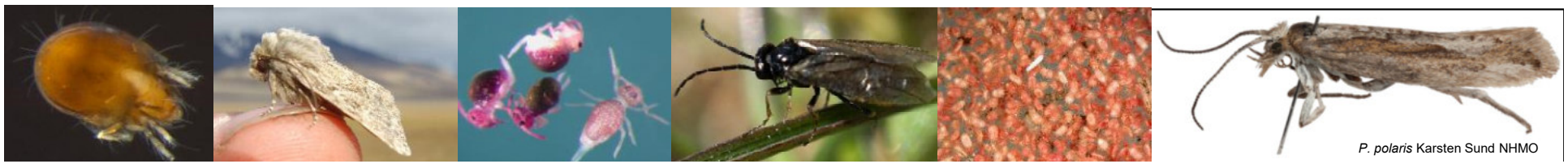
- Environmental sample, *e*DNA

- Preservative sample (trap or flask, *e*DNA?)

*e*DNA sequencing for biodiversity monitoring.

1. PCR / qPCR
   - One or few species,
   - Specific primers/probes,
   - Not ’quantitative’ for *e*DNA.

2. DNA Metabarcoding
   - No amplification,
   - Preferentially extracts high-copy fraction,
   - ’Quantitative’ (biomass).



*e*DNA sequencing for biodiversity monitoring.

1) ***e*DNA**

DNA that is collected from a variety of environmental samples such as soil, seawater, or even air

DNA sequencing for biodiversity assessment.

2) Bulk sample analysis

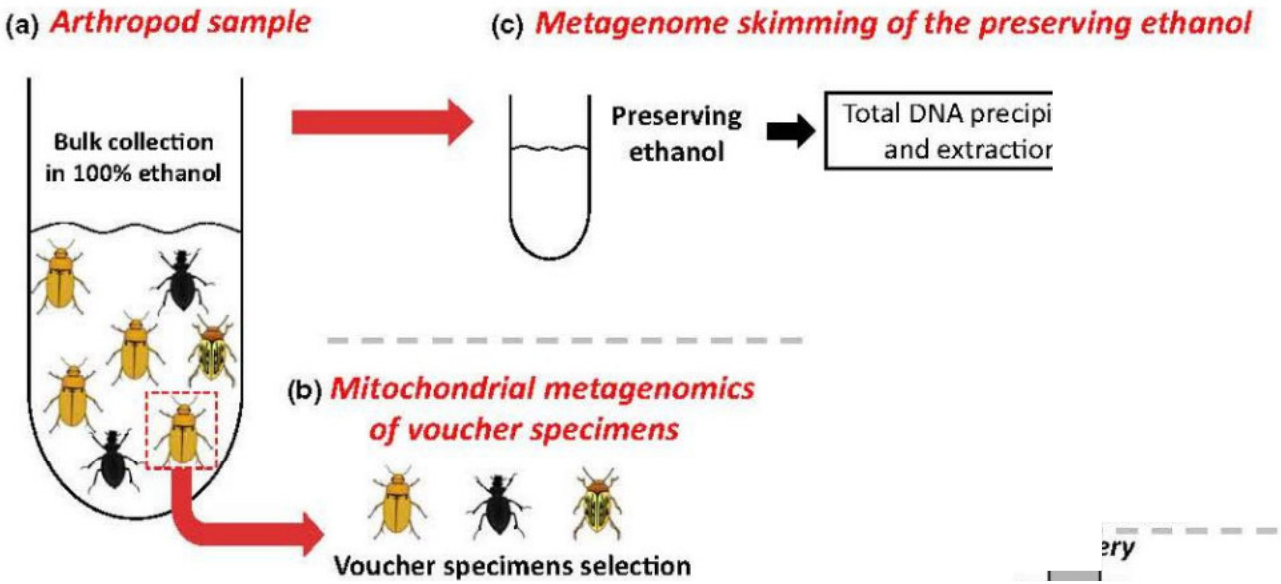
*e*DNA sequencing for biodiversity assessment.

