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LINNAEUS'S LEGACY AND BIODIVERSITY RESEARCH IN SWEDEN - PAST AND PRESENT

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ABSTRAK

Tulisan ini menyampaikan empat hal yaitu ringkasan riwayat hidup Linnaeus, sistem klasifikasi menurut Linnaeus dan Darwin, rangkaian DNA dan ilmu sistematik serta ilmu sistematik mutakhir dan penelitian keanekaragaman hayati di Swedia. Linnaeus yang dilahirkan 300 tahun lalu di Swedia selatan, sangat terkenal karena mengenalkan sistem klasifikasi dan penggunaan dua nama atau binomial untuk penamaan spesies. Sistem penamaan binomial sampai saat inf masih digunakan. Penggunaan sistem binomial untuk penamaan tumbuhan dimulai dengan diterbitkannya buku 'Species Plantarum* pada tahun 1753. Pada binatang, sistem ini pertama kali dikenalkan dalam edisi kesepuluh 'Systema Naturae' pada tahun 1758, yang menjadi titik awal untuk tatanama zoology 'the Code of Zoological Nomenclature'.Sistem klasifikasi menurut Linnaeus bertujuan untuk menyusun keragaman tanpa ada unsur evolusi. Sekitar 100 tahun kemudian Charles Darwin dalam bukunya berjudul 'the Origin of Species'memberi penjelasan lain tentang keragaman hayati yaitu 'evolusi'. Juga Darwin memberi ilustrasi yang sekarang kita sebut pohon filogenetik. dan menyampaikan pemikirannya tentang sistem klasifikasi alami yang merefleksikan 'silsilah' yaitu klasifikasi dan urutan organisme yang menunjukkan adanya hubungan evolusi. Pergeseran dalam ilmu biologi ini kita kenal sebagai filogenetik atau klasifikasi 'cladistic'. Pada tahun 1950an terjadi revolusi dalam ilmu biologi termasuk sistematika, yaitu dengan ditemukannya molekul DNA seperti yang dijelaskan oleh Crick dan Watson. Untuk ilmu sistematik, hal ini merupakan suatu perubahan dramatis yang memungkinkan merekonstruksi filogeni. Rangkaian DNA menyediakan lebih banyak karakter terutama variasi genetik yang tersembunyi dan juga dapat membandingkan jarak antar takson, yang tidak mungkin dilakukan bila hanya berdasarkan karakter morfologi. Perkembangan yang pesat dalam ilmu biologi molekuler tersebut sangat berpengaruh pada ilmu taksonomi dan sistematik mutakhir. Tehnik ini sangat membantu pekerjaan kita dalam memberi nama organisme di seluruh dunia yang sejak zaman Linnaeus sampai sekarang masih belum selesai. Sampai saat ini baru sekitar 1,7 jutajenis yang sudah diberi nama dan dideskripsi, padahal jumlah jenis seluruhnya diduga mencapai 5 sampai 100 juta. Sebagai upaya, pada tahun 2001 Pemerintah Swedia mendirikan *The Swedish Species Information Centre* dengan programnya yang disebut *Swedish Taxonomy Initiative* dan sejak tahun 2005 menyediakan anggaran sebesar US$ 9,5 juta per tahun.

Key words: Linnaeus, Linnaeus's legacy, Darwin, classification system, systematic and biodiversity research, DNA sequencing, molecular biology, Sweden.

CARLLESNAEUS

First of all I want to thank the organizers for inviting me to this conference, and it is a great honor for me to be here. I will talk about Linnaeus's legacy and biodiversity research in Sweden today. I will start by giving a brief background and some biographic notes before turning to what is happening in Sweden right now when it comes to taxonomy and systematics, and what the trends are. I will also briefly make some comments on Linnaeus's travel and his apostles.

