

Ecological and evolutionary processes and patterns shaping biological diversity

MASTS Visiting Fellowship – Final Report

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Summary

From 23 September 2012 until 21 May 2013 Skúli Skúlason, professor at Hólar University College, Iceland, was a funded MASTS Visiting Fellow (VF) based in the Centre for Biological Diversity (CBD) and Scottish Oceans Institute (SOI) in the School of Biology at the University of St Andrews. During this time the VF studied the ecology and evolution of aquatic biological diversity and speciation with a focus on conservation and management of fish and aquatic systems. This work included literature survey and writing of manuscripts for submission to peer-reviewed journals. The VF interacted with MASTS related individuals and institutions and in collaboration with them organized a three day international workshop, with 33 participants from 10 countries, focusing on the diversity of northern freshwater fishes. Workshop participants decided e.g. to construct a comprehensive research consortium on this topic and seek funding from national and international sources (including the EU). The VF also conducted a rearing experiment studying the importance of egg size for phenotypic diversity in zebrafish (*Danio rerio*). In conclusion, during this time new research initiatives were developed, existing and new research ties were strengthened and future collaborative plans made in the spirit of the goals of MASTS.

Introduction

For the period 23 September 2012 until 21 May 2013 I was a MASTS Visiting Fellow based in the Centre for Biological Diversity (CBD) and the Scottish Oceans Institute (SOI) in the School of Biology at the University of St Andrews. The stay was made possible with a £18,500 Visiting Fellowship from Marine Alliance for Science and Technology for Scotland. My host at St Andrews was Professor Anne E. Magurran.

I am a professor in the Department of Aquaculture and Fish Biology at Hólar University College in Iceland and my research emphasizes evolution of diversity with focus on aquatic systems, in particular the fishes Arctic charr (*Salvelinus alpinus*) and threespine stickleback (*Gasterosteus aculeatus*). I was on research sabbatical leave during my stay in Scotland. I - along with my Icelandic colleagues - have had long term collaboration with faculty at the School of Biology at University of St Andrew, in particular Professor Anne E. Magurran at CBD and Professor Ian Johnston at the Scottish Ocean Institute (SOI), and more recently with Dr. Michael Morrissey at CBD. Furthermore, we have collaborated closely with Professors Colin Adams and Kevin Parsons at the University of Glasgow and Dr. Daniel MacQueen at the University of Aberdeen. Thus, Scotland and the University of St Andrew was ideal place for me to spend a sabbatical visiting MASTS colleagues.

Following is a report listing activities and achievements during my stay as a Visiting Fellow.

Objective for the proposed research and activities

In my original application for the Visiting Fellowship, where the proposed research and activities were articulated, it was stated that: *"The primary objective of the study is to explore pattern- and process approach in studies on the evolution of biological diversity and speciation and to consider the implication of the interplay of ecology and evolution for our understanding, conservation and management of biological diversity with a focus on fish and aquatic ecosystems."* It was also stated that: *"These aspects are directly connected with research themes of MASTS, especially on marine biodiversity, resilience, function and services. The collaboration and involvement of University of St Andrews and MAST is thus highly relevant, especially the fact that the primary collaborator, Dr. Anne Magurran, is an authority in studies of biological diversity. The new knowledge provided by this research should be a significant contribution to University of St Andrews and MASTS. The association of the research with other past and ongoing research collaboration in this area with MASTS faculty underlines the proposed contribution."*

This basic objective was followed throughout my stay and the association with MASTS was crucial for the success of this project.

Activities and achievements

At the University of St Andrews I was located in the Sir Harold Mitchell / Dyers Bray Building where I was provided with excellent office facilities. Regular support service was provided by CBD and SOI.

Activities covered several aspects, the primary being: Literature gathering, planning and writing of manuscripts; preparation and execution of workshop in February; visits and networking in St Andrews and within Scotland; and a rearing experiment involving zebrafish (*Danio rerio*) at the Scottish Ocean Institute.