3) Preservation fluid

- Each individual its own ’ecosystem’
- Ethanol samples characterised by > 75% DNA from other groups than the voucher samples i) arthropods, ii) taxa associated with the gut, iii) bacterial symbiots
- Correlation between DNA content and biomass of species
- Dynamics of how DNA transfers to preservation fluid need to be studied
- .

*e*DNA sequencing for biodiversity assessment.

Linard et



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Preservative sampling

- 40% of arthropod species detected
- Ethanol samples characterised by > 75% DNA from other groups than the voucher samples
- Correlation between DNA reads and biomass of species


MOLECULAR ECOLOGY
RESOURCES
Molecular Ecology Resources (2016) 16, 1365–1377 doi: 10.1111/1755-0998.12539

Lessons from genome skimming of arthropod-preserving ethanol

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Linard et al. 2016

*e*DNA sequencing for biodiversity monitoring.

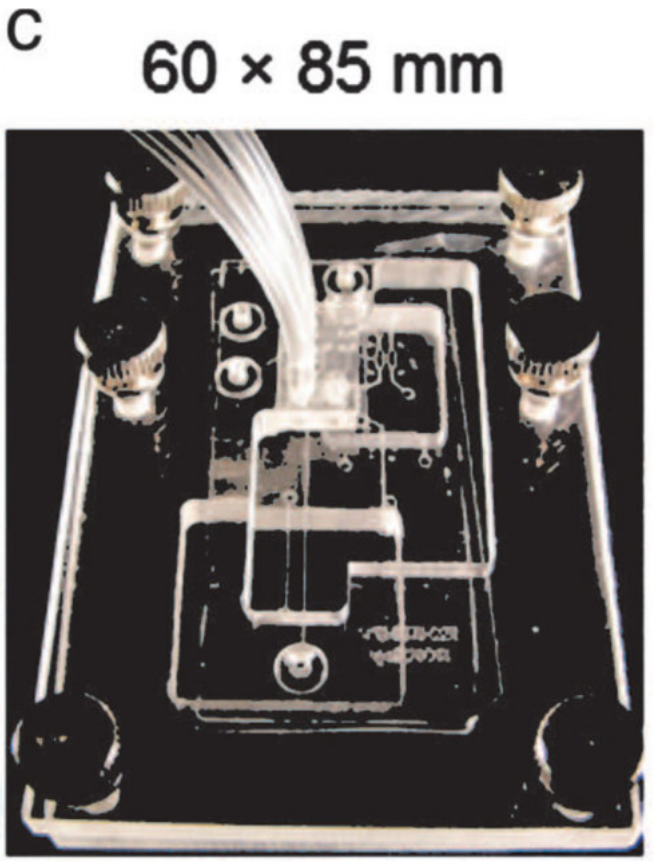
Advantages

- Standardisation,
- Non-invasive / destructive,
- Sample collections,
- Indepence from weather conditions,
- Scaleable,
- Potentially less bias,
- Cost-effectiveness ? Rapidly developing technology. New possibilities and price reductions.

