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# CHANGES OF FLORA-INFORMATION OVER TIME: EXAMPLES FROM ETHIOPIA AND ERITREA AND THE NORDIC COUNTRIES

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**ABSTRACT:** Changes in Flora-information over time can be divided into three different categories: (1) "Real changes" (species enter the region by natural dispersal or become extinct). (2) "Floristic changes" (species known from elsewhere are discovered). (3) "Taxonomic changes" (species are discovered and described, taxonomic revisions change the status of previously known species). The Linnaean taxonomic methods for describing and naming plant species, which we still use today in a refined form, were developed in the middle of the 18th century. The Nordic flora was one of the first that was subjected to the Linnaean methods, but these methods were also applied to the flora of Ethiopia and Eritrea before the end of the 18th century. An intensive activity involving floristic and taxonomic changes took place in Ethiopia and Eritrea in the 19th century, particularly before ca. 1850, after which a period with a more steady level of activities followed. The Ethiopian Flora Project, which has been active between 1980 and 2009, has resulted in more than 470 species being described as new during the period, and more than 440 species described from elsewhere have been discovered to occur inside the Flora area. Recent studies of the Orchidaceae family in Scandinavia has demonstrated considerable changes in our information about that family in Scandinavia during the last 50 years, both real, floristic and taxonomic changes. Similar, or even greater, changes are to be expected in the flora of Ethiopia and Eritrea in the future.

**Key words/phrases**: Ethiopia, Eritrea, Floristic changes, Floristic exploration, Taxonomic changes.

## INTRODUCTION

Floras – with a capital "F" – are works based on scientific studies aiming at enumerations and descriptions of plant species from a geographically defined area, with two purposes: (1) aiding identification of plants from that area, and (2) presenting data about these plants in a systematic way. The name "Flora" – derived from the name of a flower-goddess from Roman antiquity – for a work with these two purposes was first used by a Danish professor of botany, Simon Paulli, who wrote a *Flora Danica* (Paulli, 1648). The plants from a particular region are together called the flora – with a small "f" – of the region.

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The scientific naming and basic rules for species-nomenclature and –delimitation now used in Floras all over the world took a new beginning in 1753 with the work of the Swedish naturalist Carolus Linnaeus. The starting point is his *Species Plantarum* (Linnaeus, 1753), a taxonomic revision and a systematic enumeration of all the then known species of plants of the entire world (in the first edition approximately 8,000 species, in later editions increased to nearly 10,000 species). Linnaeus and other botanists in Northern Europe wrote numerous regional or country Floras, and European botanists have continued doing so ever since. It is therefore from northern Europe that we have the most complete material for looking at changes in flora-information over time, including how the utilisation of new methods – molecular and otherwise – may influence the number of taxa in the flora.

It is not possible to make direct comparisons between changes in the *Flora of Ethiopia and Eritrea* (Edwards *et al*., 1995; 1997; 2000; Hedberg and Edwards, 1989; 1995; Hedberg *et al*., 2003; 2004; 2006; 2009a; 2009b) and the range of Floras of the Nordic countries (various authors, most lately Jonsell, 2004) based on statistical analyses. As will be demonstrated here, the known number of indigenous species became relatively stable by the end of the 19$^{th}$ century. This happened earlier in the Nordic countries than in Eritrea and Ethiopia, but there are striking analogies between the histories of the floristic exploration of the two regions, however far they are from each other geographically. How the family Orchidaceae was treated in a Nordic Flora approximately 50 years ago and today will also be discussed. Perhaps these observations may shed light on the possible outcome of future studies on the Ethiopian flora.

## MATERIALS AND METHODS

The original observations made for this paper are made by simple or computerized counting of taxa in the databases and works cited here. This agrees with the methods used for the analogous statistical reviews published by Friis and Edwards (2001), at a time when fewer databases were available. The tools used for the analyses and the production of illustrations for this paper are all included in the commercial software package Microsoft Office 2007 for Windows (Microsoft Corporation Inc., Redmond, Washington State, USA; see http://en.wikipedia.org/wiki/Microsoft_Office_2007).

## RESULTS

### Reasons for changes in number of species or infraspecific taxa; "Real changes"

There are three reasons for changes in the number of species or infraspecific taxa in floras: (1) "Real" changes in species numbers take place mainly due to extinction, immigration or introduction of taxa from outside. (2) "Floristic changes" take place when botanists find more taxa; this may go on until a "saturation point" is reached, that is when nearly all the indigenous taxa have been found. (3) "Taxonomic changes" are changes in the number of taxa due to new taxonomic studies. A survey of these categories of change is given in Table 1.

