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Bishop Gunnerus as naturalist: his impact on biodiversity research today

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Abstract

Bishop Gunnerus started his work as naturalist as soon as he arrived in Trondheim. In a pastoral letter to his clergymen he instructed them to collect specimens and information on natural history in their parishes. Gunnerus was a pioneer in natural history among his contemporaries. His description of species (especially of animals), either they were new to science or not, held a high scientific standard and contained detailed information on anatomy and morphological characteristics. In addition, his publications were furnished with high quality illustrations. The publications have shown to be important as reference works and primary sources. Our publication enumerates, for the first time, that the original material from Gunnerus' collection contains botanical and zoological type specimens. In addition the collection contains specimens that are potential types, or at least are topotypic specimens.

Key words:
Natural history collections, history of science, type specimens, herbarium TRH, Flora Norvegica.

Introduction

One of Bishop Johan Ernst Gunnerus' main achievements to science was the founding of the Royal Norwegian Society of Sciences and Letters. A second main contribution was his research in natural sciences presented through scientific publications. As one of the founders he also contributed to the establishment of the oldest public natural science collection in Norway. Such collections are the basis of research in biosystematics, time series and conservation biology. For research in biosystematics (description of species, classification, species evolutionary relationship and species distribution) specimens deposited in scientific collections are important. Together with recently sampled material are old samples and original specimens often necessary to challenge hypothesis in biological diversity in general, but especially in taxonomy. Natural history museums often have an advantage in having a long history and old collections. Samples from different centuries or decades can be revised by modern standards and according to modern nomenclature, and be a valuable tool to study how nature have changed at the locality or geographical area in question.

When Gunnerus arrived in Trondheim in 1758, he was forty years old and well educated. He had a degree in philosophy and had studied theology, physics and natural law (Dahl 1918; Brenna 2009). It is not documented whether he had followed, as part of his education, natural history lessons, but it may have been so as natural resources had, at the time, expanding interest (Brenna 2009). Hence, it is reasonable to claim he had no training as a naturalist and no credentials in natural science (Brenna 2009). This was, however, a topic he planned to take on when he was appointed the position in Trondheim. This has been documented from Gunnerus' hand and referred to as he had a mission in Trondheim, as cited in Brenna (2009: 10) "…this duty and this task were given to me only so that I should devote myself to science...". At the time natural resources were in demand in the national economy and were seen as potential for growth and welfare. Exploration and documentation of natural resources had great focus. Botany and mineralogy were important in

this respect. Gunnerus took on his mission as soon as he arrived in Trondheim. During the next fifteen years, until his death in 1773 (55 years old), he sought insight in natural history as a self-taught person and by correspondence with leading naturalists at that time. His correspondence with Carl von Linné was extensive (Amundsen 1976), but the two scholars never met. Records of his correspondence demonstrate that Gunnerus actively wrote to other scientists in Europe as well, among them professor G.C. Oeder in Copenhagen (Dahl 1918). He did also send specimens to scientists in Europe and he received specimens in return (Dahl 1918; Brenna 2009). The latter explain some alien specimens in his natural collection.

The northern areas of Denmark–Norway were assumed to be potentially rich in natural resources. Gunnerus' pastoral letter (Gunnerus 1758) to the clergymen in his diocese is a first attempt to start recording these resources (Dahl 1893a; Brenna 2009). His mission was probably emphasised already during his first visitation journey in 1759. According to Suhm (cited in Dahl 1918) his diocese had so much natural resources but no one had attempted to document them scientifically. Gunnerus encouraged the clergymen to send objects of nature to their bishop. Some misunderstood and sent traditional presents like fish or berries. The return of interesting objects seems to have been rather meagre (Brenna 2009). Consequently, Gunnerus used the opportunities to study nature himself during the long-lasting and strenuous travels in his large diocese.

