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***Research Article***

# Biodiversity conservation in Botanical Gardens: collection of *Cycadales* Pers. ex Bercht. & J. Presl representatives in the greenhouses of the Peter the Great Botanical Garden (BIN RAS)

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## ABSTRACT

The role of Botanical Gardens in biodiversity conservation is considered. The analysis of the greenhouse collection of *Cycadales* representatives is carried out. Both the general characteristics of this group of plants (distribution, growth forms, reproduction, taxonomy) and the characteristics of the families and genera *Cycadales* presented in the collection of the Peter the Great Botanical Garden are given. In the greenhouses, 47 species of *Cycadales* belonging to 9 genera are grown, all species have a conservation status: CR - 7 species, EN - 10 species, VU - 6 species, NT - 16 species, LC - 8 species.

**Key words:** Biodiversity, botanical gardens, collections of tropical and subtropical plants, *Cycadales*, conservation status.

## INTRODUCTION

The decline in biodiversity is one of the main environmental problems of our time, the consequence of which can be the destabilization of the biota, as well as the loss of the integrity of the biosphere. Thus, the preservation of the diversity of living systems on Earth is becoming a necessary condition for human survival and sustainable development of civilization.

At the moment, thousands of species of living organisms are under threat of extinction; more than 11 thousand plant species are included in the IUCN Red List of Threatened Species (www.iucnredlist.org).

Botanical gardens are essential for the conservation of living resources for sustainable development. The results of work of the world's Botanical Gardens demonstrate that the introduction of plants is an effective, and sometimes the only method of preserving biological diversity. In the collections of the Botanical Gardens, rare and endangered plants of not only local, but also the world flora are presented, research of these species is carried out there, work is carried out to return them to their natural habitats, and also educational activities are carried out.

Botanical gardens can play an important role in the conservation of plant biodiversity by taking on themselves the role of conservation centers of endangered plants in the culture. The purposefulness of acquiring garden collections is now more and more acquiring a nature conservation tint, the accumulation of the gene pool of rare and endangered plants is becoming one of the priority areas of research, since the preservation of a particular species in culture is sometimes the only way to safe it on Earth. The task of Botanical Gardens is not only the ex situ conservation of rare, endangered and vulnerable plant species, but also an in-depth study of the biology of their development, flowering, pollination and fruiting in order to reproduce and increase the number of such species. Large greenhouse collections can also contribute to the conservation and reintroduction of endangered species. In our garden, we already have experience in returning to nature 100 *Cycas micholitzii* seedlings grown from seeds obtained in greenhouse conditions (Arnautova, 2010).

## MATERIALS AND METHODS

The research object is the greenhouses' collection of Peter the Great Botanical garden (BIN RAN). The collection of *Cycadales* has been revised. Plants of this group grow in subtropical and tropical greenhouses. The taxonomy has been checked with the help of the joint encyclopedic online-project The Plant List (www.theplantlist.org), the same source has provided the data concerning the number of genera and species of *Cycadales*. The conservation status is assigned, according to The IUCN Red List of Threatened Species (www.iucnredlist.org).

## RESULTS AND DISCUSSION

*Cycadales* are a very ancient group of seed plants, fossil remains are known from the early Permian period. Cycads live in all parts of the world except Europe and Antarctica.

The American group of Cycads includes the genera *Zamia* L., *Ceratozamia* Brongn., *Dioon* Lindl. and *Microcycas* (Miq.) A. DC. African Cycads are represented by the genera *Encephalartos* Lehm. and *Stangeria* T. Moore. Finally, the most extensive area (Australia, South and Southeast Asia, islands of the Indian and Pacific Oceans) is inhabited by species of the genera *Cycas* L., *Macrozamia* Miq., *Lepidozamia* Regel and *Bowenia* Hook. ex Hook. f.

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The life forms (more precisely, the growth forms) of the Cycads, reflect the centuries-old adaptability to the habitat (Stevenson, 1990). Some of the Cycads are tree-like, with their appearance resembling palms (the growth form "rosette trees"). There are treelike tall forms, undersized with a tuberous stem, epiphytic (Norstog, K.J., & T.J. Nicholls. (eds.), 1997). Some *Cycadaceae* develop in the soil, due to a shortened stem and a strongly developed and thickened main root, a tuberous formation - a stem root (in our collection - *Cycas micholitzii*).