Table 1. The main categories of floristic changes over time addressed in this paper. However, no attempt is made to analyse evolution of new taxa over time.

| **Changes in floras** | |
|---|---|
| **Category of the change** | **Examples of specific effects** |
| "Real changes" | Species or infraspecific taxa from areas of origin outside the Flora area immigrate or are introduced and establish themselves in the Flora area |
| | Due to changes in conditions, e.g., climatic change |
| | Because the taxa are short-time immigrants - escaped from cultivation or accidentally introduced |
| | Because the introduced taxa become naturalised species or infraspecific taxa |
| | The naturalised taxa may be harmless additions to the flora |
| | Some of the naturalised taxa may behave as invasive |
| | Evolutionary events – none have been demonstrated in the examples studied here |
| "Floristic changes" | Species or infraspecific taxa – usually already known from adjacent countries – are discovered in the Flora area |
| | Species or infraspecific taxa new to science are being discovered |
| "Taxonomic changes" | Taxonomic concepts of species already known from a flora may change. The results may be changes of names of species or infraspecific taxa and/or of increasing or decreasing number of species or infraspecific taxa. |

In the Nordic countries, it is unlikely that species have survived the at least four Pleistocene glacial periods. Species that arrived after the last ice age in Europe, but before a particular point in human history, in the Nordic countries often around 1,500 AD, are generally regarded as native or indigenous species. The species that arrived in the Nordic countries after that date have mostly been introduced by man, either deliberately or accidentally. The species that arrived in prehistoric time or were introduced to the Nordic countries before around 1,500 AD are called *archaeophytes* ('ancient plants'). Plants introduced since 1,500 AD are called *neophytes* ('new plants'). The latter fall into a range of categories based on how they were introduced and how well they have become established; a rough

survey of these categories can be seen in Table 1.

For Ethiopia and Eritrea, there has not been a *tabula rasa* ('cleared table') situation similar to that of the Nordic countries. The extent of the maximum Pleistocene glaciation in the Bale Mountains has been established accurately; there is clear evidence for a former glacier cover with a spatial extent of at least 70-80 km sq, possibly as much as about 180 km sq, thus covering almost the entire Sanetti Plateau. The glaciers on the Bale Mountains seem to be contemporary with the Last Glacial Maximum in Europe. An estimated equilibrium line altitude for these glaciers and the ice-cap on the Bale Mountains is 3,750-4,230 m (Osmaston *et al.*, 2005). The extent of the maximum Pleistocene glaciation in other parts of Ethiopia is less well known, but almost certainly areas above 3,750-4,230 m have been covered by glaciers. The effect of the glaciations on the vegetation has been estimated by Bonnefille and Hamilton (1986). In Ethiopia and Eritrea, an unknown number of species must have survived these unfavourable conditions coinciding with the much more extensive glaciations in the Nordic countries, where the last glaciation began about 70,000 years BP and ended 15,000-10,000 years BP. There have not yet been enough studies in Ethiopia and Eritrea to know how depauperate the flora was during periods of severe climate, probably caused by drought rather than cold temperature. Nor has it been established when a meaningful distinction between *archaeophytes* and *neophytes* can best be made.

**The development in number of taxa: Plants are introduced; botanists explore the flora; "Floristic changes"**

Information about the changing number of known plant species in all the Nordic countries as a whole cannot easily be obtained, but an example from Denmark (Friis, 2010a) may well be representative (Table 2). The number of indigenous species known from Denmark grew to approximately 1050 by the early second half of the 19$^{th}$ century, and, in subsequent accounts, the total number remained surprisingly constant, withstanding "real", "floristic" and "taxonomic" changes. The gains and losses have more or less balanced each other out.

Table 2. Number of species recorded in various Danish flora-manuals and floristic surveys.

| **Number of species in historical surveys of the Danish flora** | |
|---|---|
| **Authors of Danish Flora** | **Number of species: Indigenous / introduced** |
| Paulli (1648) | 224 / 156 |
| Oeder *et al*. (1761-1883) | 1400 / ? |
| Hornemann (1796) | 762 / 290 |
| Lange (1886-1888) | 1042 / 479 |
| Hansen *et al*. (1981) | 1007 / 391 (= 146 naturalized; 94 accidentally introduced; 151 escaped from cultivation) |
| Svart and Lyck (1991) (Foreign species recorded from Denmark during the years 1750 – 1991) | ? / 1554 |
| Lange (1994) [Foreign species cultivated in Denmark since ancient times, also indoors] | ? / c. 5000 (over 12000 if botanical gardens are included) |
| Atlas of the Danish Flora (unpublished; data from 2000) | 1025 / 387 |

The number of introduced plants in the Danish flora has fluctuated throughout the period from which records are known. This is not surprising when seen from counts made of all plant species introduced to Denmark (and grown there both out-of-doors and indoors, but outside botanical gardens), which amounts to ca. 5000 species, and to over 10000 species including those in botanical gardens (Lange, 1994). These figures are 5-10 times as high as the number of indigenous species. One might wonder about the inclusion of indoor-plants and species in botanical gardens, but some of the well established introduced species in Denmark do actually come from these two categories. The originally North American species *Elodea canadensis* Michz. was at first only grown in Denmark in aquaria and artificial garden ponds, but today it is extensively naturalized, often blocking small streams and filling natural ponds and small lakes. Similarly, *Heracleum pubescens* M. Bieb., a species indigenous to the Caucasus, was first cultivated in the Botanical Garden of Copenhagen, and from seeds obtained from the Garden where people got the seeds, and it spread and has now become a serious weed in meadows, along forest edges and on damp slopes.