Gunnerus' work as naturalist is diverse and impressive. In many respects his publications kept a high scientific standard which can be acknowledged even today. We have chosen to evaluate his zoological and botanical works separately as his approaches were rather different for these two fields of natural history. In botany he used a well-known method to preserve the plants and to describe their economical potentials, leaving a herbarium and a flora. As a zoologist he applied methods from human dissection routines learned from his father, but he also learned from the town physician Stephan Henrici in Trondheim. Preservation of zoological specimens was much more challenging than preparing plants. Most of the soft tissue animals he studied were not preserved or were lost. Even the idea to preserve and take care of the specimens he used when describing two

bird species from Trondheim and Finnmark as new to science was probably strange to him.

Gunnerus as zoologist

Gunnerus wrote approximately 30 zoological publications. His descriptions were accurate and the results were discussed thoroughly. Although he often included information he had been given from others he was careful to tell if this information could not be corroborated by his own observations from specimens. He had a clear scientific view in comparison and reference to other published works, although they were scarce at the time.

Gunnerus' accuracy in texts and illustrations has been of great importance to later scientists. He often described specimens representing species which had not been described before, hence, they were new to science, or they represented species previously described by others in far less detail. Given the techniques available at the time, his observations on morphology and anatomy, and how they were illustrated were of high quality. His species descriptions are in most cases not adequate by today's standards, but due to their detailed outline, they serve as important primary sources.

Gunnerus had great impact on the contemporary scientific work, and some of his descriptions are still important (Broch 1918; Zibrowius & Cairns 2005). Due to new technology used in taxonomy and biosystematics, his work has, in some aspects, higher impact now than stated by earlier writers (e.g. Broch 1918; Nordgaard 1918; Sivertsen 1961).

Descriptions of species

Descriptions of specimens, as well as discussions and conclusions in most of Gunnerus' papers distinguished themselves from the works of many contemporary scientists. This clearly stands out when compared to Linné's account on the animal kingdom: Linné gave a short diagnosis on each species without discussions on their natural history (Linné 1758). Linné's work was a major source for Gunnerus when he studied specimens and made descriptions. According to the correspondence between the two (Amundsen 1975) Linné's diagnoses were of great help, but they also left open questions whether specimens Gunnerus had at hand conferred to specific species described by Linné. Gunnerus was reluctant to identify a

species by Linné's name until he was confident of their characteristics. We know today that species may demonstrate variation in morphological characteristics, but this was not obvious to 18th century scientists who had a topological view on nature (species were created by God and were immutable). Gunnerus had a rather modern approach in his work, making descriptions and writing extensively on particular specimens actually observed by himself.

Gunnerus' careful attitude not to jump to conclusions was discussed by Broch (1918), referring to a description where Gunnerus was reluctant to identify specimens of one of the corals he was studying, the octocoral we now know as *Paramuricea placomus* (Linné, 1758). Rather than assigning the specimens at hand to the name given by Linné, *Gorgonoia placomus*, as Linné's descriptions were fragmentary, Gunnerus gave his specimens a new name, *Gorgonoia flabelliformis* (Gunnerus 1765). Later, when having studied original specimens of this species Gunnerus placed his previously published name in synonymy with Linné's and clearly stated it was the same species (Gunnerus 1768). Broch (1918) claimed it would have been desirable if scientists were just as accurate and careful as Gunnerus had been; it would exclude errors and poorly justified conclusions. This is even more important today, when scientists are more specialised and may not be as careful as they should consulting primary sources, or in taxonomic research, original specimens.

Detailed and good illustrations were one of the qualities Gunnerus presented in his scientific publications. Gunnerus did not draw or prepare illustrations himself (Sivertsen 1961), but he had obviously access to excellent artists. Based on correspondence with others and original illustrations, Nordgaard (1918) outlined in detail who made the drawings and prepared the illustrations to be used in Gunnerus's publications. One of the illustrations has become iconic, a beautiful line drawing giving clear details and accurate outline of the cold water reef-building coral *Lophelia pertusa* (Gunnerus 1768) (Figure 1). Linné wrote in a letter to Gunnerus (dated 4 March 1769, cited in Amundsen 1975) that this illustration was of so high quality that no one would ever misidentify the species. He was most likely correct. The drawing clearly outlines the morphological details necessary for identification of the species. This is the illustration usually used in scientific and popular writing whenever *Lophelia pertusa* is shown.