All Cycads are strictly dioecious plants. On male specimens, microstrobilis are formed, called male cones, on female specimens, megastrobilis (female cones). The exception is the genus *Cycas*, in which the megastrobilis are not collected in cones, but the pinnate sporophylls develop in large numbers at the top of the trunk.

The seed formation process is very slow. More than six months pass from pollination to fertilization, the development of the seed lasts up to two years. All Cycads are characterized by underground germination. The development of seedlings is also very slow. The second leaf in nature usually appears only after a year, the subsequent ones - one per year or even per several years (Whitelock, 2002).

Despite the extreme scientific importance and widespread popularity in horticulture, the phylogenetic relationships within Cycadales are still not fully resolved (Caputo *et al*., 2004; Salas-Leiva *et al*., 2013). According to modern taxonomy, two families are recognized – *Cycadaceae* Pers. (1 genus, 92 species) and *Zamiaceae* Horan. (9 genera, 216 species), sometimes a third, monotypic - *Stangeriaceae* Schimp. & Schenk is distinguished, but the last treatments often include it in the *Zamiaceae* family (Christenhusz *et al*., 2011).

Almost all types of Cycads are listed in the Red Data Books, both regional and global. In recent years, the number of Cycads has declined and they may face the risk of extinction due to inappropriate collection from natural habitats, as well as due to habitat destruction.

In the greenhouses of the Botanical Garden of the BIN RAS, 47 species of *Cycadales* from 9 genera are grown. Some species have already begun to produce seeds. Pollination techniques have been mastered, Numerous experiments on vegetative propagation are being carried out. *Cycas micholitzii* seedlings grown from seeds obtained in greenhouse conditions have already been returned to nature.

***Cycadaceae*** **:** The only genus of the family, *Cycas*, includes 92 species, with the greatest species diversity observed in Southeast Asia.

The natural range of this genus is Asia (from India to Japan), Indonesia, Australia, the Pacific Islands (Mariana, Fiji, Samoa), and Madagascar.

Many species of *Cycadaceae* are under threat of extinction in nature, in many tropical gardens, work is underway to reintroduce rare species in order to ensure the conservation of cycad biodiversity. The genus *Cycas* is fully included in the CITES lists (www.checklist.cites.org).

There are 16 species in the Garden collection, two of them (*Cycas circinalis* L., *Cycas revoluta* Thunb.) are from the pre-revolutionary collection, three species have not been identified yet. Seeds have already been obtained from 4 species: *Cycas brachycantha*, *C. circinalis*, *C. revoluta*, *C. micholitzii* (Table 1).

***Zamiaceae*** **:** The second family of Cycads - *Zamiaceae*, contains 9 genera: *Dioon*, *Encephalartos*, *Macrozamia*, *Lepidozamia*, *Ceratozamia*, *Microcycas*, *Zamia*, *Bowenia*, *Stangeria* (Table 2) and more than 216 species (Christenhusz *et al*., 2011; Stevenson, 1990). Perennial, evergreen or deciduous plants that resemble palms or ferns in appearance. The stem in all genera is underground or high and erect, as a rule, unbranched, cylindrical. Coral-like roots develop at the base of the stem or below the soil surface.

The leaves are pinnate, arranged spirally, sometimes among them there are underdeveloped leaves - cataphylls. Leaflets that are part of a single compound leaf can be dichotomously separated. Female and male sporophylls are arranged spirally along the main axis and collected in strobilis.

*Dioon* dates from the Jurassic period, or possibly earlier. It is represented by 13 species, in the Garden collection - 3. Representatives of the genus are distributed in Mexico and Central America, in the south of Nicaragua. Habitats include evergreen and semi-evergreen rainforests, tropical deciduous forests, pine-oak forests and dry, rocky slopes, gorges and coastal dunes.

**Table 1.** Representatives of *Cycadaceae* in greenhouse collection

| Sl. № | Species | Conservation Status | Cites appendix | Availability of seeds |
|---|---|---|---|---|
| 1. | *Cycas brachycantha* K.D. Hill, T. H. Nguyên & P.K. Lôc | NT | II | + |
| 2 | *Cycas circinalis* L. | EN | II | + |
| 3 | *Cycas debaoensis* Y.C. Zhong & C.J. Chen | CR | II | - |
| 4 | *Cycas elongata* (Leandri) D.Y. Wang | EN | II | - |
| 5 | *Cycas media* R.Br. | LC | II | |
| 6 | *Cycas micholitzii* Dyer | VU | II | + |
| 7 | *Cycas pectinata* Buch.-Ham. | VU | II | - |
| 8 | *Cycas revoluta* Thunb. | LC | II | + |
| 9 | *Cycas rumphii* Miq. | NT | II | - |
| 10 | *Cycas taitungensis* C. F. Shen & al. | EN | II | - |
| 11 | *Cycas taiwaniana* Carruth. | EN | II | - |
| 12 | *Cycas thouarsii* R.Br. ex Gaudich. | LC | II | - |
| 13 | *Cycas tropophylla* K.D. Hill & P.K. Lôc | NT | II | - |