The situation in Ethiopia and Eritrea has considerable similarities with this regarding the development of floristic and taxonomic studies over time. With the visit in 1768-1772 of James Bruce and Luigi Balugani (Bruce, 1790; 1804) Linnaean taxonomy was applied to Ethiopian plants not long after it was applied to Nordic plants. In fact, the first Ethiopian species, e.g. *Guizotia abyssinica* (L.f.) Cass (based on *Polymnia abyssinica* L.f.), described according to the Linnaean system were published from Bruce and Balugani's seeds by Linné filius (1782). But the continued development after that early start was not so rapid in Ethiopia as in the Nordic countries, partly due to the unstable political situation in Ethiopia during the Zemene

Mesafint, the 'Period of Judges' (or 'Period of Princes'), between about 1760 and 1855, in which the country was rent by conflicts between warlords, and the government of the Emperor was reduced to a formality. This chaotic time was followed by a period with more organised or centralised government, which, in periods, was fruitful for the study of Ethiopian plants. This is the period of Richard's "Tentamen" (Richard, 1848-1851) and the time of the first resident botanical collector, G.W. Schimper (Friis, 2009). As can be seen from Table 3, Richard's work accounted for a total of 1750 species. However, in spite of the significant progress, this is a figure that is less than one-third of what is known today. Within the 1750 species, Richard provided descriptions for 1018 new taxa, mostly on the species level. So, at a time when the knowledge of the Nordic (Danish) flora had reached almost the figures that are known today, the flora of Ethiopia and Eritrea was still very much in the discovering stage, also as far as the indigenous species are concerned.

Table 3. Number of Ethiopian and Eritrean species in Richard (1848-1851) and Cufodontis (1953-1972). Richard's *Tentamen* covers an area that is significantly smaller than the combined area of Ethiopia and Eritrea today, and Cufodontis' account has for the first 2/3 of the work not counted species only known from the Ogaden as occurring in Ethiopia.

| **Number of species in historical surveys of the Ethiopian Flora** | |
|---|---|
| **Author** | **Number of species** |
| Richard (1848-1851) | 1750 species |
| Cufodontis (1953-1972) (Ethiopian and Eritrean species only) | 4850 species (out of a total of 6323 for all parts covered by the Enumeratio, i.e. including Somalia and Djibouti). |

No attempts were made to make any estimation of the species known from Ethiopia and Eritrea based on the *Flora of Tropical Africa* (Oliver, 1868-1932) since no area used for recording species in the *Flora of Tropical Africa* agrees with the present area of Ethiopia and Eritrea. Nor has it been attempted to compare the flora of the Italian colony Eritrea with the flora known from the present day Eritrea.

The next specific survey of the flora of a range of countries or colonies on the Horn of Africa was the floristic enumeration by Cufodontis (1953-1972). It is also impossible to make an exact comparison between Cufodontis' *Enumeratio* and the *Flora of Ethiopia and Eritrea*, because in the first ca. 60% of Cufodontis' work the border used to demarcate between what is now the Ethiopian Somali Regional State (including part of former Harerge and Bale) and Somalia is significantly different from the current border. The exact number of species from Ethiopia and Eritrea in the present delimitation can therefore not be counted from Cufodontis' work. A count

made by the current author has resulted in approximately 4850 species (not counting infraspecific taxa) from the present day Ethiopia and Eritrea (Table 3). The total number of species included in the entire check-list from the whole of the Horn of Africa is 6323 species (Cufodontis' own count). This represents a large increase in numbers in relation to that of Richard's work (Richard 1848-1851), caused by floristic and taxonomic studies in the period between the two works.

A breakdown of the species in the *Flora of Ethiopia and Eritrea* was made from the completed Flora (Friis, 2010b), see also Table 4. The figure from Cufodontis' *Enumeratio* is ca. 700 species less than the count from the *Flora of Ethiopia and Eritrea*. As can be seen from Friis and Edwards (2001) and the observations presented here, more than 700 species have been discovered and described recently, but this is to some degree counter-balanced by the "taxonomic changes" caused by merging of species. The data in Table 4 show also that 226 families (187 flowering plants, 3 gymnosperms, and 36 pteridophytes), 1480 genera (1401 flowering plants, 3 gymnosperms, of 76 pteridophytes) and 5510 species (5315 flowering plants, 5 gymnosperms, of 190 pteridophytes), are known from the Flora-area. A diagrammatic representation of the increasing knowledge of the Flora of Ethiopia and Eritrea over time is shown in Fig. 1.

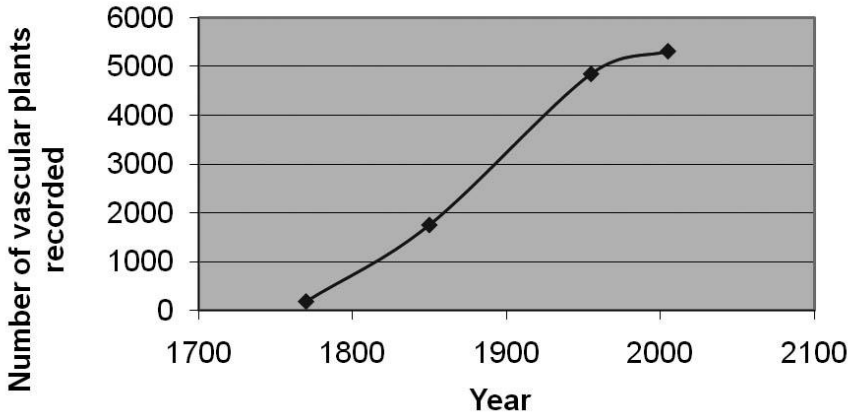


Fig. 1. Development of number of known species of vascular plants in Ethiopia and Eritrea from c. 1770 (the time when James Bruce and Luigi Balugani visited Ethiopia, and the time when the methods of Linnaean systematic botany were first applied to the Ethiopian flora) to the completion of the Flora of Ethiopia and Eritrea, i.e., year 2009.