Figure 1: *Lophelia pertusa*, the reef-building cold-water coral common in Norwegian waters. This illustration was published by Gunnerus (1768) and was the first illustration of this species. The illustration has become iconic due to its high quality. From Gunnerus 1768.

Several papers published by Gunnerus dealt with species of fish. He had good access to some species of sharks and the Chimera (*Chimera monstrosa*). A modern description would require more specific details on certain morphological characteristics, but what Gunnerus wrote is still an important primary source. Anatomy in general and reproductive traits in particular was presented to science for the first time. Both Nordgaard (1918) and Sivertsen (1961) emphasised Gunnerus's important contribution to the life history of these species.

In addition to corals, contributions on the natural history of sharks are Gunnerus's most important zoological contributions.

Zoological specimens from Gunnerus's collection

The NTNU Museum of Natural History and Archaeology has a few zoological specimens from Gunnerus's collection. Whether some of the oldest specimens actually are from Gunnerus's hand or have been added to the collection after his death cannot be established with certainty. Some may be original specimens. A good source to solve this question is the auction catalogue of items of natural history objects sold after Gunnerus had died (Fortegnelse 1774).

The zoological specimens left are labelled with name and geographic origin. Unfortunately these are not original labels; they have been replaced at some stage. It is well known that this unfortunate action of replacing original labels took place (Broch 1918), however, it is not known when it happened.

Original specimens of species new to science are particularly important (see below). Other specimens may also have considerable value as documentation of what was sampled. In some cases these specimens demonstrate how important natural history collections are in documentation of nature in time and space. The early collections also have a cultural history aspect, showing which topics, problems and groups of organisms which where of particular interest to scientists in certain periods.

Gunnerus as botanist

Although Gunnerus probably was familiar with some plants when he lived as a boy in Christiania (Oslo), Nordhagen (1960) assumed that his interest in botany arouse from the contact with the German-Danish botanist Georg Christian Oeder (1728–1791) who Gunnerus had met in Copenhagen even before he was appointed bishop. A few years later, Oeder travelled in Norway to collect information on the Norwegian flora for the magnificent project Flora Danica. Oeder stayed in Nidaros (Trondheim) when Gunnerus was still rather unsettled there. Oeder, and Peter Friederich Suhm encouraged Gunnerus to document the flora of Norway (Nordhagen 1960). Some plants were collected already during the first visitation journey in 1759 to Nordland and Finnmark. However, it was not until 1764 that Gunnerus seemed to start collecting plants in a more systematic

way to provide information for his main botanical work, Flora Norvegica. At that time botany was a discipline supporting medicine and economy. Gunnerus, who had never been studying botany during his academic career, must have taken the task very seriously. The first volume of Flora Norvegica was printed in Nidaros already in 1766. The second volume was published posthumously in Copenhagen in 1776, edited by his nephew Niels Dorph Gunnerus (1751–1789).

Flora Norvegica

The flora was certainly a remarkable piece of work. It was the first effort to document the Norwegian flora where the binomial nomenclature of Carl von Linné was used. It was written in Latin, aiming at a scientific and international public. When starting his floristic studies Gunnerus had few tools available and he had to provide literature for determination of plants and a lens (often referred to as his microscope (Eckblad 1984)). The contemporary knowledge of plants' habitat preferences and distribution was in general very scarce. It could not have been easy to identify the plants he found, to know whether these were well known to other scholars dealing with botany or whether the species could be "new to science", or whether his observation of a species in a certain habitat was typical or extraordinary to the species in question. The correspondence with Linné was a strong support in his efforts to get a grip of plants.

Gunnerus became one of the pioneers in the research of the Norwegian flora. However, from a 21st century point of view, his Flora Norvegica has some surprising traits. He did not use the plant system developed by Linné, whom he admired so much in many respects. He seems to have been working in such a hurry that he made no effort to make a systematic survey of all the species he studied. They are presented in an accidental order. The majority of the species is vascular plants, but mosses, algae, fungi and lichens are also included, even some sponges, as he was not sure whether they were plants or animals. Furthermore, the flora does not cover the entire Norwegian territory; it is focused mainly on what Gunnerus observed and collected in his diocese, or species which were sent him from the vast area between Romsdal in central Norway and Finnmark in the northeast. On the other hand, the flora

is not merely an early attempt to make a list of species in these northern territories, it is also a source for ethnobotanical research.

