ORCHID COLLECTIONS – THEIR PURPOSE AND USE

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Bulbophyllum imbricatum, Vanilla aphylla, Hoffmanseggella cinnabarina
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**Abstract**

The number of botanic gardens and arboreta in the world is currently around 3000, collectively cultivating approximately 100 000 species of the world’s estimated 391 000 vascular plant species. Botanic Gardens Conservation International (BGCI) has defined botanic gardens as: “institutions holding documented collections of living plants for the purposes of scientific research, conservation, display and education.” In our changing world where loss of biodiversity is one of our greatest societal challenges, botanic gardens need to develop their collections in carefully planned ways to contribute to the conservation of biodiversity. With orchid collections as role models and based on the BGCI criteria, this study investigates what botanic gardens consider to be their main purpose today, and whether this has changed over the last five years. A questionnaire was sent to 1833 gardens in the BGCI network, yielding almost 100 answers from orchid collections from all over the world. In addition, three gardens were visited for in-depth interviews, Copenhagen, Munich and Kew Gardens. The largest percentage of gardens (38 %) considers ‘Display’ as most important criterion when making acquisitions and prioritizations in orchid collections today. In contrast, the criterion that has increased most in importance over the last five years is ‘Conservation’, where this increase was recorded in 35% of all gardens. Together, these results show that aesthetic values have dominated the choice of which orchid species to cultivate in most botanic gardens. But since the importance of conservation increases for many gardens, this situation is now expected to change.

**Sammanfattning**

Orkidésamlingar - syfte och användning

Det finns omkring 3000 botaniska trädgårdar och arboreta i världen som tillsammans odlar ungefär 100 000 av de uppskattningsvis 391 000 kända växtarter i världen. Botanic Gardens Conservation International (BGCI) definierar botaniska trädgårdar som: institutioner med dokumenterade samlingar av levande växter för forskning, artbevarande, display (visning), och utbildning. Världen förändras och förlust av biologisk mångfald är en av vår tids största utmaningar. Därför behöver de botaniska trädgårdarnas arbete med sina samlingar utvecklas för att på bästa sätt bidra till bevarandet av den biologiska mångfalden. Baserat på BGCI:s definition och med orkidésamlingar som exempel, undersöker den här studien vad botaniska trädgårdar ser som sina samlingars viktigaste syften och om de har förändrats de senaste fem åren. En enkät skickades ut till 1833 trädgårdar i BGCI:s nätverk vilket resulterade i cirka 100 svar från orkidésamlingar i hela världen. Dessutom har Köpenhamn, München och Kew gardens besökt för intervjuer. Den största andelen trädgårdar (38%) anser att 'Display' är viktigast vid nyfövärv och prioriteringar av växter i orkidésamlingen idag medan 'Artbevarande' har ökat i betydelse för flest trädgårdar (35%). Sammantaget visar dessa resultat att estetiska värden har dominerat vid valet av vilka orkidéarter som odlas i de flesta botaniska trädgårdar. När nu artbevarande blir allt viktigare för fler trädgårdar kan en förändring förväntas.
Introduction

Of the world’s estimated 391,000 vascular plant species (State of the World’s Plants 2016) approximately 100,000 species are cultivated in botanic gardens and arboreta around the world. There are currently around 3000 Botanic Gardens (BGCI, 2012) of which many keep orchid collections, the sizes, compositions and purposes of which vary hugely. However, no comprehensive information on this variation is readily available.

Orchidaceae is one of the largest families of flowering plants consisting of an estimated 27,801 species (The Plant List, 2017.03.22) which are found on all continents except Antarctica. Orchids grow in varying biotopes from cold mountainous areas to tropical rainforests. Many species are threatened by habitat destruction, degradation, fragmentation, climate change and over-collecting (Cribb et al. 2003), and a large number of orchids are listed as endangered or critically endangered in the International Union for Conservation of Nature (IUCN) Red list.

The spectacular flowers of orchids, with their intriguing ways of pollination and richness in colors and shapes, have made them popular to home growers as well as collectors, botanical gardens and similar institutions.