Table 4. Families, genera and species of flowering plants, gymnosperms and pteridophytes in Ethiopia and Eritrea (according to Friis, in press). Infraspecific taxa are not counted.

| | **Families** | **Genera** | **Species** |
|---|---|---|---|
| Flowering plants | 187 | 1401 | 5315 |
| Gymnosperms | 3 | 3 | 5 |
| Pteridophytes | 36 | 76 | 190 |
| Total | 226 | 1480 | 5510 |

## Diversity and endemicity of plants in the Flora of Ethiopia and Eritrea and in the Flora of the Nordic countries

Mutke and Barthlott (2005) have made an attempt at mapping plant biodiversity globally, using *inter alia* the figures discussed here for Ethiopia, Eritrea and the Nordic countries. From their map it appears that, compared with other tropical African countries, Ethiopia and Eritrea are fairly rich in wild plant species and richer than other areas found at the same latitude. According to the maps in Mutke and Barthlott (2005), Cameroon and Gabon have the highest species richness in tropical Africa (4,000-5,000/10,000 km²), while the average richness in Ethiopia is 1,500-2,000/10,000 km². This contrasts with lower richness in countries west of Ethiopia, where the richness is 500-1,000/10,000 km² in the Sudanian zone and 200-500/10,000 km² in the Sahel zone. The higher species richness in Ethiopia and Eritrea is due to a more varied climate, topography and geology than in the Sudanian and the Sahel zones of western Africa. In Ethiopia and Eritrea the species richness is, however, not evenly distributed, with the highest richness (3,000-4,000/10,000 km²) found in the former Sidamo, Shewa and Kefa regions. The Eritrean coastal zone has a richness of only ca. 2,000/10,000 km² and Afar only ca. 400/10,000 km². In the Nordic countries species richness is comparable to that of the Ethiopian and Eritrean woodlands and wooded grasslands, that is 500-1,000/10,000 km² in the southern parts (Denmark, Southern part of Norway, Sweden and Finland), and the richness in the Nordic countries drops to values comparable to those found for Afar if one moves up to the Arctic and subarctic parts of the Scandinavian peninsula.

Seventeen percent (17%) of the species in Ethiopia and Eritrea are endemic or have a limited extension into Somalia. The flora of Somalia has over 25% unique plant species, and the proportion of endemic species increases towards the tip of the Horn of Africa (Friis *et al*., 2005). There are 127 endemic taxa in the Nordic countries (46 species, 45 subspecies, 32 varieties and 4 hybrids with dispersal capability). The highest number of these endemic taxa (77) is found in Sweden, the second highest number (66) in

Norway (66) (Jonsell, 2004). A degree of endemism has not yet been calculated for the Nordic flora because the total number of taxa – including infraspecific ones – is still uncertain. However, estimates show that the current Nordic Flora includes a little over 2,500 species (Mossberg and Stenberg, 2010) and it seems therefore likely that the well-explored Nordic Flora has a species endemism of less than 2%, when infraspecific taxa are included.

## Improved floristic knowledge of the flora of Ethiopia and Eritrea; "Floristic" and "Taxonomic change"

One way the number of species (or other taxa) can increase over time is the description of new taxa from the area. This is the most immediately noticeable part of what was referred to as "taxonomic change." The other way the number of species can change is the discovery of previously unnoticed species and their identification. These two different ways are described here with the description of new taxa first, since the description of new taxa adds to the global biodiversity and usually attracts more attention than the discovery and identification of previously unnoticed species.

## Description of new taxa since the beginning of Linnaean taxonomy in Ethiopia and Eritrea

The number of new taxa described in connection with the Ethiopian Flora Project was analysed in Friis and Edwards (2001). The findings in that paper are summarised in Table 5. A diagrammatic representation of the data set is shown in Fig. 2.

It appears that the number of newly described taxa was highest around the middle of the 19$^{th}$ century, and that about 1,500 taxa were described on material from Ethiopia and Eritrea during relatively few decades. Slightly less than a third of that number, *ca*. 450 new taxa, were described in association with the Italian colonial period in Eritrea and the occupation of Ethiopia. More than 500 new taxa were described by a much more international team of botanists during the establishment and up to the completion of the Ethiopian Flora project. For the first time new taxa from Ethiopia were described by Ethiopian botanists and botanists from other African countries.

These observations are not in conflict with the previous comment that the count in the number of taxa in the flora of Ethiopia and Eritrea is still growing. It is impossible to say for how long these figures may continue to grow, but new species and infraspecific taxa can continue to be discovered

in a rather well known flora, as will be shown below for the Nordic Orchid flora over the last 50 years.

