The Swedish and Norwegian Taxonomy Initiatives

– collaborating to survey and describe the biodiversity

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Cover photo: *Omalus puncticollis.*
Photo: Alexander Berg (CC BY 4.0)

Photo: Christopher Reisborg

Two gargantuan interconnected projects are presently being undertaken in the Nordic neighbouring countries of Norway and Sweden. Hundreds of researchers and surveyers crisscross bogs and heathlands, dense forests and agricultural land, high mountains and deep seas. In museum collections and universities in both countries, organisms are identified, described and DNA sequenced, species by species, group by group.

The two Nordic countries are collaborating to survey and describe the biodiversity that forms the basis of our ecosystems. The work of Linnaeus, Artedi and Sars is to be completed. Which neighbouring country will join next?

Here we'll give a short presentation of The Swedish and Norwegian Taxonomy Initiatives, with emphasis on the strong collaboration between these.

The Swedish and Norwegian Taxonomy Initiatives – two unique projects in the World

Photo: Johan Södercrantz

In both Sweden and Norway, scientists are working hard to survey the diversity of multicellular animals, plants and fungi. No other countries in the World have explicitly set the goal to explore their entire biodiversity. These studies have been enormously successful: c. 3,000 species new to Sweden and c. 2,400 new to Norway have been found so far, including c. 1,800 species new to science!

In 2002, the Swedish Species Information Centre at the Swedish University of Agricultural Sciences (SLU) was commissioned by the Government of Sweden to initiate the Swedish Taxonomy Initiative. The aim of this initiative was to identify and describe all Swedish multicellular organisms. These would be studied through surveys and taxonomic research, and the biological museum collections would be given extra support. The results were to be disseminated through scientific and popular science publications.

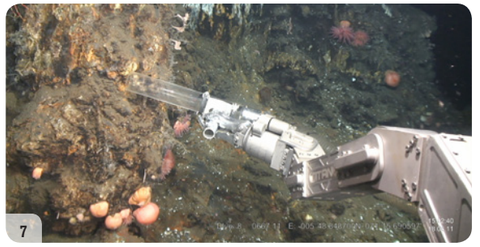
Seven years later, in 2009, the Norwegian Biodiversity Information Centre was given the task by the Norwegian government to initiate the Norwegian Taxonomy Initiative. The goal was to improve the knowledge about the Norwegian biodiversity with special emphasis on poorly known species. Special funds were allocated to surveys of species. Moreover, a research school of biosystematics was founded to increase taxonomic expertise.

The Swedish and Norwegian taxonomy initiatives have been collaborating extensively as the two neighbouring countries share much of their biodiversity. A cooperation agreement was signed during the inaugural ceremony when the crossborder national park Kosterhavet/Ytre Hvaler was established in 2009.

The collaboration between the two taxonomy initiatives is manifested through coordinated support of taxonomic research on, and surveys of, poorly known groups of organisms that occur in both countries. In many cases, Swedish researchers have carried out work in Norway and vice versa, and joint surveys have also been undertaken. Taxonomic experts from both countries have contributed to the other country's taxonomic databases, as well as assisted in evaluation of research grant applications. Both countries' taxonomy initiatives have representatives in the other's advisory committee.

Species are vitally important

The biodiversity is the foundation for our existence. Mankind could not survive without the ecosystem services provided by this diversity. As the biodiversity consists



of species, expert knowledge about the different species is of crucial importance to society. In order to understand nature, we need to be able to identify different species and, for communication purposes, these species need to have unique names (taxonomy). We also need knowledge about how different species are related to each other (systematics/phylogeny). Taxonomic/systematic knowledge is also a prerequisite for other research on organisms (e.g. on ecology and physiology), as well as for conservation purposes. Last, but not least, a thorough knowledge about species is required to meet international commitments to protect species and their habitats.