It is now exactly 300 years Carl Linn6 (Linne" is his Swedish name - he later Latinized it to Linnaeus) was born in a small village in southern Sweden. He was the son of a priest and his parents wanted him to study to become a priest. After a few years in elementary school, he moved to the nearby university in the city of Lund - in those days, there was only two universities in Sweden. The one in Lund, and another in the city of Uppsala, just north of Stockholm. The young Linné had been inspired to study plants by both his father and his school teacher, and when he went to university he started to study medicine, which required a good knowledge of plants and herbs. After a short time in Lund he was encouraged to move to Uppsala, where he then spent his entire academic career except a period in Holland where several of his books were published.

He soon became a famous person in Uppsala, and after his time in Holland, also worldwide. It is in Holland where he presents his thesis for a doctoral degree, and he stayed there for some years. Linnaeus is famous mainly for two things, his classification system, and for his suggestion to use binominals for naming species (i.e. the name

consists of two parts the first given the genus and the second the species). Although his classification system did not survive, his naming system did and this is how we still communicate species names. For us, it may not seem like a great achievement but it in fact revolutionized communication between natural historians. Before the binomens, they had to give long and cumbersome accounts when describing what species they referred to. He was not himself consistent with using these binomens to start with, but from his *Species Plantarum* published in 1753 and onwards he gave all plants binominal names. For animals, the name system was introduced with the 10th edition of *Systema Naturae* in 1758. This is also the official starting point for the Code of Zoological Nomenclature.

There were several competing classification systems in the beginning of the 18th century. Linnaeus's system was unique in its consistency and in its use of the flower's reproductive organs - hence the name "sexual system". Linnaeus needed specimens of plants and animals to be able to apply his system and he viewed travel as a scientific method to achieve this. He himself did some famous journeys in Sweden, but when it came to more distant traveling he relied on his "apostles", students trained in using his classification system. The term "apostle" comes from his wish not only for them to collect the specimens, but also to "pray" his system, to spread his words. Around 20 of the apostles traveled the world - half of them died during the journeys and never made it back home.

Four of them sailed as priests on board the Swedish East India Company's ships bound for China. They were commissioned by the Swedish Royal Academy of Science, of which Carl Linnaeus was one, the founders, to collect information and specimens of foreign plants and animals. Linnaeus himself strongly believed that tea would be possible to grow in Sweden, and on the list of his wishes there was always as first priority a tea plant to bring home. In the end, he actually managed to get one, just to experience that tea cannot grow in the cold climate of Sweden! The ships often stopped in Batavia (Jakarta) and for example the Linnaeus's student Carl Thunberg has collected many plants from Indonesia later to be named and described by himself and Linnaeus.

THE CLASSIFICATION SYSTEM OF LINNAEUS AND DARWIN

Linnaeus's classification system aimed to create order in the vast diversity created by God, and there was obviously no evolutionary component. The process behind the diversity was the creation. It was sorting things in boxes without thinking of whether these boxes should symbolize a process. In this sense it was horizontal, and did not take into consideration any time aspect.

Linnaeus books are major events in the history of biology. About one hundred years later Charles Darwin published his book about the Origin of Species. Of course Darwin had another explanation to biodiversity, and that was evolution. In the first edition of The origin of Species, there is in fact only one single illustration, and that is a figure of what we today would call a phylogenetic tree. Darwin devotes one chapter in this book on classification, and in this chapter he clearly expresses what he thought characterizes a natural system of classification. A natural system should reflect genealogy, that is, one should classify and order organisms to reflect their evolutionary relationships. This is an important shift in how classification is viewed as compared to Linnaeus's system. Today we refer to this as phylogenetic or cladistic classification. Darwin himself, however, did not use the term phylogeny it was later coined by the German biologist Ernst Haeckel.

Still, for many years after Darwin the actual classification/taxonomy and the way it was carried out did not change in any essential way. Adherents to Darwin framed their taxonomy in other words, but the actual way of reaching the taxonomic conclusions did not change for many years. The problem was that if you want to classify organisms in a way that reflect the evolutionary history, the first step is to find this history. The problem is not trivial - in some way you need to estimate what has happened in the past from information (morphology, DNA, etc) you can observe today. It took almost 100 years after Darwin, before someone came up with the good theory, and

most famous is the German entomologist Willi Hennig who in the 1950's wrote about what became known as cladistics. From this, there has been an enormous development when it comes to methods and mathematical algorithms for how to reconstruct the evolutionary history of biological organisms.