'+' : seed available; '-' : seed not available

**Table 2.** Representatives of *Zamiaceae* in greenhouse collection

| Sl.№ | Species | Conservation Status | Cites appendix | Availability of seeds |
|---|---|---|---|---|
| 1 | *Dioon edule* Lindl. | NT | II | - |
| 2 | *Dioon rzedowskii* De Luca, A. Moretti, Sabato & Vazq. Torr. | EN | II | - |
| 3 | *Dioon spinulosum* Dyer ex Eichl. | EN | II | - |
| 4 | *Encephalartos altensteinii* Lehm. | VU | I | - |
| 5 | *Encephalartos ferox* G. Bertol. | NT | I | - |
| 6 | *Encephalartos hildebrandtii* A.Br. & Bouche | NT | I | - |
| 7 | *Encephalartos lehmannii* Lehm. | NT | I | - |
| 8 | *Encephalartos longifolius* (Jacq.) Lehm. | NT | I | - |
| 9 | *Encephalartos sclavoi* De Luca, D.W. Stev. & Moretti | CR | I | - |
| 10 | *Encephalartos septentrionalis* Schweinf. ex Eichl. | NT | I | - |
| 11 | *Encephalartos transvenosus* Stapf. & Burtt Davy | LC | I | - |
| 12 | *Encephalartos trispinosus* (Hook.) R. A. Dyer | VU | I | - |
| 13 | *Encephalartos whitelockii* P.J.H. Hurter | CR | I | - |
| 14 | *Macrozamia fawcettii* C. Moore | NT | II | - |
| 15 | *Macrozamia lucida* L.A.S. Johnson | LC | II | - |
| 16 | *Macrozamia miquelii* (F. Muell.) A.DC. | LC | II | - |
| 17 | *Macrozamia moorei* F. Muell. | NT | II | - |
| 18 | *Macrozamia riedlei* (Fisch. Ex Gaudich.) C. F. Gardn. | LC | II | - |
| 19 | *Macrozamia spiralis* Miq. | EN | II | - |
| 20 | *Lepidozamia peroffskyana* Regel | LC | II | - |
| 21 | *Ceratozamia kuesteriana* Regel | CR | I | - |
| 22 | *Ceratozamia mexicana* Miq. | VU | I | - |
| 23 | *Ceratozamia miqueliana* H. Wendl. | CR | I | - |
| 24 | *Ceratozamia norstogii* D. W. Stev. | EN | I | - |
| 25 | *Microcycas calocoma* (Miq.) A.DC | CR | I | - |
| 26 | *Zamia fairchildiana* L.D. Gómez | NT | II | - |
| 27 | *Zamia fischeri* Miq. ex Lem. | EN | II | - |
| 28 | *Zamia floridana* A. DC. | NT | II | - |
| 29 | *Zamia furfuracea* Aiton | EN | II | + |
| 30 | *Zamia integrifolia* L.f. | NT | II | - |
| 31 | *Zamia muricata* Willd. | NT | II | - |
| 32 | *Zamia pumila* L. | NT | II | - |
| 33 | *Zamia vazquezii* D.W. Stev., Sabato & De Luca | CR | II | - |
| 34 | *Stangeria eriopus* (Kuntze) Baill. | VU | I | + |

'+' : seed available; '-' : seed not available

*Dioon* is becoming increasingly rare in its native habitat, due to the fact that the seeds are used for food.

In an evolutionary sense, *Encephalartos* is one of the most primitive gymnosperms. The genus is distributed in equatorial and southern Africa, mainly on the southeastern coast of Africa. In natural conditions, they grow in open places, are found in savannas, on coastal sandy slopes, in mountain forests. The stems are often underground and can be up to a meter in length. The pith of some species has traditionally been used to produce starchy sago, which is used as food instead of bread by local tribes. As a result, all species in the wild are endangered.