In our changing world where loss of biodiversity is one of our greatest societal challenges, botanic gardens need to develop their collections in carefully planned ways as to contribute to the conservation of biodiversity.

The collections of a botanic garden where perhaps several thousands of species are cultivated, with often a single or a few specimens per species, demand skilled and intense maintenance to avoid lowering the value of the collection by loss of difficult or rare species. The risk of bringing more specimens to the collection than resources allow could be that the number of plants increase, but the value of the collection is lowered.

Different aims need different approaches. For example, if the ambition is having a collection for primarily use in research, the choice of species and facilities is not the same as for a collection with the purpose of display (to attract visitors). These aims can and perhaps should intertwine sometimes using different parts of the collection for different ambitions, but clarifying the purpose of a collection or specimen is of importance. A documented clear purpose, acting as support for acquisition and prioritization of plants, should increase the possibility of achieving the objective.

Botanic Gardens Conservation International, BGCI, is an independent UK charity established in 1987 to link the botanic gardens of the world in a global network for plant conservation. BGCI has defined botanic gardens as: “institutions holding documented collections of living plants for the purposes of scientific research, conservation, display and education.”

The orchid collection in Gothenburg Botanic Garden provides a good example of how a collection has developed through the love of plants and with an ambition to show variety. This has consequently resulted in a collection with “a bit of everything”. As part of the process of planning for new public greenhouses in Gothenburg Botanic Garden we now need to clarify and strengthen our purpose and aim. We need to state our needs as regards to the greenhouse area in square meters, which climates will be needed, and the arrangements of the propagation houses, exhibition houses and other facilities such as quarantine, classrooms, facilities for seed storage etc. The intention is to create a collection that is a valuable resource for the university and well utilised by scholars and by society as a whole.
This study is devised to gain knowledge about orchid collections from around the world and what they consider to be their main purpose and aim. In order to find out whether those aims and purposes are static or change over time, the study reports changes over the last five years. It also examines whether the purpose the gardens see as most important are met. For example, for gardens which regard 'Scientific research' as the most important criterion: do they have many research projects? In the case of 'Display' being most important: do they have many visitors? And for 'Conservation', are there many on-going conservation projects?

**Material and Methods**

**Interviews**

The start of the project was to identify three botanic gardens with large orchid collections suitable for deeper investigation and interviews about their conditions, approaches and purposes. I attempted to find collections with variation in foci and size and a person willing to be interviewed. For this selection, I used internet searches, personal contacts, and a listing of the 10 largest orchid collections provided by the Botanic Gardens Conservation International. From the information gathered, and for practical reasons, I choose the Natural History museum of Denmark Botanic garden in Copenhagen, Munich Botanic garden in Munich-Nymphenburg, Germany, and the Royal Botanic gardens, Kew, in London, United Kingdom, to visit for interviews.

**Questionnaires**

The second step was to make a questionnaire and have it distributed to as many botanic gardens as possible. A first questionnaire (from now referred to as mailq) was sent out as an e-mail intended to be replied and filled in. For this I again took advantage of BGCI. More than 500 botanic gardens in 96 countries are members of BGCI and more can be reached within their network as associates. The database Garden search [http://www.bgci.org/garden_search.php](http://www.bgci.org/garden_search.php), comprises 3,371 botanic institutions worldwide. Its data are primarily provided and managed by individual institutions. The search terms 'orchids' yielded 178 gardens, 'orchid' 43 gardens and 'Orchidaceae' 100 (accessed 2017.01.14).

Out of the 178 gardens identified, I was able to obtain e-mail addresses for 135, of which 34 bounced as undeliverable. This resulted in six completed questionnaires after a week. In addition, I received several e-mails with information and explanations regarding the current situation of some orchid collections.