At the starting points of the taxonomy initiatives, many groups of organisms were so poorly known that they could not be adequately studied with respect to their ecology, conservation and potential ecosystem services. The situation is much better today, although very much remains to be done, and many species are likely to go extinct even before we become aware of their existence.

A knowledge explosion

Since the taxonomy initiatives began, c. 3,000 species new to Sweden and c. 2,400 new to Norway have been found. Of these, c. 1,800 were previously totally unknown to science. Approximately 80% of the new species are insects and other terrestrial and aquatic invertebrates and c. 20% are algae, mosses and "fungi" (including lichens).

A large proportion of the new insects have been discovered within the Swedish Malaise Trap Project which is partly financed through the Swedish Taxonomy Initiative. During a three-year period, c. 80 million insects were collected in 75 Malaise traps throughout Sweden. This material now constitutes the World's largest collection of insects, which has so far been studied by 125 researchers in 24 countries. Among the many new species to science there is a gall midge which has been named *Aprionus victoriae* in honour of HRH Crown Princess Victoria of Sweden who is the Patron of the Swedish Taxonomy Initiative. The same researcher who described this species has named a new genus of gall midges after the Swedish Taxonomy Initiative: *Svenartia*.

Within the Norwegian Taxonomy Initiative, surveys of a wide spectrum of poorly known species groups have been undertaken – from low to high elevations, in forests, streams, lakes and along the sea coasts, as well as at great depths in the ocean. The taxonomy initiative has led to a strong rejuvenation of Norwegian academic environments in the field of biosystematics. As a result, the knowledge of which species occur in Norway, their geographical distributions, as well as their habitat requirements have been much improved. This is crucial for a knowledge based management, and forms an important basis for Red List assessments. University museums have obtained reference collections of high standard, some comprising unique collections for certain taxa.

National and international collaborations have been crucial for the taxonomy initiatives. Researchers, students, museum staff and in many cases also amateurs have found a common arena for the exchange of knowledge and build-up of taxonomic competence.

1. Norwegian and Swedish researchers and students on a moss excursion in the Jotunheimen mountains. Photo: Torbjørn Høitomt (CC BY 4.0).

2. Collecting of sponges from the Arctic Schultz massif in the Greenland Sea. Photo: Hans Tore Rapp (CC BY 4.0).

3. Transfer of competence between Norwegian and Swedish lichenologists in Finnmark. Photo: Mika Bendiksby (CC BY 4.0).

4. Swedish expert collecting soil samples to survey the Norwegian earthworm species diversity. Photo: Endre Willassen (CC BY 4.0).

5. *Blasia pusilla* is a liverworth, which is one of the large groups of plants that is being studied. Photo: Kristian Hassel (CC BY 4.0).

6. Survery of fungus gnats in decidious forest in northeastern Norway. Photo: Yudai Okuyama (CC BY 4.0).

7. Collecting of sponges using ROV with a suction pump at hot underwater thermals in the Norwegian Sea. Photo: Hans Tore Rapp (CC BY 4.0).

8. *Cortinarius bayeri* was recently found in Norway, growing on sandy ground in pine forest. Photo: Tobias Frøslev (CC BY 4.0).

Sphagnum palustre. Photo: Tomas Hallingbäck

Carbon storage moss

Mosses have existed on the Earth for some 475 million years. They are small plants with a simple body form, which favour wet environments, such as bogs, mires and dense forests. Peat mosses are of fundamental importance for the carbon balance on Earth as they create extensive peatlands which hold a large proportion of the Earth's carbon deposits. In Sweden and Norway there are in total c. 1,200 species of mosses, which exceeds the number in most other regions of Europe. The different species vary extensively in size, shape and colour, and it takes considerable effort to become an identification expert. Through joint efforts we have produced richly illustrated books and digital identification keys which have contributed to stimulating an interest in,
and knowledge of, mosses.

