

Effects of climate change on soil animals in the Arctic - population ecological, ecophysiological and ecotoxicological approaches

A Nordic workshop held in Silkeborg, 19-20 November 1999

Workshop synthesis

Following the presentations there was a discussion of the key research issues that were judged to be of both significant scientific value and necessary for qualified political decision making. It was agreed early on that the effects of small temperature increases *per se* were unlikely to be of any significance to the Arctic soil ecosystem. The organisms found in or near the Arctic are characterised by their ability to survive extreme temperature regimes (both high and low). Time was therefore expended on constructing a table of key issues for the Arctic soil ecosystem where little data is available (see below).

Community Interactions		Stress/Tolerance		Invasion/Extinction	
		Natural disturbances		Anthropogenic disturbances	
trophic interactions	life history strategies	desiccation	susceptibility/resilience	climate change	dispersal active/passive
cyano bacteria	physiological time	temperature stress	synergism	chemical stress	genetic diversity
dispersal of fungi/cyano bacteria	time scales	freeze-thaw events	catastrophic events	mining	time scales
functional significance of soil invertebrates	thermal budgets	membrane phase-shifts	critical disturbances	wheel tracks	topography
spatial patterns	respiration				hydrology
	costs of maintenance				water relations

As a result of this discussion, five key issues were identified as being of primary importance for assessment of the vulnerability of Arctic terrestrial ecosystems to global change.

Research priorities within the network

1. Functional significance of terrestrial invertebrates in the Arctic

The main functional significance of soil fauna at low latitudes is regarded to be their impact on decomposition processes, and thereby contribute to the release of plant nutrients (e.g. nitrogen) to the soil. However, in the high Arctic decomposition processes are very slow, and the soil fauna may be more important through their interactions with Cyanobacteria. Cyanobacteria is a characteristic component of primary production in the high Arctic and plays an important role in terrestrial ecosystems through their ability to fixate atmospheric nitrogen that subsequently becomes available for higher plants.

Many high arctic soil invertebrates (like most Collembola) depend to a great extent on Cyanobacteria as food, and there are evidences suggesting that these soil invertebrates may influence production of Cyanobacteria and the release of nitrogen to the soil through grazing. Possibly they may also play an important role in short distance dispersal of Cyanobacteria (within and between habitats). So far we know little about these processes, and the workshop agreed in that these are among the most important interactions we need to focus on for a better understanding of the dynamics and vulnerability of arctic soil systems.

2. Desiccation tolerance and wind dispersal

There was consensus at the meeting that hydrology and water balance are the key selective forces on organisms in the Arctic. Extreme water shortages occur frequently due to the low precipitation during summer and the lack of free water in the frozen winter habitat. There is now evidence that winter survival is better correlated with the ability to tolerate desiccation than the ability to tolerate low temperatures. Similarly, there is a growing body of evidence that the surface hydrology and micro-topography can explain species distributions in the Arctic.

Soil invertebrates are extremely widespread in the Arctic but characterised by such low active dispersal rates that their present distributions since the last glaciation are something of an enigma. Wind dispersal has previously been ruled out due to the high cuticular permeability in many Arctic invertebrate species. The workshop concluded that this wind dispersal should be revisited in the light of new evidence suggesting high desiccation tolerance in combination with high cuticular permeability. An understanding of dispersal mechanisms and abilities is a major factor in assessing potential changes in biodiversity with global change and the vulnerability of Arctic ecosystems.

3. Effects of freeze-thaw events

Small increases in the average temperature in the Arctic may result in an increased annual frequency of freeze-thaw events. It was suggested at the workshop that freeze-thaw events provide an important but little understood constraint in soil invertebrate population dynamics. Examples of this phenomenon already exist in freeze tolerant insects, but the effects of 0°C transitions in the majority of Arctic invertebrates remain uninvestigated.

4. Synergism between climatic and toxic stress

The vast majority of studies of physiological adaptations in invertebrates have concerned themselves with single stress types. The Arctic environment is a sink for a large number of environmental contaminants and there is a growing body of evidence suggesting that tolerance to climatic stress may be decreased by pollution. The ecological implications of this synergism is that pollution in arctic regions may play a much more dramatic role for local extinction and the geographical distributions of species than in more benign climates. Investigation of this type of synergism will be a central element in Arctic risk assessment.

5. Genetic diversity

Terrestrial Arctic ecosystems are characterised by low species diversity in comparison to more benign environments. This has been one of the fundamental elements behind the dogma that Arctic ecosystems are vulnerable to global change. It was suggested at the workshop using examples from the Arctic flora, that intraspecific genetic diversity may be remarkably high compared to lower latitudes. This would result in ecosystem resilience being greater than expected from biodiversity measures. The consensus at the workshop

was that there is a pressing need for studies of genetic diversity in Arctic invertebrate populations.