A second questionnaire (from now on referred to as internetq) was sent by Abby Hird Meyer, BGCI, directly to members and associates. Prior to that, she remade the questionnaire in Survey monkey and added a few questions of relevance for their organisation. The internetq was sent out to 1,833 staff contacts from Garden Search 2017.01.27 as an e-mail with a link. Reminder emails were sent out to 362 gardens who had made reports of orchid taxa in Plant Search 2017.02.09. Plant search [https://bgci.org/plant_search.php](https://bgci.org/plant_search.php), is BGCI’s global database of living plants, seed and tissue collections, where 1144 institutions have registered their collections. The survey closed on the 20th of February. When rating importance of criteria on a scale from 1-5 (question no 7), more than one criteria could be given the same status. Two respondents answered no 5 (most important) on all four criteria and one respondent answered 1 (least important) on all. In mailq two respondents answered 5 for all criteria. These answers were still included. For the number of visitors, I recreated new intervals and regrouped the answers together on a more suitable scale than originally requested. Both questionnaires are provided in Appendix.
Results

Questionnaires

The first questionnaire (mailq) received 9 completed answers, while the second questionnaire (internetq) had 89 completed questionnaires. The responses from these two questionnaires were combined for all subsequent analyses unless otherwise stated.

Distribution of responses:

**Oceania** (10): Tasmania 1, New Zealand 4, Australia 4, Papua New Guinea 1  
**South America** (3): Brazil 1, Colombia 1, Costa Rica 1  
**Asia** (6): Indonesia 1, Malaysia 1, Nepal 1, Russia 2, China 2  
**Africa** (5): Kenya 1, Namibia 1, Republic of South Africa 2, Zimbabwe 1  
**Europe** (27): Austria 1, Belarus 1, Belgium 1, Czech republic 1, Estonia 1, France 1, Germany 1, Greece 1, Italy 4, Norway 1, Poland 2, Scotland 1, Spain 1, Switzerland 1, UK 4, Hungary 1, Netherlands 1,  
**North America** (39): Canada 6, Mexico 5, The Bahamas 1, USA 28, Turks &Caicos Islands (UK) 1

Importance of criteria

![Importance of criteria](image)

**Figure 1.** Criteria, most important and least important 2017 Orchid Collections Questionnaire Question no. 7 and Mail Questionnaire Question no. 10. *"Please rate the importance of these criteria when currently making acquisitions and prioritizing in your orchid collection 5 (most important) 1 (least important)"

Documented clear purpose and database

A documented clear purpose is used by 52% of the gardens while 42 % do not have a documented clear purpose. 5 % answered that this is unknown.  
Electronic plant records databases are used by 69% while 12 % do not have one, and for 18 % an electronic plant database is in progress.  
The electronic plant records database is accessible to the public for 21 % of the gardens (internetq) while database is uploaded to BGCI Plant Search for 34% of the gardens (internetq).
Change in importance of criteria

**Figure 2. Change in importance of criteria: Display**

2017 Orchid Collections Questionnaire Question no 7 part 2. “Please characterize importance with the following criteria today compared to 5 years ago.” Mail questionnaire Question no.10 part two: “How important was this five years ago?”

**Figure 3. Change in importance of criteria: Conservation**

2017 Orchid Collections Questionnaire Question no 7 part 2. “Please characterize importance with the following criteria today compared to 5 years ago.” Mail questionnaire Question no.10 part two: “How important was this five years ago?”

**Figure 4. Change in importance of criteria: Education**

2017 Orchid Collections Questionnaire Question no 7 part. “Please characterize importance with the following criteria today compared to 5 years ago.” Mail questionnaire Question no.10 part two: “How important was this five years ago?”

**Figure 5. Change in importance of criteria: Scientific research**

2017 Orchid Collections Questionnaire Question no 7 part 2. “Please characterize importance with the following criteria today compared to 5 years ago.” Mail questionnaire Question no.10 part two "How important was this five years ago?”
Change in number of visitors, conservation projects, number of students and scientific research projects

Figure 6. Number of visitors compared to five years ago (internetq) 2017 Orchid Collections Questionnaire Question no 1 part 2: “Please characterize your living orchid collection with the following criteria today compared to 5 years ago.”

Figure 7. Number of conservation projects compared to five years ago (internetq) 2017 Orchid Collections Questionnaire Question no 1 part 2: “Please characterize your living orchid collection with the following criteria today compared to 5 years ago.”