Volume I (Pars prior, 1766) comprises 314 species, and volume II (Pars posterior, 1776) 813 species. Thus, the flora is very incomplete, even when only native vascular plants are considered. The ambitions where high and some of the first descriptions, especially those of ferns, are very detailed. It is obvious from his text that the morphology of plants, the function of spores etc. were very poorly understood (also by many of his contemporaries), and that a terminology describing morphological and functional traits was lacking. Gunnerus demonstrated, however, his sincerity as a botanical researcher by writing a "diagnosis", a short description of a species. The descriptions are mostly insufficient to identify the species in question, although they are often copied from one of his reference books. The references are sometimes numerous and were most probably prepared by his assistants. Norwegian plant names (if any) and vernacular names in other languages are often given. When visiting Sami districts he must have been keen to ask for native plant names and usage. The amount of information differs from species to species, but may include rough characteristics of habitat, where Gunnerus himself or informants had observed or collected a species, if the species is used as a medical plant, and for which disease, used for food, dying etc. He must have spent much time in field observing domesticated animals' preferences for wild plants, and he reported certain plants as especially good for dairy cows, some as favourites for horses etc. Some of the information is rather anecdotic. Today, at the first glance, we may find Flora Norvegica more entertaining or curious than botanically informative. Still, the work has potentials as a source for studies of traditional vernacular names, ethnobotany, plant geography etc. For instance, he is the only observer ever of some rare species which have never been refound in the districts where he recorded them, cf. Fægri's (1960) comments on Gunnerus' observation of the orchid *Neottia nidus-avis* in Central Norway, and Fremstad & Jørgensen's (2011) view on his report of having seen *Gentiana pneumonanthe* in the Gudbrandsdalen valley, East Norway, far outside the present distribution of the species. Actually, there is a specimen of *Gentiana pneumonanthe* in his herbarium (No. 1108). He was the first observer even of some alien species in Norway. Gunnerus must have had a sharp eye for details, otherwise he should

not have been able to describe plant species new to science (see below).

During his floristic research (that mainly took part in the years 1764–1773) Gunnerus must have realized that he had to reduce his ambitions and limit the size of the flora, at least considering future printing expenditure. In volume II the texts are shorter and often less informative, and the mixture of plant groups even more conspicuous than in volume I. Some Icelandic species are also included, sent him by colleagues. Obviously, he was not aware that some of these species also grow in Norway. The second volume is clearly an unfinished job.

Gunnerus's herbarium

Gunnerus collected plants and preserved them in a herbarium, consisting of many separate paper sheets with plant specimens, and a folio). The herbarium is kept in herbarium TRH at NTNU Museum of Natural History and Archaeology. During the years it has been stored and treated in ways which have reduced the quality of many specimens, and parts of the herbarium have been lost. For many Norwegian taxa Gunnerus' specimens are the oldest kept in any of our herbaria: his specimens are the oldest which can be controlled and revised according to modern species concepts. Furthermore, the flora and the herbarium enable us to throw some light on changes in the vascular flora from the 1760s to our times (Fremstad 2010).

The flora and the herbarium have been scrutinized repeatedly, by M.N. Blytt already in the 1820s, and in 1844 (Blytt 1847). The botanist Ove Dahl (1862–1940) compared the flora and the herbarium, reorganised the collection, revised the determinations of vascular plants etc. Thanks to Dahl's publications (Dahl 1893 a, b; 1894) and a later catalogue (Krovoll & Nettelbladt 1985) it has been possible to have an overview of the contents. Some groups have been revised by specialists: bryophytes by (Hagen 1897; A.A. Frisvoll in 1983), lichens (C. Kindt in 1892; Lynge 1921; T. Tønsberg in 1983), fungi (Eckblad & Høiland 1985), algae (Foslie 1886; J. Rueness in 1985), and other, more occasional revisions of particular specimens. Types have recently been chosen for those plant species Gunnerus' described as new to science, all together ten species (with a reservation on the number of algae types).