68 species are recognized in the genus. The collection of the garden - 10 species:

*Macrozamia* includes 39 species (6 species and 1 cultivar in greenhouses). All members of the genus are endemic to Australia: Queensland, New South Wales, Northern Territory and Western Australia. They grow in subtropical and moderately warm regions, as a rule, on poor soils in sclerophytic communities, common in Australia from its warm-temperate regions to the subtropics. All of them live in sclerophilous communities along with other plants that make up the ancient Australian element.

The pride of the collection is the large specimens of *Lepidozamia peroffskyana*, an endemic genus from the tropical and subtropical parts of Eastern Australia. The honor of discovering and describing the genus, and its two species, belongs to E.L. Regel. The plant got into the greenhouse of the St. Petersburg Botanical Garden in 1841 from the famous collector Baron von Müller, later director of the Botanical Garden in Melbourne (Arnautova E.M., 2011).

In 1857, Regel described it as a new genus and species, calling it *Lepidozamia peroffskyana*. Lev Alekseevich Perovskiy in 1852 was appointed Minister of Fate and Administrator of His Majesty's Cabinet, subordinating to him the Academy of Arts, the Moscow Palace of Architecture School and the Art School and the Botanical Garden. The type specimen of *Lepidozamia peroffskyana* died during the siege of Leningrad, but after the Botanical Congress in Leningrad in 1975, Australian botanists sent seeds collected in the same place where the type specimen had once been found. There are now both male and female specimens in the Garden. It has not been possible to pollinate yet.

The native land of the genus *Ceratozamia* is the southeastern regions of Mexico and Guatemala. Plants are found in pine-oak foggy forests on steep slopes with deep soil mixed with limestone rocks. *Ceratozamia miqueliana* is endemic to Mexico. Its natural habitat is subtropical or tropical humid lowland forest.

*Microcycas calocoma*, monotypic, endemic species to a small area in western Cuba in the province of Pinar del Rio. In its natural range, *Microcycas calocoma* grows in small groups of 10-50 plants in mountain forests or on the slopes of ravines and in open meadows and bushes. Plants from these groups are considered to have a very unbalanced sex ratio, which results in low seedling yield. However, Cuban botanists believe that the seeds of *Microcycas* are actively eaten by rats, which reduces the population. According to the latest statements by local botanists, another large population has been found, which significantly increases the chances of survival of *Microcycas*. The plant was donated to the Botanical Garden by the Cuban Academy of Sciences.

The genus *Chigua* is a genus of cycads of the family *Zamiaceae*, consisting of two species, endemic to small areas in northwestern Colombia. Representatives of the genus are found in humid lowland tropical forests at an altitude of 100-200 m above sea level. Currently, both known species are considered in the genus Zamia. They are not represented in the Garden collection.

The genus *Zamia* is a genus of cycads of the family *Zamiaceae*, where it is typical. The genus includes about 58 species distributed in the tropical and subtropical regions of South, Central and North America.

Small plants with a massive barrel-shaped stem and feathery leaves. A characteristic feature of the genus is the regular arrangement of the leaves. There are 8 species in the collection of the Garden. In 2019, *Zamia furfuracea* seeds were obtained for the first time.

*Stangeria eriopus* is a very long-lived, perennial, evergreen cycad that is endemic to coastal regions of southern Africa. The stems are completely underground, and the root tuber is carrot-shaped and reaches a diameter of 10 to 25 centimeters. It grows on various soils: from sandy granite to heavy black clays. It is the only species of the genus *Stangeria* that is closest to the Australian genus *Bowenia* (absent in the garden's collection), with which it is sometimes combined into the *Stangeriaceae* family. There are both male and female specimens in the greenhouse, the seeds have already been received.

## CONCLUSION

Botanical gardens are centers of complex nature protection. Plants here not only preserve, but also study the peculiarities of their development and reproduction, search for the reasons for the reduction in numbers, carry out introduction and reintroduction, and conduct educational work.

The collection of Peter the Great Botanical garden (BIN RAN) has 1500 rare and endangered species, among which representatives of *Cycadales.* In the greenhouses, 47 species of *Cycadales* belonging to 9 genera are grown, all species have a conservation status: CR - 7 species, EN - 10 species, VU - 6 species, NT - 16 species, LC - 8 species and all species included in the CITES lists.

Seeds of 6 species of cycads were obtained: *Cycas brachycantha*, *Cycas circinalis*, *Cycas micholitzii*, *Cycas revoluta*, *Zamia furfuracea*, *Stangeria eriopus*.

Peter the Great Botanical garden (BIN RAN) participated in the reintroduction *Cycas micholitzii*.

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