Figure 8. Number of students visiting today compared to five years ago (internetq) 2017 Orchid Collections Questionnaire Question no 1 part 2: “Please characterize your living orchid collection with the following criteria today compared to five years ago.”

Figure 9. Number of scientific research projects today compared to five years (internetq) 2017 Orchid Collections Questionnaire Question no 1 part 2: “Please characterize your living orchid collection with the following criteria today compared to five years ago.”
To assess whether there are more visitors to gardens that regard Display as most important and have a documented clear purpose (totalling 32), that group was subdivided in two: those with documented clear purpose (14 gardens) and those without documented clear purpose (18 gardens). The gardens with unknown number of visitors were disregarded, 5 with documented clear purpose and 8 without. The sum of visitors to each group was divided by the number of gardens in the group (when there was a span in number of visitors, the average was used). Those with clear purpose had a total number of 2 007 031 annual visitors and those without documented clear purpose had 1 175 330 visitors. This resulted in an average number of visitors of 223 003 for the gardens with clear purpose and 117 533 for the gardens without documented clear purpose.

**Figure 10. Number of visitors (89 gardens) 2017 Orchid Collections Questionnaire, Question no.1 “Please characterize your living orchid collection with the following criteria: Orchid collection visitors Approximate current total/ Annual Average.”** (internetq)

**Figure 11. Number of visitors to gardens that regards display as most important (32 gardens). 2017 Orchid Collections Questionnaire Question no 1 “Please characterize your living orchid collection with the following criteria: orchid collection visitors Approximate current total/ Annual Average.”** (internetq)
To investigate if gardens with a documented clear purpose and aim are more successful in their ambition to work with conservation (have more ongoing conservation projects), the group that regards conservation as most important was subdivided into two: those with a documented clear purpose and aim (18 gardens), and those without a documented clear purpose and aim (6 gardens). Unknown and skipped answers were disregarded. The total number of conservation projects for the gardens with a documented clear purpose was 44-96 projects (answers given in interval), and for the gardens without documented clear purpose 8 projects. This results in 2.4-5.3 conservation projects per garden for those who do not have a documented clear purpose.
To assess whether more scientific research is conducted in collections with a clear purpose, the group that regards Scientific research most important (totalling 16) was subdivided in two: those with documented clear purpose (10 gardens) and those without documented clear purpose (5 gardens). One answer which had an unknown number of scientific research projects was disregarded. The total number of research projects in gardens with documented clear purpose was 48-138, and for those without documented clear purpose 13-17. This results in an average of 4,8-13,8 scientific research projects per garden for gardens with documented clear purpose and 2,6-3,4 scientific research projects for those without documented clear purpose.

An electronic plant record database is utilized by 81 % of the gardens that regard scientific research as most important criteria, while 13 % have an electronic database in progress and 6 % have no electronic database. The electronic database is online and accessible to the public in 12 % (2 gardens) and data are uploaded to BGCI Plant search for 19% (3 gardens) in this subgroup that regards scientific research as most important.
Interviews

Copenhagen Botanic Garden, interview with Rasmus N. Kloster, team leader of the greenhouses.

The garden was established already in the 1600’s. The orchid collection today consists of approximately 1000 accessions distributed over 500 botanical taxa. All accessions are today of wild documented origin, whereas almost all accessions of cultivated origin have been considered less important and redundant. Visitors to the garden are about one million a year including a great number of tourists in the summer. The number of visitors has increased over the last 5 years. Garden entrance is free as is the entrance to the greenhouses. The garden belongs to the university, and is dependent on its economy. There is an orchid display house and a closed collection house which opens for pre-booked guided tours only. Plants from the collection house are never displayed, due to lack of time and risk of plants being stolen.

During the last few years the number of staff has been reduced and there are now concerns about the possibility of keeping the orchid collection, as well as the other plant collections, at an acceptable maintenance level. More plants will be planted in beds instead of pots to decrease time consuming watering and repotting. A new database is needed, as today staff have difficulty finding accessions.

Years ago, the collection of tropical orchids was intensely used for scientific research but today there is no research on the collection. Scientific research made in the collections in the future would be very important for their development and economy.

