Meeting report

Biodiversity matters in a changing world

Carole Di Poi^{2,3}, Guillaume Diss^{1,2,3,*}
and Luca Freschi^{1,2,3}

¹PROTEO

²Institut de Biologie Intégrative et des Systèmes (IBIS)

³Département de Biologie, Université Laval, Pavillon Charles-Eugène-Marchand, 1030, Avenue de la Médecine, Québec, Canada G1V 0A6

*Author for correspondence (guillaume.diss.1@ulaval.ca).

All authors equally contributed to this work.

It is now widely accepted that the climate of our planet is changing, but it is still hard to predict the consequences of these changes on ecosystems. The impact is worst at the poles, with scientists concerned that impacts at lower latitudes will follow suit. Canada has a great responsibility and potential for studying the effects of climate changes on the ecological dynamics, given its geographical location and its scientific leadership in this field. The 5th annual meeting of the Canadian Society for Ecology and Evolution was held in the International Year of Biodiversity, to share recent advances in a wide variety of disciplines ranging from molecular biology to behavioural ecology, and to integrate them into a general view that will help us preserve biodiversity and limit the impact of climate change on ecosystems.

Keywords: CSEE; annual meeting; biodiversity; molecular ecology; behavioural ecology; global warming

1. INTRODUCTION

Humanity was already trying to classify the known living species at the time of Aristotle. Two thousand years later, scientists know more about the number of stars in the galaxy than the number of species living on land and in the oceans. Nevertheless, the scientific community is united in its concern that the environmental changes caused by human activity have greatly accelerated losses of biodiversity. In 2002, the governments of the United Nations set 2010 as a deadline to achieve a significant reduction in the rate of loss of biodiversity [1]. We failed! 2010 is a critical year because it is time to reflect about what has been done and what needs to be done to change this trend. It is in this context that the 5th Canadian Society for Ecology and Evolution (CSEE) meeting was held at Université Laval in Quebec City, Canada, from 9 to 12 May 2010. The conference gathered together more than 480 attendees, including 295 students and 194 researchers, who shared advances in life sciences and improved knowledge concerning biodiversity preservation. The main objectives of CSEE are to promote the study of ecology and evolution in Canada and to raise public awareness of the

importance of these disciplines to Canadian Society. Plenary talks and symposia gathered renowned invited speakers, who together provided a broad overview on some of the most pressing issues, and illustrated the role of research in ecology and evolution. The CSEE scientific programme was particularly rich, with more than 283 oral presentations and about 95 posters, which highlighted once again the interdisciplinary work of biologists in life science in Canada.

2. BIODIVERSITY AND GLOBAL WARMING: CONNECTING THE DOTS

(a) *Impacts of a changing climate on northern terrestrial ecosystems*

Global warming is changing the entire biosphere and the pace of this process is fastest in northern biomes. The Arctic is particularly affected: even in this ecosystem, where human activities are quite limited, change is evident [2]. In the first plenary session of the meeting, Douglas Morris (Lakehead University), President of the CSEE, reaffirmed the importance of discussing global warming and showed that it is possible to forecast future habitats of given species by integrating information about the current habitat, the most probable future one and the interactions between species and their habitat.

In a symposium on the impact of global warming on northern terrestrial ecosystems, Robert Bradley (Université de Sherbrooke) and Gregory Henry (University of British Columbia) showed how abiotic changes in soil composition can lead to modifications in microbial, animal and plant communities, and potentially alter the flows of exchange between the biosphere and atmosphere. This phenomenon has been observed in particular in the tundra biome. In Alaska, in the past 30 years temperatures have warmed by 0.5°C per decade, causing a progressive melting of the permafrost layer that characterizes the soil of this zone. This melting has many consequences, including range expansions of particular plant species (e.g. shrubs) [3] and altered dynamics of trace gas exchange between the biosphere and atmosphere [4].

A perturbation in a given trophic level usually affects, directly or indirectly, other trophic levels. Consequences include alterations in habitat use, migration patterns, demography and foraging or predation. As an example, Steeve Côté (Université Laval) described the effect of climate change on the seasonal distribution of two herds of migratory caribou [5]. According to their projections, in 50 years the seasonal and spatial distribution of these two herds will be dramatically altered. David Hik (University of Alberta) presented results on the population dynamics of two small northern alpine herbivores (*Marmota caligata* and *Ochotona collaris*) and described the current difficulties in making precise predictions about the dynamics of herbivores. More information about the interactions between species, habitat and trophic levels are required to make better predictions. Dominique Berteaux (Université du Québec à Rimouski) showed how the structure of the communities of Arctic predators is rapidly changing. Snow and ice strongly influence predator ecology through effects on prey availability. These effects can be idiosyncratic: for example, the population of

Arctic foxes (*Alopex lagopus*) is declining, whereas the population of red foxes (*Vulpes vulpes*) is expanding.