Gunnerus in a digitized world

Realizing that Gunnerus is a phenomenon in early Norwegian botany and still of scientific importance and interest (Jørgensen 2010), the Section of Natural History at NTNU Museum of Natural History and Archaeology, has started the work of presenting his life and achievements as a naturalist on the Internet. In 2009–2010 his herbarium was digitally scanned at high resolution. Then the collection was registered in herbarium TRH's database, except for a small number of algae for which the nomenclatural basis is lacking. The process revealed that Dahl's lists were incomplete. The Gunnerus herbarium comprises (at least) 2586 vascular plants, 74 mosses, 42 fungi and 103 lichens. The number of vascular plant species may increase in the future, after new revisions (Jørgensen & Fremstad in prep.).

At the same time, the NTNU Gunnerus Library scanned *Flora Norvegica*. The flora (the original Latin text and Norwegian translation), selected parts of the herbarium, photos of species, comments and short introductory chapters etc. will make information on Gunnerus' life and botanical work available to a large audience.

The few zoological specimens are in a process of being registered in the museums database. Most of these are dry and mounted and will be photographed. Photos are included as documentation in the database. Providing high quality photos online is important as it reduces handling of fragile herbarium specimens, as well as fragile dried zoological specimens such as corals and sponges.

The museum's databases deliver data to international online service providers on biological diversity, such as the Norwegian Biodiversity Information Centre (Artsdatabanken) and the Global Biodiversity Information Facility (GBIF). Hence, data on Gunnerus's specimens will be shared to the international community when the quality of the information has met required standards.

The type concept – original specimens

The NTNU Museum of Natural History and Archaeology has stored some of the original specimens which Gunnerus used in descriptions of species new to science. Species new to science should be presented in a publication by descriptions and illustrations based on a given set of specimens. These specimens are "type specimens" or

"types". Original specimens left from Gunnerus's collections are few, but are nevertheless of great importance, as they always will serve as reference specimens in taxonomic revisions. The original description, with text and illustrations, will stand forever as the first description, and be the primary source. Later scientists working on taxonomic revisions that necessitate redescription of a species, or who will revise the apprehension we have today of the species in question, depend on the original description and specimens, if they exist. Type specimens are today regulated by international conventions. They should be deposited in a public collection, preferably a natural history museum. It is paramount that types are available to researchers who work on taxonomic revisions, or on biodiversity in general.

Gunnerus described approximately 15 zoological species new to science (the number depending of what is recognized as a proper description), of which 10 are valid. His collections of specimens and books were sold to H. Meincke who donated the collection to the Society (Midbøe 1960). Specimens from the collection may later have been scattered between different collections and private collectors. Hence, it is difficult to keep record of type specimens that may still exist. The museum has for certain one zoological type, but several others from Gunnerus's collection are likely to be kept in our collections.

Type specimens are regulated through international conventions, i.e. the botanical and zoological codes of nomenclature. Different kinds of types are termed differently in the two codes, which will not be outlined here. The holotype (botany and zoology) is an individual plant or animal chosen by taxonomists to serve as the basis for naming and describing a new species or a variety. The actual specimen is used to give the new species a binomial scientific name. Still other types are chosen according to other criteria. In the 18th and 19th centuries the type concept did not exist, it was established early in the 20th century and has been revised several times. Even though the type concept did not exist, 18th and 19th century scientists often referred to, and labelled, their specimens used in original descriptions, as e.g. "original specimens".

Gunnerus's zoological type

There is only one specimen that has been confirmed to be a type specimen. This is a dry specimen of the hydrocoral *Stylaster norvegicus* (Figure 2). Broch (1914; 1918) stated that the specimen was stored in the collections, and this seems to be likely according to the original label which corresponds to the handwriting used on herbarium specimens. Later Zibrowius & Cairns (2005) has revised the group and used the type material in their revision.

Other specimens of the same species may be represented in the collection, but neither labels (no original labels exist) nor studies published by specialists (Broch 1914; Zibrowius & Cairns 2005) indicate this.

Figure 2: The original specimen of *Stylaster norvegicus*, with original label. Photo: Torkild Bakken.