Signs with information about plants are made by the department for communication at the university. The collection of orchids most probably contains threatened species, but under the present circumstances the collection is not curated or used for scientific work. The aim and purpose of this garden has changed, earlier it has been to collect as many interesting plants of any kind as possible to be of use in research, for education and display, today it is to keep the collections alive. For the future, the question about more staff, gardeners and curators, or significantly less plants, is overshadowing all other subjects.

Munich botanical garden, interview with Dr Günther Gerlach, Chief Curator, and Bert Klein, Head gardener Orchids

The garden was established on its current location in the early 1900’s when moved out from the city centre. The orchid collection consists of approximately 3500 accessions of which 1800 are botanical taxa. These numbers have been stable over the last five years. The garden belongs to the state rather than the university.

The number of visitors to the orchid collection (greenhouses) is 400 000 to 500 000 per year and this has been stable or slightly increased during the last five years. There is a fee for entrance to the greenhouse. Large numbers of students and school children visit the greenhouse regularly, and this has increased.

Currently there are no conservation projects in the orchid collection in the garden, but there is a satellite garden with projects of reintroduction of local orchids.

The number of staff working with the collection has decreased somewhat, but not at all as dramatically as other gardens in the area. The greenhouses have one orchid display house with one display case behind glass, but most of the collection is in production greenhouses with no access to the public. There is no documented clear purpose of the
orchid collection, but the garden is specialised in certain genera; other than this, the overall aim is to show the diversity of orchids, and to raise the interest of biodiversity. There is an electronic plant records system, but not all plants are registered yet, and in the near future the database needs to be renewed. The database is accessible to all staff in the garden. The lack of information about origin for very old plants is a problem. There is research made in the collection today, by the curator of the collection, who also works closely with universities in South America, and therefore scientific articles are also written in Spanish. It is regarded important to have research on the collections in the future, for the economy and development of the collection. Years back, more fresh material was needed for research.

The collections are used for education in many ways, tours for schoolchildren are carried out by the organisation who runs classes for school children in all museums of the state. The garden also runs its own guided tours, for local groups and students. Every second Sunday there are lectures with different themes. “We like to impress the visitors with interesting stories”. The overall message is to inspire and inform people about nature, but also to talk about destruction of habitats and other threats. People can then make their own decision on how to act. There is also an ambition to work more with information signs, but time for this is lacking.

Display in general and attracting many visitors is very important. The climate in the display house is not suitable for growing cold-adapted orchids, so these cannot be on display. To attract visitors during the winter one greenhouse is arranged to host butterflies with their associated plants, which has been very successful.

New plants are brought to the collections by exchange with gardens and growers, and sometimes plants are bought. The botanic gardens in this country have annual meetings and good cooperation between gardens for exchange of plants, experiences and lectures

For the future, there are concerns about the priority and approach to the orchid collection when the curator retires in a few years.

Kew gardens, Interview with Andre Schuiteman, research leader and curator of the Asian part, and Bala Kompalli, horticulturist Orchid unit

The garden was founded in mid 1700’s. The orchid collection consists of 10 000 accessions with known origin, representing 1500 species plus some very old hybrids which have a cultural and horticultural value.

There are approximately one million visitors per year. The number of staff has decreased over the last five years. There is a fee for entrance to the garden that includes entrance to all greenhouses. Collection houses are separated from the Display house which has a more natural part and a glassed display case for flowering orchids in pots. A lot of visitors are important for the economy, and therefore also display. A reduced entrance fee is used to encourage schools to visit the garden which has resulted in an increase of schools visiting.

The main theme here is to show the beauty of nature, the variation of biotopes and that the habitat is completely different in a natural forest than in a planted one. It is important to use few pictures and few words so that visitors do not feel they are in school.