DNASEQUENCINGAND SYSTEMATICS

Another thing happened in the 1950's, which revolutionized not only systematics but also biology in general - the paper by Crick and Watson describing and explaining the DNA molecule. In the beginning, it was difficult, expensive, and time-consuming to actually find the nucleotide sequences in the DNA molecule, but today this is standard practice in biological laboratories. For systematics, it has meant a dramatic change in the possibility for phylogeny reconstruction. Not only does DNA sequencing provide us with a much larger number of characters, but it also allows comparisons between distant taxa, which is otherwise impossible based on morphological characters.

RECENT TRENDS IN SYSTEMATICS AND BIODIVERSITYRESEARCH

What are the current trends in systematics and taxonomy, how much influence has molecular techniques in present systematic research? First, we need to finish what Linnaeus once started - describing and naming the biodiversity. There are 1.7 million species described and named today, but the actual number of species is estimated to be from 5 up to 100 millions. And this is not only small and inconspicuous animals and plants - zoologists still describe several new bird species every year, and even primates new to science are discovered now and then. We need to reconsider other ways of working with taxonomy if we ever will have a chance to even getting close to describe all this diversity. We also need to survey floras and faunas to establish what diversity we have. A huge task in a country like Indonesia with its immense number of species. The Swedish Government some years ago decided to take on this task in Sweden, which of course is much easier with an estimated number of 20-30 000 species of plants and animals. In 2001, the government gave the Swedish Species Information Center direction to organize what has become known as called Swedish Taxonomy Initiative. There are two aims, the first being to investigate the distribution, abundance and taxonomy of all biological species in Sweden that can be observed and studied without the aid of microscopes, that is, the macro-fauna and -flora. The second aim is to produce a series of handbooks with keys and descriptions of the Swedish plant and animal species, the Encyclopedia of the Swedish Flora and Fauna. From 2005 the Government has spent 9.5 million US$ per year on this project. One part of this grant goes to the encyclopedia, another to museum collections and herbaria, and a third to taxonomic research and inventories. There are five volumes of the encyclopedia published so far. They are aimed for the general public and the pricing is subsidized to make them affordable basically for everyone.

The more we use DNA information in our systematic and taxonomic work, the more we see how much genetic variation is hidden under the same morphology. Sometimes, we also observe the reverse - many morphs described, as different species are genetically very similar and probably the same species. These kinds cryptic species are probably much more common than hitherto know, which will increase the number of undescribed species more. DNA sequences do not only reveal hidden taxonomic variation, but the molecular techniques can also be used to identify already named and known species. Species identification in for example marine surveys is often very tricky and would ideally involve a large number of trained taxonomists, which is for most of the time impossible due to lack of expertise and money. A current project trying to solve this is the Barcoding of Life Consortium. This is an international collaboration between taxonomists with the aim of building a database with short stretches of DNA sequences that could be used to identify species. The idea is that if one encounters a specimen and wishes to identify it to species, one sequence the agreed upon DNA sequence, submit it to the database for a search and hopefully will the answer be the species, together with additional information like

geographic distribution, colour polymorphism, or whatever relevant in the particular case. This so-called DNA barcoding has the further advantage of being applicable to parts of plants and animals, and to all life stages.

Molecular biology has made an immense impact on current taxonomy and systematics and has taken the field far away from what it looked like in Linnaeus's days. I think Carl Linnaeus would have been fascinated and excited about the possibilities it has brought. But maybe he had been equally thrilled by the way we now can travel the world and explore all the diversity he could only dream of. It is also clear that to fulfill the goal of describing and naming all organisms, we not only need to apply new techniques, we also need to collaborate. Hopefully my visit here in Indonesia and all the contacts I have made will lead future collaboration in an effort to describe and document your vast diversity.