All these presentations confirm the importance of feedback between the species occupying an environment and the environment itself, which is still incompletely understood. A deeper knowledge of these interactions is required in order to estimate the consequences of global warming at ecosystem levels and make precise predictions of future biodiversity.

(b) *Marine ecosystems in a changing world*

Oceans regulate the weather and climate, generate most of the oxygen on the planet, feed the growing human population and provide important natural resources. On the other hand, climate change and human activities have been putting increasing pressure on marine environments, causing major changes in all marine ecosystems. Some of these perturbations have translated into dramatic consequences, threatening future extraction of marine resources and the long-term viability of marine biodiversity. In a symposium on marine ecosystems in a changing world, Tom Webb (University of Sheffield) and Paul Snelgrove (Memorial University) agreed that our current knowledge of marine biodiversity is uneven: we know much more about big species than small species. Along the same vein, the upper 200 m of the pelagic oceanic environments are well studied, whereas the deep ocean is fairly alien. One very interesting example was described by Steven Campana (Bedford Institute of Oceanography). Despite considerable knowledge of the biology of porbeagle sharks *Lamna nasus*, their distribution and birthing grounds are only now starting to be identified [6]. The placement of such a key life-history stage in largely unregulated waters poses problems for the conservation and management of shark species, which are commercially fished in Canadian and international waters.

Understanding the functional roles of different taxa, ecosystems and processes occurring across a broad range of spatial scales is crucial for the improvement of marine conservation. Through the historical cases of killer whales and Pacific salmon or grey seals and Atlantic cod, Mike Hammill (Fisheries and Oceans Canada) presented examples of how the macroecological approach could be put into practice by adopting an ecosystem management approach instead of considering species management [7]. Although the ecosystem approach promotes a more simplistic and holistic process for conserving listed species, this approach must still attend to the management and monitoring requirements of key species in the ecosystem, in order to ensure that it maintains the integrity of its constituent species.

A dramatic example of marine ecosystem change is observed in the Arctic region. As Louis Fortier (Université Laval) reported, the Arctic regions warm faster than other Northern Hemisphere regions, and ice pack is melting faster than expected by most pessimistic models. Arctic ecosystems are changing as Arctic hyper-specialist species, such as the emblematic polar bear and other species that hunt among the ice floes, are likely to be replaced by boreal generalist species,

which already surround them. Among the environmental impacts, the Arctic marine ecosystem provides services to native communities and fisheries that are or will be severely affected by a shift in sea-ice regime.

Finally, in the third plenary session of the meeting, Paul Falkowski (Rutgers University) talked about biogeochemical cycles, pointing out the role of marine organisms in molecular oxygen production. Production and consumption are in dynamic equilibrium, and organic matter sequestration into sediments by plate tectonics has shifted this equilibrium towards the production of free molecular oxygen. Its increased level was responsible for great transitions in Earth evolutionary history (e.g. appearance of eukaryotes, mammals, etc.), but nowadays we are shifting this equilibrium in the opposite direction by extracting and consuming organic matter.

(c) *Biodiversity: a molecular perspective*

Advancements in molecular evolution provide the opportunity to survey deeply and accurately the history and the relationships between different evolutionary lineages. Combined with ecology, it is possible to understand the fundamental molecular bases of phenotypic diversity between and within species, and maybe one day we will be able to integrate all this knowledge to better understand the evolutionary history of whole ecosystems and eventually to predict their modifications.

During the second plenary session, Belinda Chang (University of Toronto) clearly illustrated the importance of molecular evolution tools for ecological studies. Notably, she explained how, using bioinformatics methods, she reconstructed the ancestral sequence of an archosaur visual pigment. This approach was validated by expressing this pigment in mammalian cells and performing functional studies [8]. From a more ecological point of view, she showed that guppies *Poecilia reticulata* express a variable set of visual pigments that allow them to see a broad range of colours, a trait that can be important for their behavioural ecology [9].

The threespine stickleback *Gasterosteus aculeatus* is an emerging model system for molecular and evolutionary ecology. Rowan Barrett (University of British Columbia) used this model to show that the gene Ectodysplasin, largely responsible for variation in the number of bony lateral plates on this fish, evolves rapidly in novel habitats. He reared two groups of stickleback with the same allele frequencies in two different environments (freshwater and saltwater) and showed that two alleles are differentially favoured in the two environments, providing a remarkable example of a gene under environment-specific pleiotropic effects: alleles at this locus affect both adaptive morphological and behavioural traits [10,11].