Scientific research is carried out in the collections but as there are fewer botanists now there is also less research. Plants collected in the wild are still introduced to the
collection from researchers with a permit to collect, but at a lower level. All such plants are placed in quarantine for one year. Since it is difficult to get permits to collect in the wild, the plant collections will be even more valuable in future. To be attractive to researchers, collections must specialize in something, focus on genera or groups, country or area, grow it well and create an identity around it to get contacts for exchange and collaboration. Database with all accessions is now online and researchers can find species and request DNA samples which they pay for. This has increased the use of the orchid collection. Plant material cannot be sent because of certain rules. There are currently conservation projects with reintroduction of species from the collection. For this type of project, propagation by seed is necessary and also distribution of plants among gardens. Pollination of orchids for seed production and storage of seeds in the Millennium Seedbank is a huge conservation project. Due to new storage techniques, orchid seeds can now be stored safely for a longer time. Seed propagation of orchids take a lot of space. Micropropagation has also been done but that has scaled down. As Display to attract many visitors to the garden is very important, there is an orchid festival with different themes each year, many hybrids are bought in and they are sold or given away afterwards. Plants are also bought from nurseries at times, when they contribute to variation or are interesting in some way. The importance of using nurseries with a documented fulfilment to CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is obvious.

There is no documented clear purpose for the collections, but the overall aim is to gather “as much interesting material of everything as possible”. For the future, it is believed that scientific research is changing, and that there might be less scientific research made in living collections. On the other hand, the values of living collections are increasing as climate change and loss of habitat is making many species severely threatened or even extinct. The thoughts for the future is more collaboration with other gardens, to propagate more and to propagate on demand. The overall ambition is to increase the awareness of the values of plants and nature.

Discussion
Representativeness of the responses
Finding gardens with orchid collections for this project, with information about the size and specializations of collections, was rather difficult as websites are primarily for visitors. The BGCI website with Garden finder is useful, but dependent on the gardens to keep their information correct and updated. Personal contacts were essential and several colleagues confirm that this is the case. Future collaboration and interactions among gardens depends on the capability of identifying fellow gardens, and the ability to communicate efficiently. For Scientific research and Conservation to be effective it is especially important that there is a possibility of finding information about which garden cultivates what, so that the gardens can concentrate on different genera or species and find each other for exchange. This could also be useful to students and visitors.

E-mails to the contact net of BGCI finally yielded 89 answers, which is a satisfactory answer rate considering that the number of gardens that report orchids in Plant search are 362. It also shows that the communication in the network of the BGCI works reasonably well. In the end the support from BGCI saved the project, as the number of answers then were sufficient to complete the study. The fact that the study only reached gardens in the BGCI network is limiting, and even the fact that the questionnaire was in English only. Europe and North America have a far higher number of answers than other
continents, but there are also far more gardens in these parts of the world (Aplin, 2014). Given this background on participants in the survey and interviews, it is obvious that this study should be looked at primarily in a qualitative way.

**Variations among gardens**

The first striking observation is the large variation between the gardens themselves, the economical and organizational conditions under which they work, and the history that has formed the gardens and their specializations. It seems that many gardens are currently facing important questions about development, prioritization, and use of the collections for the future.

Display is the criteria that the largest percent of gardens regard as most important when currently making acquisitions and prioritization in the collection, which means that the choice of plants for these gardens have been dominated by aesthetic values (fig 1).

The number of visitors is most probably very important for these gardens, for economic reasons, either that the garden rely on income from entrance fees and sales, or that the number of visitors is an important purpose stated by stakeholders. Many gardens are also likely to combine this criterion with others. Display has been equally important during the last five years for most gardens, and has increased in importance for some, but only very few state that the importance has decreased (fig 2).

Leaving the importance of criteria and if it has changed, and instead looking at the number of visitors to the gardens, it is evident that this has been steady during the past five years for a large number of gardens, but has increased for a quarter of the gardens. Only a small percent has seen the number of visitors decrease, although a fairly large number of gardens do not know if the number of visitors have increased or decreased (fig 6).

With exception for those gardens that have a clearly stated different mission, attracting visitors (investing on Display) will continue to be very important also in future. This combination of many visitors and a scientific approach to collections and the information about them and related issues can be the strength and uniqueness of the botanic gardens. During the interviews, I have also noticed a genuine interest in showing fascinating and beautiful plants to the visitors by garden employees. Telling the stories in an easy and exciting way, plants with not such conspicuous beauty can also contribute to the experience.