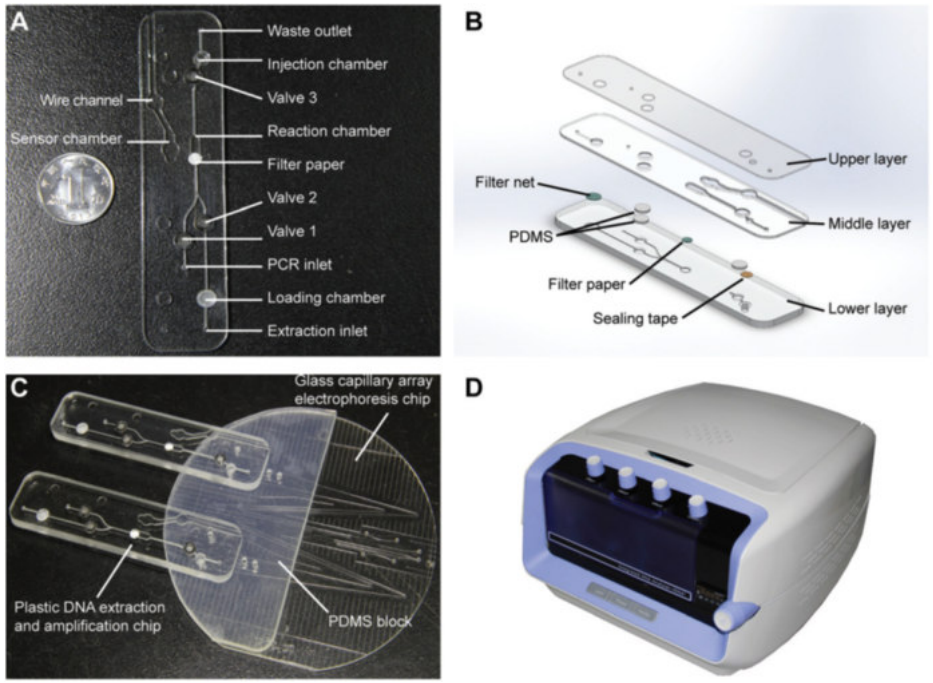
eDNA sequencing for biodiversity monitoring.

Advantages

- Standardisation
- Non-invasive / destructive
- Sensitivity
- Indepence of weather conditions
- Rapid assessment of target taxa
- Scaleable
- Potentially less bias and suitable for auditing by neutral parties.
- Bioinformatics – eg. raw sequence processing, composition-based machine learning. Classify sequences, classify communities
- Vetebrate DNA can occur in traps. Blood? Used to estimate mammalian diversity?
- Cost-effectiveness ? Rapidly developing technology. New possibilities and price reductions



Easley *et al.* 2006 *PNAS*



Han *et al.* 2017 *Analyst*

*e*DNA sequencing for biodiversity monitoring.

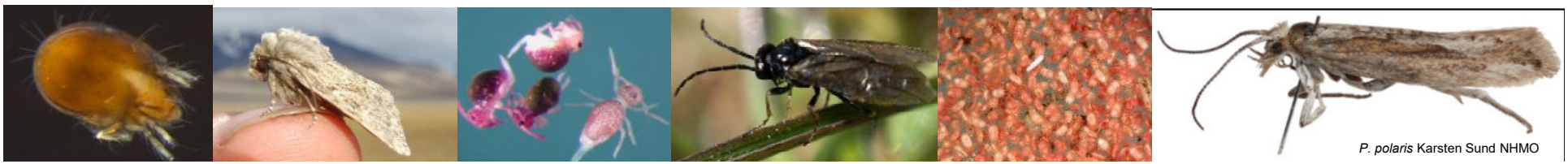
CHALLENGES

Biological

- Can be selective. Not all taxa sequence and amplify equally.
- Limited population information. Age classes? Abundance?

Technique

- New technique
- Extraction, purification, contamination
- DNA reference databases
- Single species detection vs. metabarcoding



DNA sequencing for biodiversity monitoring.

CHALLENGES cont.

- Integration of data types. Sequence data requires metadata in order to be meaningful.
- Growth of reference databases. Requires voucher taxa to be present in GenBank etc
- Hardware improvements
- Coverage estimates lacking. How many reads/sequences required to measure diversity?

SUMMARY

- Invertebrate communities key to many ecological process
- Poor understanding of diversity and tropic links
- Poor understanding of response to environmental drivers
- Coordinated long term monitoring and reporting lacking
- Limited resources hamper monitoring
- Sequencing techniques may provide a ***partial*** answer to monitoring and also open new opportunities