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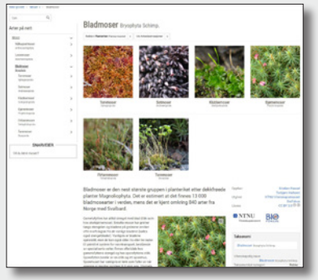

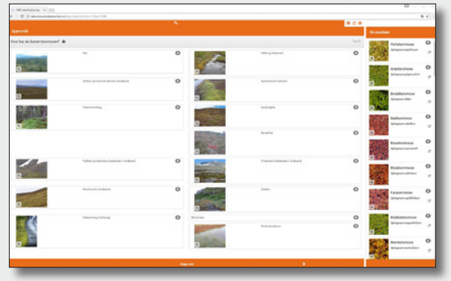

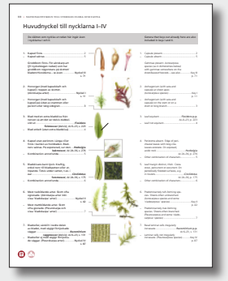

Chaetozone sp. Photo: Arne Nygren (CC BY-SA 4.0)

Indicators of environmental health

Annelids (segmented worms) comprise two main groups: clitellates and polychaetes. The former occur mainly in terrestrial environments and in freshwater, whereas the latter are chiefly marine. Species from both groups provide important ecosystem services, and many are used as indicators of environmental health. Decreasing numbers of such environmental indicator species might warn of ecosystem changes, for example due to pollution. The use of annelids in environmental monitoring requires both knowledge of how to identify different species and their distribution. Through joint efforts, Sweden and Norway have investigated the annelid diversity and also elucidated phylogenetic relationships. Analyses of DNA data have revealed that the number of species is much greater than previously assumed. For example, several "well known" species have been shown to consist of complexes of species with similar appearances.

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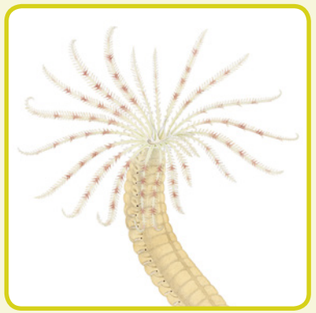


Polychaete in family Sabellidae.
Illustration: Helena Samuelsson

INTERVIEW WITH A RESEARCHER:

Ellen Larsson

What is your background, and what are you working with?

– I am an Associate Professor of Systematics and biodiversity at Gothenburg University, employed as Director of Fungi, and responsible for the mycological collections at Herbarium GB.

Which group of organisms are you studying?

– My research concerns systematics and diversity of basidiomycetes. My favorite genera are *Inocybe* and *Hygrophorus*.

What has your research resulted in?

– In recent years, I have had the chance to carry out fieldwork in Arctic and alpine areas, where we have found many species new to the Nordic countries, including several species new to science. When I started studying *Inocybe*, approximately 90 species were known from the Nordic countries. Today, 232 species are known plus an additional 25 that still are without proper names.

How are your results disseminated?

– The results from my studies are mainly published in scientific journals, but also in popular science magazines in order to reach out to Nordic amateur mycologists. I also frequently give talks to mycological societies and at conferences to inform about new research and species of particular interest.

Apart from curating the herbarium collection and carrying out research, I try to establish and keep up contacts with skilled amateur mycologists in order to document and learn from their taxonomic knowledge, and to make sure that their private collections will be preserved for the future. These collaborations are very valuable and stimulating.

What is the relevance of the Swedish Taxonomy Initiative?

– The financial support from the Swedish Taxonomy Initiative (STI) has been of fundamental importance for my career as a mycologist. The STI has also provided me and other colleagues who study poorly known groups of species an invaluable platform and network for exchange of ideas. I am currently advising one PhD student who is studying a complex and conspicuous group of corticioid fungi that form mycorrhizal symbiosis with trees and shrubs in virtually all plant ecosystems. This PhD position is largely financed through the STI. It is very rewarding to get an opportunity to help educating the next generation of researchers in systematics. They are much needed for the continued efforts to document and protect the biodiversity.