Reading, writing and presentations

Throughout the period, and especially during the autumn months of 2012, I collected and read a number of recent publications on the ecology and evolution of diversity. This included a special effort regarding recent papers on fish diversity. This effort was used among other things to formulate and later outline a review manuscript with the working-title '*Understanding the nature and evolution of biological diversity: Lessons from Northern Freshwater Fishes*', which also represents one of the outcomes of the workshop that was conducted on February 25-27 2013 (see below). I gave a lecture on October 30 2012 in the seminar series of CBD with the title: '*The evolution of diversity: interplay of ecology, genetics and development*', and on April 26 2013 I gave another talk for a discussion group at CBD with the title: '*Thoughts on process and integration in studies of divergent*

evolution'. The latter presentation forms the basis of a manuscript that I am working on. April 19 2013 I gave an invited seminar of my research at the University of Nottingham.

Networking

During the stay I made an effort to network and develop new relations and collaboration. The most organized outcome of this was the workshop in February (see below), but networking also involved visits with other MASTS institutions and participation in MASTS related activities. For example, I participated in a MASTS orientation meeting at University of Stirling on November 1 2012 October and visited the The Scottish Centre for Ecology and the Natural Environment at University of Glasgow, hosted by Professor Colin Adams, which is located at Loch Lomond on October 24-28 2012. Throughout the stay I interacted actively with St Andrews faculty, post-docs, associated academics and graduate students which was highly rewarding for me and in several cases created longer term relations. I participated in academic activities, e.g. attended talks at seminar series and discussion groups, and participated in the Graduate Student Conference at the School of Biology in March 2013. Furthermore, I was external examiner in one PhD viva at the University of St Andrews on November 23 2012 and another at the University of Glasgow January 23 2013.

Workshop

The highlight and most laborious part of my stay was a MASTS workshop organized and run in collaboration with Professor Anne Magurran. The title of the workshop was '*Patterns and Processes of Intraspecific Divergence and their Relevance to Aquatic Biological Diversity*'. The workshop was held on February 25-27 in the Senate room at the University of St Andrews and was collaboration among the Centre for Biological Diversity/Scottish Oceans Institute at University of St Andrews and Hólar University College, Iceland. The workshop brought together 33 biologists from Scotland, Finland, Iceland, Norway, Sweden, Switzerland, Canada, USA, England and Wales. The Scottish participants came from several MASTS institutions, Universities of St. Andrews, Glasgow and Aberdeen as well as Scottish Natural Heritage and Marine Scotland.

The organization of the workshop was greatly facilitated by MASTS people and support staff of the University of St Andrews, especially the offices of CBD and SOI.

The objectives of the workshop were to:

1. Overview studies on the ecology and evolution of Northern freshwater fishes and identify relevant future research with a focus on the questions that this system is particularly well-placed to address;
2. connect these findings with the general understanding of ecology and evolution of biological diversity, with a focus on aquatic systems;

3. highlight the relevance of intraspecific diversity for management and conservation strategies, e.g. related to fisheries, aquaculture, invasive species and climate change;
4. promote international research collaboration between scientists with the aim of writing application(s) for funding, e.g. from EU framework programs.

The organization of the workshop involved prior interaction with all participants which e.g. contributed written points on several workshop themes. This was done to facilitate organized discussion groups during the workshop, and it significantly elevated its quality and outcome.



Workshop participants outside St Mary's College University of St Andrews

In short, the workshop overviewed, in presentations and discussion groups, the impressive within and among species diversity of Northern freshwater fishes and articulated relevant and challenging research questions. Future collaboration and funding opportunities were identified, involving a range of projects including comparative studies of fish communities over large geographical areas of the North. It is believed that better understanding of the ecology and rapid evolution of diversity in Northern freshwater fish will significantly advance our understanding of the nature of biological diversity at large and aid management and conservation strategies in the face of major environmental threats to biodiversity, such as climate change.