Gunnerus's botanical types

Gunnerus was the first to describe several vascular plants, one lichen and some algae. The number of algae is at present uncertain and type specimens should be reconsidered for two species. The herbarium contains types of three vascular plants and one lichen. Numbers below refer to *Flora Norvegica* and to the registration numbers in the TRH database.

No. 1100.3 in the flora: *Arenaria norvegica*, Nordland, Steigen: Laskestad 30.07.1770. Lectotype. TRH 44003. Gunnerus's name is still valid: *Arenaria norvegica* Gunnerus, cf. Figure 3.

No. 1017.1 in the flora: *Carex maritima*, Finnmark, Måsøy, Maasøe 27.06.1767. Epitype. TRH 44006. The name is still valid: *Carex maritima* Gunnerus. (For some time the species was called *Carex incurva*.)

No. 841.5 in the flora: *Gnaphalium norvegicum*, Møre og Romsdal, Aure, Ormsæt fieldet 06.07.1768. Lectotype. TRH V-192488. The species has later been transferred to the genus *Omalotheca* and is now named *Omalotheca norvegica* (Gunnerus) Sch.Bip. & F.W.Schultz.

No. 973 in the flora: *Lichen normöricus*. Holotype. TRH L-650002. The present name is *Cornicularia normoerica* (Gunnerus) Du Rietz.

Gunnerus is also listed as the author of the vascular plant *Draba norvegica* Gunnerus (no. 846 in the flora, cf. Elven in Lid & Lid 2005). The typification of the species is a rather complicated and still unfinished story, which will not be outlined here. However, Gunnerus's description was based on an illustration in Oeder's Flora Danica, which is the holotype of *Draba norvegica*. The herbarium contains no specimen of *Draba norvegica* (R. Elven, pers. com.).