Table 5. Number of taxa named according to Linnaean methods on material from the Flora area during different periods since 1753 (data from Friis and Edwards, 2001 and Friis, 2009).

| **Period and category of work** | **Approximate number of taxa described** |
|---|---|
| New taxa described on material collected by Bruce and Balugani (who collected in Ethiopia 1769-1771 – the period ended c. 1810). | 40 |
| New taxa described in connection with the Tentamen Florae Aethiopicae (main collectors Henry Salt, Rüppell, Quartin-Dillon & Petit, "early" Schimper; period ca. 1800-1851) | 1420 |
| New taxa described by botanists mainly associated with Flora of Tropical Africa, most of them British (main collector "late" Schimper; period ca. 1860-1932) | 280 |
| New taxa described by botanists of the "Engler Period," most of them German (main collectors "late" Schimper, Steudel, Schweinfurth, etc.; period ca. 1875-1925) | 480 |
| New taxa described by Italian botanists of the "Italian Colonial period" (period ca. 1870-1945). | 450 |
| New taxa described by other European botanists not associated with the above groups (period ca. 1860 – ca. 1940) | 35 |
| New taxa described by botanists associated with the Flora of Tropical East Africa during the period ca. 1952 to ca. 1980. | 40 |
| New taxa described by botanists directly associated with the Ethiopian Flora Project during the period ca. 1975-2009 | 350 |
| New taxa described by botanists loosely or not associated with the Ethiopian Flora Project during the period ca. 1975-2009 | 120 |
| Total | 3220 |

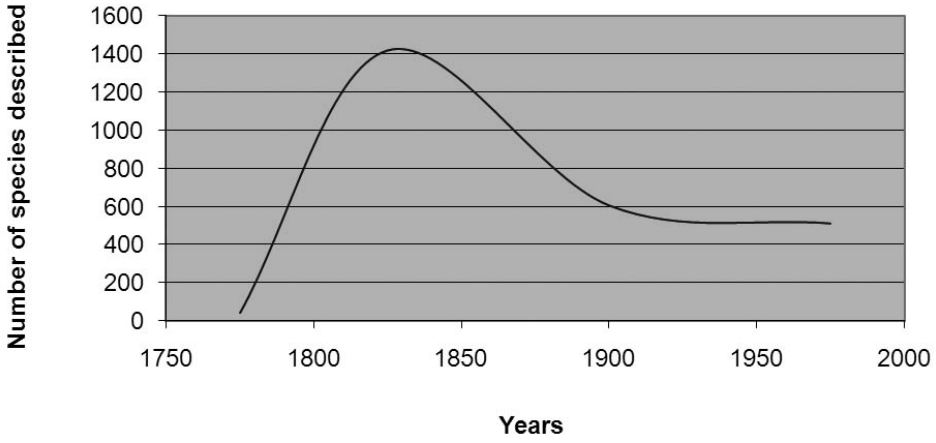


Fig. 2. Number of Ethiopian and Eritrean species of vascular plants described as new to science per 50 years.

## Discovery of additional species in Ethiopia and Eritrea ("Floristic change")

Previous to this survey, no attempt had been made to estimate the number of new records for Ethiopia and Eritrea made during the period in which Flora was prepared. This is attempted here and presented in Table 6, where the Flora of Ethiopia and Eritrea has been studied volume by volume in order to observe likely new floristic discoveries. The number of such species has been recorded for each volume.

Table 6. Estimation of new floristic discoveries made during the period of the Flora of Ethiopia and Eritrea.

| | **Number of species described from material collected in other countries and represented in the FEE by only one record, which was made during the period of the project** | **Number of additional species added in Appendices after their main family account had been published in the FEE** |
|---|---|---|
| Vol. 1 (2009). | 22 | 104 |
| Vol. 2 (in two parts; 1995-2000). | 54 | 20 |
| Vol. 3 (1989). | 31 | -- |
| Vol. 4 (in two parts; 2003-2004). | 39 | -- |
| Vol. 5 (2006). | 52 | -- |
| Vol. 6 (1997). | 67 | |
| Vol. 7 (1995). | 43 | |
| Tesfaye Awas *et al.* (2007). | n.a. | [6 - new records are also included in the Appendix to FEE, Vol. 1] |
| Friis *et al.* (2011) | n.a. | 8 |
| Total | 308 | 132 |

The basic criterion for inclusion in the left column is that only one collection is cited.

- If there is more than one collection, e.g., one type and one additional collection, the species has not been counted.
- Species with only one collection that are significantly older than the Flora project have been omitted, e.g., specimens collected by Schimper, Baldrati, Pappi, Ruspoli & Riva, Pappi, Corradi, or other similar records.
- Species that are known from a type collection made inside the Flora area after the approximated beginning of the Flora project have not been counted either.

The volumes appeared in non-numerical sequence, as they were completed: Vol. 3 (1989) – Vol. 7 (1995) – Vol. 2:2 (1995) – Vol. 6 (1997) – Vol. 2:1 (2000) – Vol. 4:1 (2003) – Vol. 4:2 (2004) – Vol. 5 (2006) – Vol. 1 (2009) – Vol. 8 (2009).

Species counted as new floristic records in Table 6 obviously include those that appear in the Appendices to Vol. 1, Vol. 2(1) and Vol. 2(2) with new records made after the publication of the main Flora account of the particular family. However, it has also been attempted to count newly recorded species in the main family accounts of the Flora. Likely candidates for this category are such species that, according to the text of the Flora

accounts, are known from only one floristic province and only have one collection cited. An additional criterion for inclusion in Table 6 is that the collector cited in the Flora has been active in the period during which the Flora was produced.