The program and list of participants is attached to this report, but further details regarding the workshop can be found on its homepage: <http://www.st-andrews.ac.uk/biotime/program.php>

The spirit in the workshop was very good and participants were highly motivated and eager to maintain connections and develop future research projects. The following items were agreed: Firstly, to consider that this group would become a future consortium/network that would meet

regularly to work on these aspects. Secondly, that a review paper based on the results from the workshop would be published in a peer-reviewed journal, and that other connected publications should be considered. Thirdly, that we would jointly apply for support from the upcoming Horizon 2020 research framework of the European Union, as well as considering other funding opportunities both at national and international levels. I offered to lead these efforts. Thus, after the workshop I spent much time interacting with participants to guarantee that these decisions would become materialized. This task will naturally be a significant part of my academic effort for the next years and my employer Hólar University College supports this. At the end of my stay in St Andrews an outline and a working plan for the respective review paper was completed; an edited volume with publications was being considered; we had made progress to create a joint database for the several fish species involved in this project (e.g. to facilitate meta-analyses) and first steps had been made to organize the group with regard to development and facilitation of work-packages in an EU-application.

In addition to support through my Visiting Fellowship, MASTS supported the workshop additionally with £1.000 funding from its Small Grants Scheme.



The workshop took place in the Senate room of the University of St Andrews

Experiment

In relation to the collaboration with Professor Ian Johnston and Dr. Vera Vieira Johnston I conducted a rearing experiment with zebrafish (*Danio rerio*) at the Scottish Ocean Institute. The

objective of this experiment was to test the hypothesis that embryos developing in small eggs will develop critical skeletal structures more rapidly than embryos from large eggs. Thus, in Dr. Johnston's laboratory two breeding lines of small *versus* large zebrafish, differing accordingly in egg size, had been developed and were used for this research. The rearing part of the work, including sampling of embryos from fertilization until after first exogenous feeding, was successfully completed in April – May 2013. Staining for cartilage and bone will be done later this year and results published in a peer-reviewed journal in 2014.

Future prospects

During my stay in St Andrews the respective scientific relations in Scotland were significantly strengthened and new connections were born. It is clear that the future will foster increased collaboration between Scottish and Icelandic scientists in this area. This will consist of new research projects and joint research applications, involving also the Nordic countries and other international partners, in relation to ongoing activities after the workshop in February 2013. Thus, the activities initiated during my stay will continue.

Support of MASTS to Visiting Fellow

In addition to the financial support through the Visiting Fellowship (£18.500) and Small Grants Scheme (£1.000) I received constant support from MASTS office staff. They were ready to meet and discuss things at any time which was very helpful. Furthermore, they advised me and made helpful suggestions throughout my sabbatical.

In the beginning of my stay it was somewhat unclear how my fellowship would be processed, in terms of how to charge costs etc. This is not unexpected considering that Visiting Fellows are usually foreign and are not familiar with the system and traditions in Scotland. This was later clarified and things went smoothly. I suggest that in the future MASTS Visiting Fellows should be well informed in the beginning of their stay regarding how to deal with these matters.

Concluding remarks

For me, the stay in St Andrews and Scotland was extremely productive and in every way welcoming and pleasant. The same applies to my wife, Sólrún Harðardóttir, but during this period she worked as a volunteer at the St Andrews Botanic Garden, which was facilitated by Professor Thomas Meagher at CBD, and was involved in various other activities. My sabbatical from Hólar University College followed my 13 year period as rector (principal) of the institution and this was an important opportunity for me to organize and substantiate my academic activities as a returning

full time professor, foster ongoing relations and develop new collaboration. The environment at the University of St Andrews and the surrounding community was perfect for this.

It is my hope that my work was a useful contribution to the objectives of MASTS and that resulting future activities will also support MASTS and the University of St Andrews. I was impressed with the objectives and operation of MASTS and I have already presented this as a partnership model that the respective Icelandic institutions should strongly consider.

Acknowledgements

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I thank Professor Ian Johnston and Dr. Vera Vieira Johnston very much for their involvement, help and support during my stay.

I thank faculty, post-docs, graduate students and associated academics in St Andrews that I interacted with for providing inviting academic environment and stimulating interactions.

I thank the support staff at CBD and SOI for their great help throughout my stay, and with the organization and execution of the workshop, especially Faye Moyes, Lianne Baker, Harry Hodge, Jane Williamson and Paula Whiscombe.