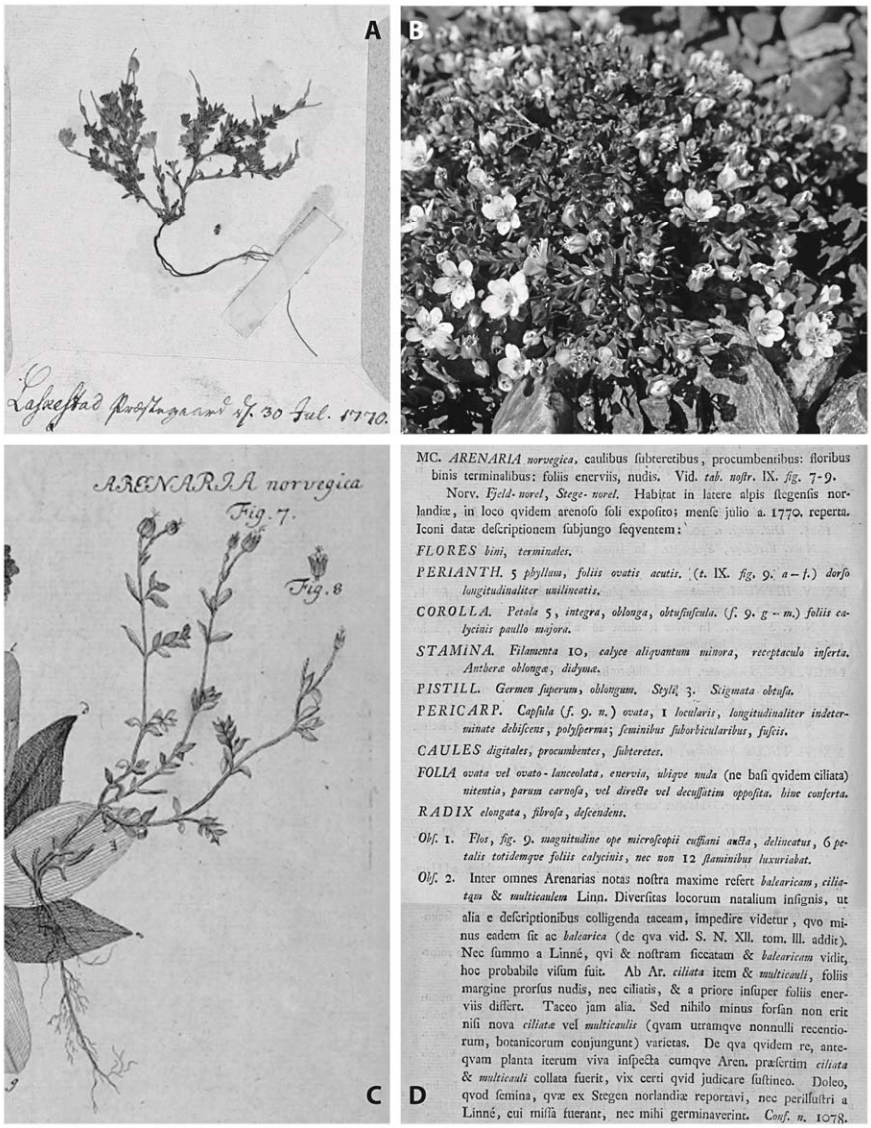

Figure 3: The vascular plant *Arenaria norvegica* was described by J.E. Gunnerus. A: the type specimen in herb. TRH (TRH 44003). B: the plant in a scree in Dividalen, Troms. Photo: Eli Fremstad. C: the illustration in Flora Norvegica, vol. II, plate IV. D: the text of species no. 1100 in Flora Norvegica vol. II, pp. 144–145, being the original description of *Arenaria norvegica*.

Type localities

Type localities are becoming increasingly important, especially in research on biosystematics. A type locality is the site or geographical area where specimens described as new species to science have been sampled. Such localities have become more important today than pointed out by earlier biographers (e.g. Broch 1918). The last two decades, when genetics has become a common tool in biology in general and in biosystematics in particular, references to original material and their geographic origin emphasise this importance. An increasing number of studies demonstrate that species have a limited distribution, and are restricted by geographical barriers as well as barriers in habitat conditions. The consequence of this is that species which we earlier believed had a wide geographic distribution turn out be quite restricted, e.g. to a single habitat type, or an oceanographic regime. When biosystematic research reveals a larger variety within a species than earlier anticipated, more than one species may be involved and a new species have to be described. To be able to compare well known species with newly discovered ones genetical samples from the type locality of the well-known species, is needed. New samples from this type locality will provide topotypic specimens for genetic analyses. Museum records may often provide the information on type locality, i.e. where the original sampling took place. Newly sampled specimens from the type locality can then be used to delineate species boundaries, how we apprehend the species in question today, and restrict the geographic distribution for each species. Specimens sampled at the type locality are chosen to represent the originally described species, and will keep the old name.

Exact localities were usually not given in 18th and 19th century publications nor collections, not even approximate geographic references were given. Gunnerus was an exception. He was not necessarily very precise, but approximate, which in many cases is good enough.

Lichen normöricus was named after the region were it was detected, and three of the vascular plants Gunnerus described as new to science have rather precise information on locality and date (see above). However, many of his herbarium specimens lack such information and have, accordingly, reduced scientific value.

Corals sampled at Nord-Møre, central Norway, were carefully described by Gunnerus (1768) with approximate geographic localities, hence the original description can be used to document the type locality (Broch 1918). As modern tools as molecular markers are being used in different organism groups, establishment of type localities by documentation from original sources becomes desirable and often necessary. This was shown for the bristle worm described by Gunnerus, *Hydroides norvegica*, by Moen (2006).

Did Gunnerus ever think of species and evolution?

At the time of his death in 1773, the main object of the naturalists was to describe the glory of the nature as it was created by God. The greatest naturalist of the century, Linné, dedicated his work to the Lord. As a bishop, Gunnerus, even if he was a modern and radical man eager to observe and describe nature, had no reason to believe anything else than that nature was created as a static construction, given us to admire and describe. However, Linné with his enormous experience of biological diversity, had some thoughts in his elder days that maybe the Creator did not make all the details himself; maybe He just created one or two species pro Genus or even pro Order and that all the variation at the species level had arisen through hybridization (Larson 1971). Such ideas were taken up again in the beginning of the next century by among others Lamarck. But that is a generation after Gunnerus – and at least one generation before anybody started to think about evolution in the Royal Society of Sciences and Letters in Trondheim.

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