Ellen Larsson in Sårjåsjaure, Padjelanta. Photo: Gro Gulden.

Inocybe leiocephala. Photo: Ellen Larsson.

INTERVIEW WITH A RESEARCHER:

Aino Hosia

What is your background, and what are you working with?

I have a PhD in marine biology, and I am presently employed as a researcher and coordinator for ForBio, the Research School in Biosystematics at the University Museum of Bergen.

Which group of organisms are you studying?

– I am mainly interested in cnidarians (Cnidaria) and ctenophores (Ctenophora), and through the Norwegian Taxonomy Initiative (NTI) I am currently studying pelagic hydrozoans (Hydrozoa) in Norwegian waters.

What has your research resulted in?

– During the course of this project, we have observed and collected many interesting hydrozoans, including several species not previously found in Norway. We are in the process of creating a database with "DNA barcodes" that can be used for e.g. species identification. In combination with morphological data, these genetic data have been important for establishing which species occur in Norway. These studies have discovered that some species are actually two or more species with very similar appearances, so-called "cryptic species". Conversely, we have revealed cases where morphological variants within single species have previously been misclassified as different species.

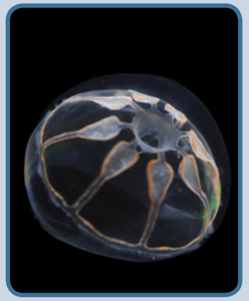
Many hydrozoans have a lifecycle comprising both a pelagic and a sessile stage (medusae and hydroids, respectively). Traditionally, the different life stages have been studied by different groups of researchers. This has resulted in the classification of different life stages of the same species as different species. Moreover, it has often been unclear which medusae and hydroids are of the same species. DNA data have been instrumental in sorting this out.

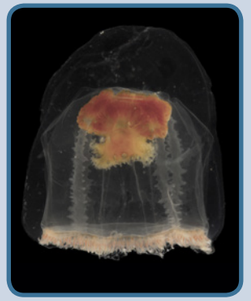
How are your results disseminated?

– Our results are published in scientific journals and presented at scientific meetings and conferences. In addition to DNA sequences, our research is used to update The Norwegian Biodiversity Information Centre's web applications with information on names, taxonomy and distribution in Norway. The material will also be published in the online species information Arter på nett.

What is the relevance of the Norwegian Taxonomy Initiative?

– The NTI has been enormously important for the possibility to carry out research in taxonomy and systematics, as it is usually difficult to obtain funding for such projects through the usual channels. For many species there is no information about status in Norway, and the taxonomy is often confusing and in need of revision. Knowledge about species is crucial for our understanding of ecosystem functions. Improved knowledge is also a prerequisite for monitoring changes in species numbers and composition, e.g. as a result of competition from invasive species or climate change. The NTI is also important as a resource for ForBio, the research school in biosystematics, which aims to educate the next generation of taxonomists and systematists.





Neoturris breviconis, Botrynema ellinore. Photo: Aino Hosia.

Mycena meliigena. Photo: Michael Krikorev

Decomposers

Fungi occur everywhere, but most of the time they are invisible to the naked human eye as they exist in the form of very thin thread-like mycelium in/on the soil. They provide indispensable ecosystem services, such as being the main decomposers of organic material in our forest ecosystems. Moreover, in the form of mycorrhiza, fungi assist plants in uptake of water and nutrients. In addition, all lichens contain one or more fungal parts. Until recently, ecological studies and identification have focused on the fruiting bodies (such as mushrooms). However, fruiting bodies are usually short-lived and weather dependent, and many fungi do not form fruiting bodies. During the past few years, both Sweden and Norway have hosted large-scale studies of fungal DNA in order to clarify the taxonomy and systematics. These studies have discovered a large number of DNA sequences which cannot be associated with any known species, and they have revealed that fungal diversity is considerably greater than previously believed. They have also concluded that the presence of fruiting bodies is a poor estimator of which fungi occur in a certain area and their density. Thanks to DNA analyses in combination with traditional morphological techniques, we are gradually obtaining a better understanding of fungal diversity, as well as distribution, ecology and roles in different ecosystems.