These presentations, among many others, demonstrated once again the importance of studies at the molecular level to answer fundamental questions relevant to ecology and evolution.

3. CONCLUSIONS

The 5th CSEE meeting was an excellent occasion to take stock of some of the most challenging problems

facing ecology and evolution, and to propose new ideas and objectives for the future. In northern biomes, the data show a northward and altitudinal expansion of many species, which is a major threat for the biodiversity of these zones. A key goal in this field is to make accurate predictions about the effects of global warming at the ecosystem level. To accomplish this objective requires a multi-disciplinary approach. Each ecosystem is characterized by a network of relationships that goes beyond the classical ecological networks and includes the abiotic world. By understanding the most important parts of these networks, we can more effectively target conservation efforts to preserve the biodiversity of a given ecosystem.

According to projections, in the near future the oceans will be more exploited by humans, more subject to environmental and biological changes, and there will be more ocean conflicts about unresolved boundaries and fewer living resources. The optimistic view is that we will have more information, more transparency and better planning.

The authors gratefully acknowledge Nadia Aubin-Horth, Christian Landry, Sarah P. Otto, Louis Bernatchez and François-Christophe Marois-Blanchet for their advice on this meeting report. Many thanks to all the volunteers, students and researchers from Université Laval for organizing this wonderful 5th CSEE meeting in the 400-year-old Quebec city.

- 1 UNEP. 2002 Report on the sixth meeting of the Conference of the Parties to the Convention on Biological Diversity (UNEP/CBD/COP/6/20/Part 2) Strategic Plan Decision VI/26 (CBD, 2002). See www.biodiv.org/doc/meetings/cop/cop-06/official/cop-06-20-part2-en.pdf.
- 2 Post, E. *et al.* 2009 Ecological dynamics across the Arctic associated with recent climate change. *Science* **325**, 1355–1358. (doi:10.1126/science.1173113)
- 3 Sturm, M., Schimel, J., Michaelson, G., Welker, J. M., Oberbauer, S. F., Liston, G. E., Fahnestock, J. & Romanovsky, V. E. 2005 Winter biological processes could help convert Arctic tundra to shrubland. *BioScience* **55**, 17–26. (doi:10.1641/0006-3568(2005)055[0017:WBPCHC]2.0.CO;2)
- 4 Repo, M. E., Susiluoto, S., Lind, S. E., Jokinen, S., Elsakov, V., Biasi, C., Virtanen, T. & Martikainen, P. J. 2009 Large N₂O emissions from cryoturbated peat soil in tundra. *Nat. Geosci.* **2**, 189–192. (doi:10.1038/ngeo434)
- 5 Sharma, S., Couturier, S. & Côté, S. D. 2009 Impacts of climate change on the seasonal distribution of migratory caribou. *Glob. Change Biol.* **15**, 2549–2562. (doi:10.1111/j.1365-2486.2009.01945.x)
- 6 Campana, S. E., Joyce, W. & Fowler, M. 2010 Sub-tropical pupping ground for a cold-water shark. *Can. J. Fish. Aquat. Sci.* **67**, 769–773. (doi:10.1139/F10-020)
- 7 Bundy, A., Heymans, J. J., Morissette, L. & Savenkoff, C. 2009 Seals, cod and forage fish: a comparative exploration of variations in the theme of stock collapse and ecosystem change in four Northwest Atlantic ecosystems. *Prog. Oceanogr.* **81**, 188–206. (doi:10.1016/j.pocean.2009.04.010)
- 8 Chang, B. S., Jönsson, K., Kazmi, M. A., Donoghue, M. J. & Sakmar, T. P. 2002 Recreating a functional ancestral archosaur visual pigment. *Mol. Biol. Evol.* **19**, 1483–1489.
- 9 Weadick, C. J. & Chang, B. S. W. 2007 Long-wavelength sensitive visual pigments of the guppy (*Poecilia reticulata*): six opsins expressed in a single individual. *BMC Evol. Biol.* **7**(Suppl. 1), S11. (doi:10.1186/1471-2148-7-S1-S11)
- 10 Barrett, R. D. H., Rogers, S. M. & Schluter, D. 2009 Environment specific pleiotropy facilitates divergence at the Ectodysplasin locus in threespine stickleback. *Evolution* **63**, 2831–2837. (doi:10.1111/j.1558-5646.2009.00762.x)
- 11 Barrett, R. D. H., Vines, T. H., Bystriansky, J. S. & Schulte, P. M. 2009 Should I stay or should I go? The Ectodysplasin locus is associated with behavioural differences in threespine stickleback. *Biol. Lett.* **5**, 788–791. (doi:10.1098/rsbl.2009.0416)