The list in Table 6 does not include cultivated garden plants that have not been recorded as escaped. Similarly, unnamed species, only identified by collector and number, have been omitted unless they were subsequently described and included in one of the Appendices. Species known from only a type collection from Ethiopia or Eritrea have not been counted either, because species in that category have been counted in the evaluation of new taxa described during the Ethiopian Flora Project (Friis and Edwards, 2001).

It seems worth noting that about 450 previously described species have been added to the flora during the period of the Ethiopian Flora project. To this has to be added the ca. 470 taxa newly described during the Flora period. This means "floristic" and "taxonomic" changes of over 900 species or taxa of lower rank during a period approaching 40 years.

A summary and a diagrammatic representation of the recent changes in our knowledge of the flora of Ethiopia and Eritrea are shown in Fig. 3.

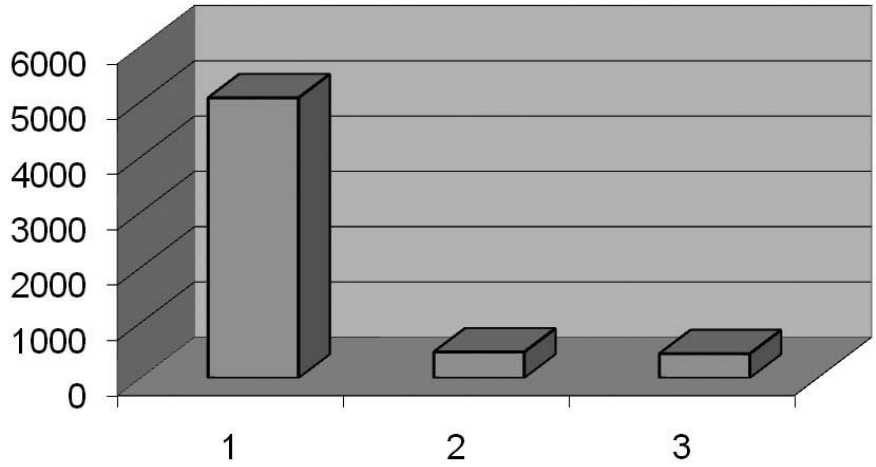


Fig. 3. Recent changes in the Ethiopian and Eritrean flora. (1) Number of known species at the beginning of the Flora project. (2) Number of newly described species during the Flora project. (3) Number of described species found during the Flora project.

## Studies of introduced, naturalised and invasive species

It is likely that one could extract more information about introduced, naturalised and invasive species from the *Flora of Ethiopia and Eritrea*, in combination with other literature, and with detailed observations of herbarium material. Such studies should preferably be based on a combination of studies in the field to observe the behaviour of the species in nature and of studies in the herbarium and in the literature. For certain invasive species in Ethiopia, e.g., *Parthenium hysterophorus* L. (Asteraceae), originally a species of the American tropics, and *Salvia tiliifolia* Vahl (Lamiaceae), originally a species of the central American mountains, the author has been able to follow their increasing frequencies in the field, and it would seem desirable if others made systematic studies of these and similar potentially harmful species. About *Parthenium hysterophorus* there is a reasonably detailed note in the Flora: "*P. hysterophorus* was recently (probably between 1974 and 1980) introduced in the Flora area. The seeds of this species were brought into the country with imported and/or donated grains. The species first established itself in and around Dire Dawa (in HA) and later on spread as far as Nazareth, central SU. It is believed that the shipments containing this species were transported on the Ethio-Djibouti railway line. We have also come across this notorious weed in air fields in Welo, northern Ethiopia, which strengthens the view about its entry routes and mode of introduction into the country." The notes about *Salvia tiliifolia* are similar, but less detailed: "According to Sebsebe Demissew …, the species was introduced in Ethiopia in the 1980's, and it is now spreading vigorously, replacing native herbs at some sites."

## The Orchidaceae in the Nordic countries; An example of "floristic" and "taxonomic" changes in 50 years

For the sake of comparison, a case of changes in a well-studied family in the Nordic flora is presented in detail here.

The two contributors to the account of the Orchidaceae for the *Flora Nordica*, Dr. Henrik Aerenlund Pedersen, Copenhagen, and Dr. Mikael Hedrén, Lund University, have now reached their main taxonomic and floristic conclusions. H.A. Pedersen presented their preliminary findings in a recently held *Flora Nordica*-symposium, and a summary of that presentation, with courtesy of the authors, is presented here as an example of what changes can occur in a well-studied flora. Niels Hylander's treatment of the Orchidaceae in his "Nordisk Kärlväxtflora" volume 2 from

1966 has been used for comparison (Hylander, 1966). The survey given below is outlined in Table 7.