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Aleurodiscus amorphus.
Photo: Viacheslav Spirin (CC BY-SA 4.0)

Eristalinus aeneus. Photo: Krister Hall

Pollinators

Many insects provide invaluable ecosystem services in the form of the pollination of plants. In recent years, numerous pollinating insects have declined globally and many species are considered threatened. The most important pollinators in Sweden and Norway are hymenopterans (bees, wasps, ants, etc.), dipterans (especially hoverflies), coleopterans, and butterflies/moths. Thanks to extensive surveys, our knowledge of the diversity and distribution of pollinating insects has increased substantially. This is of great importance for e.g. Red List assessments. Nearly all Norwegian, and most Swedish, species of bees (including bumblebees) nowadays have unique genetic barcodes which are accessible from an international database and which facilitate species identification.

Many insects provide invaluable ecosystem services in the form of pollination of plants. The most important pollinators in Sweden and Norway are bees, wasps, ants, hoverflies, coleopterans, and butterflies/moths.

Bombus distinguendus.
Photo: Arnstein Staverløkk (CC BY 3.0).

Photo: Geir Søli, Naturhistorisk museum, Universitetet i Oslo, CC BY-SA 4.0

We build and disseminate knowledge

Norway and Sweden cooperate to increase expertise in taxonomy and systematics. One particularly important part in this is ForBio, the Research School in Biosystematics, which is funded by the Norwegian Taxonomy Initiative and the Research Council of Norway. ForBio provides a platform for facilitating teaching and research collaboration between Nordic research institutes and organises advanced practical and theoretical courses and meetings in collaboration between Norwegian and Swedish and other European universities and institutes. Thanks to the taxonomy initiatives, a large number of projects are run in collaboration with foreign researchers, and foreign experts are frequently engaged to assist Swedish and Norwegian colleagues with identifications. The Swedish Taxonomy Initiative has also provided substantial financial support to biological museums to assure that the material collected within the Swedish Taxonomy Initiative is preserved, for example by funding museum curators, as well as geographical referencing of previously collected material.

Knowledge of taxonomy and systematics forms the basis of most studies in biology.

Photo: Mattias Starkenberg

Photo: Geir Mogen

We build infrastructure for species information

The taxonomy initiatives are vital for gathering high quality information about species. The taxonomic databases Dyntaxa (Sweden) and Artsnavnebasen (Norway) contain taxonomic information on nearly all known multicellular organisms in the two countries. Artfakta (Sweden) and Arter på nett and Artskart (Norway) present digital information about species with illustrations, identification keys, distribution maps, etc., and Sweden also publishes the handbook series Nationalnyckeln till Sveriges flora och fauna (Encyclopedia of the Swedish Flora and Fauna). In creating this wealth of information, both countries' taxonomy initiatives benefit from each other. With the collaboration between the Norwegian Barcode of Life (NorBOL) and the Swedish Barcode of Life (SweBOL), both taxonomy initiatives also contribute to the creation of a global reference library for DNA barcodes, BOLD Systems. This infrastructure is, and will remain, of central importance for nature conservation in both countries.

The taxonomy initiatives are vital for gathering high quality information about species. This infrastructure is, and will remain, of central importance for nature conservation in both countries.

Photo: Malin Strand

The Swedish and Norwegian Taxonomy Initiatives are of central importance for nature conservation in Sweden and Norway. Since the start of these projects, c. 3 000 species new to Sweden and c. 2 400 species new to Norway have been found, of which c. 1 800 are new to science!

The work goes on!

Photo: Christopher Reisborg

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The Swedish and Norwegian Taxonomy Initiatives aim to survey and describe the diversity of species that forms the basis of our ecosystems.

In this brochure we give a short presentation of the ongoing work, with emphasis on the strong collaboration between the two projects.

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