Many gardens have special events for a shorter time of the year, an annual orchid exhibition, orchid festival, or temporarily commercial display. Other featured specialities are intertwining of arts and plants, displaying orchids with other plants as a part of an ecosystem, orchid wall, showing miniatures and a historical theme.

The criterion Display is connected to number of visitors but a comparison between number of visitors to total group (fig 10) and to the subgroup which regards Display as most important (fig 11) does not reveal much difference between the two groups (internet only).

I suspect that this question was unclear/misunderstood because it is strange that in the subgroup that regards Display as most important, there are still many gardens with zero or less than 100 annual visitors. I also wanted to investigate if gardens which regard Display as the most important criterion, and have a documented clear purpose, had more visitors than those without a documented clear purpose. However, as the span of number of visitors was very large, the results were totally dependent on the answers of the three gardens in the group with one million visitors each. The number of visitors
should, of course, be influenced by many other variables as well (several of them not included in my analyses, such as social and economic factors, proximity to cities).

Scientific research is regarded as most important when currently making acquisitions and prioritization in collection for the least number of gardens, and 34 % answered that this is the least important criterion. This places Scientific research with good margin in the top for the least important criteria (fig 1). One of the questions of interest was if the number of scientific research projects in living orchid collections are decreasing due to new techniques and change of foci. The results showed that the number of scientific research projects have been the same during the last five years for most of the gardens while for a part of it has increased. Only a small number of gardens have seen the number of research projects decrease (fig 9).

The interviews pointed out three completely different scenarios concerning scientific research: one had economic reasons, lacked researchers, and had no curator; one had an active curator working with research in the collections, and the third had several ongoing research projects and a service of sending DNA samples to researchers on request. All three pointed out that scientific research projects in collections are important for their economy, and for development of the collection to allow species and genera to be updated with correct names and information, and supplemented if needed.

Comparing the number of research projects in the subgroup that regards scientific research as most important, with the total group, shows that the subgroup has more research projects, which shows that most gardens fulfil their purpose in this case (fig 14,15). The study shows that most gardens in the subgroup that regard scientific research as most important (internet only) have an electronic plant record database already functioning, while a minor part answers “in progress”. However, today only 12 % (internet only) have the database accessible to the public, and so far, no more than 19 % (internet only) in this subgroup have uploaded their data to BGCI’s Plant Search. Uploading data from already existing databases to Plant Search or making it accessible to the public would further connect researchers and gardens, benefitting them both and making the work for biodiversity more effective. From the interviews, I gathered that there is a concern about the consequences of making the database public, such as increased risk for theft of plants, and pressure from others than researchers and conservationists to obtain plants. It was suggested that sensitive species should be shielded, so that not all species could be seen by everyone on the database. It would be interesting to find out from gardens which have made their database accessible to the public, what their experiences are, if the use of the collection has increased and if there has been any kind of problems connected to this.

Conservation has been equally important over the last five years for the majority of the gardens. In contrast, comparing between the criteria, Conservation has increased in importance for a larger percent of gardens than the other criteria (fig 3). This might indicate that choice of plants for these collections will be done differently in the future.

The number of Conservation projects in the collections has also been stable for the last five years for the majority of the gardens, but for a quarter of the gardens it has increased (fig 7). What exactly counts as a conservation project is unclear and could have been defined beforehand, but this is a rather complex issue. Is cultivation of one threatened species in a greenhouse a conservation project, or is it only when there is a plan for its reintroduction in the wild? Conservation may also include storage and propagation of seeds. More information on this subject can be found in the BGCI publication International Agenda for Botanic Gardens in Conservation.
Comparing the number of conservation projects in the total group with the subgroup that regards conservation as most important reveals that the number of conservation projects is higher in the subgroup (fig 12,13). Still, 11% of gardens that regard conservation as most important have no ongoing conservation projects. In this subgroup, there is also a clear indication that those with ambitions for conservation projects (regarding it as most important) and those having a clear purpose and aim are fulfilling their ambition to a higher degree than those which do not have a clear purpose and aim. However, this could also be due to other reasons, such as more staff or resources. Surprisingly, the gardens with an electronic database had slightly less number of conservation projects than those without. The gardens with a database in progress were included in the group who do not have an electronic database, which might have affected the result. But once again, it is not possible to establish causality considering the many variables involved, so these links should be interpreted as only indicative and calling for further examination.