Table 7. Some selected examples of "taxonomic" changes in the Nordic Orchidaceae from Hylander (1966) to Pedersen and Hedrén (unpublished account for Flora Nordica). Varying from case to case, fewer and more taxa appear as a result of the changes.

| | **Hylander (1966)** | **Pedersen and Hedrén (in prep.)** |
|---|---|---|
| Changes in generic delimitation | *Listera* and *Neottia* | *Neottia* |
| | *Anacamptis* and *Orchis* | *Orchis*, *Anacamptis* and *Neotinea* |
| Combined merging and splitting | A range of *Dactylorhiza* species | Fewer species, but more subspecies of *Dactylorhiza majalis* than before |
| | *Epipactis helleborine* var. *Neerlandica* | *Epipactis helleborine* subsp. *neerlandica* with two distinct varieties |
| Merging species | *Epipactis confusa* and *Epipactis phyllanthes* var. *Pendula* | *Epipactis phyllanthes* |
| More complex taxonomy has appeared | *Dactylorhiza incarnata* var. *incarnata, cruenta, ochroleuca, borealis* and *latissima* | *Dactylorhiza incarnata* var. *incarnata, cruenta* and *ochroleuca* |
| | *Dactylorhiza incarnata* var. *dunensis* | *Dactylorhiza incarnata* subsp. *lobelii* |
| | *Dactylorhiza traunsteineri* var. *pycnantha* and *blyttii* | *Dactylorhiza majalis* subsp. *lapponica* |
| | *Dactylorhiza traunsteineri* unnamed var. with unspotted leaves | *Dactylorhiza majalis* subsp. *sphagnicola* |

## "Real" changes in the Nordic Orchid flora

There have been a few cases of what can be described as "real" changes in the Nordic Orchid flora, changes that are simply due to extinction or immigration, both natural and caused by man. One species has gone extinct in the flora area, the ground orchid *Spiranthes spiralis* (L.) Chevall. It has not been observed since two individuals flowered in Denmark in 1981.

Three taxa have immigrated naturally during the last 50 years or have become naturalised:

(1) *Dactylorhiza majalis* (Rchb.) P.F.Hunt & Summerh. subsp. *integrata* (E. G. Camus) H.A. Pedersen – also known as *Dactylorhiza praetermissa* (Druce) Soó – has probably immigrated naturally to Denmark.

(2) The origin of two populations of *Ophrys apifera* Huds. in Denmark is uncertain. The species may have immigrated naturally from the nearest populations to the south, or the species may have been naturalised from cultivated plants.

(3) Two confirmed Nordic occurrences of *Dactylorhiza majalis* (Rchb.) P.F.Hunt & Summerh. subsp. *baltica* (Klinge) H.Sund. have apparently

originated from casual introduction by timber from the Baltic countries.

Table 8. Net changes in genera and species – including both "real", "floristic" and "taxonomic" changes in the orchid flora of the Nordic countries from Hylander (1966) to Pedersen and Hedrén (unpublished account for Flora Nordica).

| | **Hylander (1966)** | **Pedersen and Hedrén (in prep.)** |
|---|---|---|
| Genera | 24 | 23 |
| Species | 48 | 47 |

## "Taxonomic" changes in the Nordic Orchid flora due to new methods and techniques

"Taxonomic" changes are more numerous than the changes due to extinction and immigration. In most cases, the new interpretations are based on methods and techniques not available in the 1960s, including basically two groups of methods:

(1) DNA sequencing and fingerprinting techniques, and

(2) Computerised multivariate statistical analysis of large molecular or morphometric data sets.

### Changes in generic taxonomy

Analyses of DNA sequence data has in two cases led to changes in generic delimitation:

(1) In the *Neottia*/*Listera*-group, Hylander (1966) recognized two genera: the autotrophic *Listera* R. Brown in W. T. Aiton and the mycoheterotrophic *Neottia* Guettard. However, recent DNA-studies indicate that *Neottia* is embedded in *Listera*, and when the two genera are combined, the name *Neottia* has priority over *Listera*.

(2) A more complicated case is that of the *Orchis*/*Anacamptis*/*Neotinea*-group. Hylander (1966) recognized a monotypic *Anacamptis* L. C. Richard and a widely delimited *Orchis* L. But recent analyses suggest that the eight Nordic members of the group are to be reorganized into three genera: *Orchis*, *Anacamptis* and *Neotinea* Rchb. f. These can no longer be distinguished by floral features, but morphological distinction of them is still possible if vegetative features are also used.

### Taxonomic changes involving both merged and newly described species and infraspecific taxa

There are two examples involving both merged and newly described species and infraspecific taxa in the new *Flora Nordica*:

(1) Molecular studies have demonstrated that a number of tetraploid taxa in *Dactylorhiza* Necker ex Nevski combine diploid genomes from the two species *Dactylorhiza incarnata* (L.) Soó (in a wide sense) and *Dactylorhiza maculata* (L.) Soó (in a wide sense). Most of these allotetraploid taxa were treated as distinct species by Hylander (1966). But due to their close genetic relationships they are now placed in one species, for which the oldest available name *Dactylorhiza majalis* has priority. Some of Hylander's allotetraploid species are maintained as distinct subspecies under *Dactylorhiza majalis*.

(2) Since Hylander (1966), a few Nordic endemic infraspecific taxa have been described as new to science, e.g., in the genus *Epipactis* Zinn, and some of these will be accepted for the new *Flora Nordica*, but not necessarily at the taxonomic level at which they were first described. Hylander recognized a so-called *Epipactis helleborine* (L.) Crantz var. *neerlandica* Verm., comprising populations of mainly outcrossing as well as consistently self-pollinated individuals. Var. *neerlandica* has been raised to the level of subspecies as subsp. *neerlandica* (Verm.) Buttler; this will be accepted in *Flora Nordica* and the outcrossing and selfing populations will be placed in two different varieties.