Education has increased in importance (fig 4), and so have the number of students visiting. Notably, for many gardens it is unknown if the numbers of students and visitors has increased or decreased (fig 8).

It is easy to state that more international cooperation is important and that a lot of effort should be put into networking and communication between gardens, but in reality, this is often a question of prioritization among other important tasks. With BGCI as a unifying and coordinating partner to facilitate cooperation and communication between gardens, this important exchange is more likely to take place.

Future research could attempt to tease apart the different variables, in order to assess the effect of single variables - such as purpose - on the number of visitors, research projects, and other metrics, while controlling for confounding variables. Since Conservation is increasing in importance, short concrete advice and evaluations of ongoing projects is necessary. For display and information, assuming the botanic gardens can reach a large number of visitors, and that the overall ambition is working for continued biodiversity, irrespective of the basic message that Biodiversity is important - what is the most fruitful concern that will make a change?

**Conclusions**

There is a huge variation among the botanic gardens in the world, what they are specialized in, their assets and problems, and under which conditions they work. Cooperation and contacts between gardens is crucial, and will be even more important in the future, to increase the effectiveness of the work for biodiversity. During this study, I have come to realize the importance of putting the collections in Gothenburg in a wider context. Considering that we are part of the ongoing work in all the 3000 botanical gardens around the world makes the work we do at once appear more powerful and efficient.

Out of the four criteria ‘Display’, ‘Conservation’, ‘Education’ and ‘Research’, Display is the criterion that the largest number of gardens consider as most important when making acquisitions and prioritizing collections today (38%). This means that acquisition of plants is dominated by aesthetic values in these gardens, but also points at the importance of attracting visitors. The combination of large numbers of visitors and sharing deep scientific and up to date knowledge about the collections, plants and biodiversity will most probably be the uniqueness and strength of botanic gardens and their role in the work for biodiversity.
For all four criteria, a majority of the gardens sees no change in importance of the criteria over the last five years. But comparing the four criteria, what has increased in importance over the last five years for most gardens is ‘Conservation’, where an increase was recorded for 35% of the gardens. Definition of what a conservation project is, practical aspects of the implementation, and evaluation of former projects are needed.

The change in techniques and foci of scientific research has not resulted in fewer research projects in these living collections. The number of scientific research projects has been about the same during the last five years for most of the gardens, and for some this has increased. Only a small number of gardens have seen the number of research projects decrease.

Although nothing can be said about cause and effect, those gardens that have a documented clear purpose and ambitions of conservation or scientific research, seem to have more conservation projects and research projects, respectively, than those that do not have a clear purpose and aim.

With the knowledge gained in this study, I draw the conclusion that

- it is best that every garden puts up a plan based on its assets and conditions, identifies what the uniqueness of the garden is and what the specializations are and should be in the future.

- The four criteria: Display, Conservation, Scientific research and Education can help in discussions and with identifying today and future the use of specimens and collections.

- A balance between resources and maintenance of collections and other activities in the garden is of great importance to increase the possibility of fulfilling ambitions.

- It is important to communicate what the specializations are, for improvement of the collection, exchange of knowledge and plants, and for increased use of it.

- Uploading electronic plant records database to BGCI’s Plant search and updating information about the garden and contact details in Garden search can facilitate communication and cooperation between gardens.

From the interviews, I bring these words: - Grow what you can, do it well, and tell everyone about it!
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**References**

D.Aplin, BGCI 2014 BGjournal Vol11(2) 03-08


State of the World´s Plants 2016, Royal Botanic Gardens Kew

IUCN red list  http://www.iucnredlist.org/ International Union for Conservation of Nature

The plant list  http://www.theplantlist.org/

Appendix 1: The Mail questionnaire (enclosed as word document)

Appendix 2: The Internet Questionnaire (enclosed as pdf)