**Merging of taxa since Hylander's Flora**

Examples of merging taxa considered distinct in Hylander's treatment. One case is concerned with species in a complex of self-pollinated *Epipactis*. Hylander (1966) recognized two taxa: *Epipactis confusa* D. P. Young and *Epipactis phyllanthes* G. E. Sm. var. *pendula* D. P. Young. However, new studies – morphometric and genetic – have failed to find any genetic discontinuity, for which reason all populations are placed in one species, *Epipactis phyllanthes*.

**Cases where a more complex taxonomy has emerged**

In two cases, work for the new *Flora Nordica* has given more complex results than presented in Hylander's Flora:

(1) The case of *Dactylorhiza incarnata* (L.) Soó. Hylander (1966) recognized 6 varieties in *Dactylorhiza incarnata*: var. *incarnata*, var. *cruenta* (O. F. Müll.) Hyl., var. *ochroleuca* (Boll) Hyl., var. *borealis* (Neum.) Hyl., var. *latissima* (Zapol.) Hyl. and var. *dunensis* (Druce) Hyl. The new treatment will maintain var. *incarnata*, *ochroleuca* and *cruenta*, while var. *borealis* and *latissima* will merge with var. *incarnata*. The Nordic plants that Hylander called var. *dunensis* had a name based on material from

Scotland that, in all probability, is a form of the British *Dactylorhiza incarnata* subsp. *coccinea* (Pugsley) Soó. The Nordic material should be referred to a continental European subspecies of *Dactylorhiza incarnata* called subsp. *lobelii* (Verm.) H. A. Pedersen, described on material from the Netherlands.

(2) The case of an allotetraploid population that Hylander (1966) assigned to *Dactylorhiza traunsteineri* (Saut.) Soó. Hylander recognized three distinct varieties in *Dactylorhiza traunsteineri*: var. *pycnantha* (Neum.) Hyl., var. *blyttii* (Rchb. f.) Soó (both with spotted leaves) and var. *traunsteineri* (with both spotted and unspotted leaves). These varieties are now found to be members of an allotetraploid complex and all will be assigned to *Dactylorhiza majalis*. But the question is how many "*traunsteineri*-like" infraspecific taxa to recognize under *majalis*? In *Flora Nordica*, all spotted plants in this complex will be called *Dactylorhiza majalis* subsp. *lapponica* (Hartm.) H. Sund., as the epithet *lapponica* has priority over *traunsteineri* at subspecies level. The unspotted forms that were mentioned, but not formally recognized by Hylander, will be treated as *Dactylorhiza majalis* subsp. *sphagnicola* (Höppner) H.A. Pedersen & Hedrén, a taxon that is morphologically, genetically and ecologically distinct from subsp. *lapponica*.

The bottom line figures for this review involves a very small net loss of orchid-taxa in the Nordic Flora on the generic and species-levels, but that net result hides quite a number of changes that involve both extinction and immigration, discovery of new taxa and splitting and merging of already known taxa.

## DISCUSSION

From the preceding observations and summaries, it is clear that, as a flora gets better known, the number of indigenous species reaches gradually a relatively steady level. Only man-made destruction or indirect extinction through changing environmental conditions may change that number, which, however, may be counter-balanced by immigration. The situation in the Nordic countries is relatively well known, whereas that in Ethiopia and Eritrea is difficult to ascertain because a steady-state level of the number of known indigenous taxa seems not yet to have been established.

In the Orchidaceae of the Nordic flora, taxonomic changes in the indigenous flora seem to have made the numerical size of the flora fluctuate more than what extinction does. Again, the situation in the *Flora of Ethiopia and Eritrea* is difficult to record as of yet.

The number of non-indigenous species may fluctuate considerably more than the number of indigenous species, and species come and disappear. Generally, the overall number seems to be relatively stable or slightly rising, from 290 in 1796, through 479 in 1886-1888 to 391 in 1981 and 387 in 2000 (Table 2). Again, the situation in the *Flora of Ethiopia and Eritrea* is difficult to record.

Refined taxonomic studies may cause changes. In the Orchidaceae of the Nordic countries, these have affected some species, but mainly at the infraspecific level. Some may argue that such taxonomic 'refineries' are unnecessary in Ethiopia and Eritrea, and that it is a luxury to study a plant group in such detail. It is only in families where there are many detailed studies of chromosome-taxonomy, molecular systematics and morphometric studies that such conclusions can be drawn. We can only wait and see if the techniques become cheaper and easier to perform.

What has the future in store for the information in the *Flora of Ethiopia and Eritrea*? We can only say with certainty that it will become outdated, a milestone and an important historical document like those of Richard (1848-1851) and Cufodontis (1953-1972) for Ethiopia and Eritrea and Lange (1886-1888) and Hylander (1966) for the Nordic countries, with information that is highly useful for comparison with the situation at a later time. Extinction and immigration will continue to occur; taxonomic changes will be made. For the Nordic countries, about 50 years elapsed between the attempt by Hylander (1966) to write a Nordic Flora and that of the current attempt. Will it also take 50 years before we see a new Flora to cover Ethiopia or Eritrea, incorporating these changes?

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