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Ex situ Conservation Base of Global Status Woody Species Protected by International Union for Conservation of Nature (IUCN) "Red List" and Georgian "Red List" at Batumi Botanical Garden

Julieta Jakeli* **and Mariam Metreveli****

* *Batumi Botanical Garden, Batumi*
***Institute of Phytopathology and Biodiversity, Batumi Shota Rustaveli State University, Batumi*

(Presented by Academy Member Vano Papunidze)

ABSTRACT: The article deals with some bioecological peculiarities of 46 species of 28 genera and 13 families of global status woody plants protected by IUCN "Red List" and Georgian "Red List" that grow at Batumi Botanical Garden: potential and possibilities of their growing, reproductive restoration and development in the humid subtropics soil-climatic conditions along the Georgian Black Sea littoral. It highlights the significance of these factors for creation of a conservation base for the species with protected status in new environmental conditions and analyzes the present outcomes: most species under study can be included for the perfection of the conservation base at the Batumi Botanical Garden. According to the worldwide protection status in the orangery conditions the following planting materials were received: 4 samples of 2 Critically Endangered (CR) species, 186 samples of 5 Endangered (EN) species, 26 samples of 6 Vulnerable (VU) species, 65 samples of 6 Near Threatened (NT) species and 296 samples of 28 Least Concern (LC) species. Total planting and reserve gene-pool comprise 577 samples of 47 species, including 30 seed samples of local reproduction and 17 – delivered through the seed exchange programs between the botanical gardens worldwide. © *2015 Bull. Georg. Natl. Acad. Sci.*

Key words: *bioecological peculiarities; growing-development; reproduction; biostimulators.*

One of the main objectives of the Botanical Garden is to create collections of rare and endangered species included into the national as well as worldwide "Red Books" and "Red Lists". It corresponds with the goal of the International Union for Conservation of Nature (IUCN) – fighting against species crisis and conservation of ecosystems integrity [1].

Introduction and *ex situ* conservation of the species with protection status is a possible and additional measure for their protection and restoration of natural populations.

At the Batumi Botanical Garden the protection and conservation of the fund collections of IUCN species of global status as well as elaboration of *ex*

situ measures have been conducted since 2004. At present 160 species of woody plants of IUCN "Red List" are subjected to conservation according to the following categories: Critically endangered (CR), Endangered (EN), Vulnerable (VU), Near threatened (NT), Least concern (LC), Data deficient (DD). We consider the cultivation of rare and endangered species, their conservation in the collection of Batumi Botanical Garden and the study of their biological peculiarities as a very important endeavor. On this base, these species may become the source of new genetic resources and branches of agriculture, decorative gardening, pharmacology, medicine, etc. At the same time, with the elaboration of effective conservation methods and creation of reserve fund of sowing and planting materials even the further repatriation of these taxons may become possible. It will provide the prevention of their complete extinction in the habitats [1].

Materials and Methods

The objects of study are 46 species of 28 genera and 13 families of global status woody plants protected by IUCN "Red List" and Georgian "Red List" growing at Batumi Botanical Garden.

For the study of the bioecological peculiarities of the objects the following methods have been used: the Serebryakov method (1974) for the study of growth and development rhythm and the biology of the shoots, the Beydeman method (1974), Elagin and Lobanov's guidebook of plant phonological phases (1979); biometric indices were determined in accordance with Tsitsvidze's "Dendrology" (2004), Kolesnikov's "Decorative Dendrology" (1974) and Tkavadze, Kiladze "Decorative Dendrology" (2011); reproduction properties – with the method Khromova (1980) [2-7].

Mobilization of the introductive materials (live plants and seeds) was conducted through gathering of the seeds of fruiting plants of the collection as well as within the frames of the international seed exchange programs and expeditions of the Department of Local Flora and Conservation. The study of the reproduction peculiarities of the materials under study was conducted in the orangery conditions and the open soil against the usual agro-technical background.

The natural habitat of the global status woody plants under our study, protected by the International Union for Conservation of Nature (IUCN) "Red List" and Georgian "Red List" that grow in the soil-climatic conditions of humid subtropical climate of the Batumi Botanical Garden, comprises the following floristic regions: East Asia, North America, South America, the Himalayas, western part of Africa, the Caucasus and the Kolkheti refugium.

The integral index of the adaptation of plant species into a new environment is represented by their bioecological peculiarities. Especially significant is the index of their reproductive development and self-regeneration.

For the purpose of evaluation of the biological state of the species in *ex situ* conditions, the following three groups were singled out on the basis of the study conducted on the seasonal dynamics of the species development:

1. The regularly flowering and fruiting species that give self-seed. To the group belong the following species: *Chamaecyparis formosensisn* Matsum., *Chamaecyparis lawsoniana* (A. Murray bis) Parl., *Cryptomeria japonica* (Thunb. ex L.f.) D. Don, *Buxus colchica* Pojark., *Cephalotaxus fortune* Hook., *Cupressus qudalupensis* S. Watson, *Metasequoia glyptostroboides glyptostr* Hu & W. C. Cheng, *Taxodium mucronatum* Ten., *Platycladus (Thuja) orientalis* L., *Diospyros lotus* L., *Ginkgo biloba* L., *Pterocarya pterocarpa* (Michaux) Kunth ex Iljinsk., *Liquidambar styraciflua* L., *Abies nordmaniana* (Steven) Spach, *Cedrus deodara* (Lamb.) G. Don, *Torreya grandis* Fortune ex Lindl., *Pseudolarix amabilis* (J. Nelson) Rehd, *Podocarpus macrophyllus* (Thunb.) Sweet, *Lespedesa floribunda* Bunge, *Pinus pinaster* Aiton, *Pinus roxburghii* Sarg., *Pinus wallichiana* A. B. Jacks., *Pinus taeda* L. The specimens of these species are distinguished by high longevity at all stages of ontogenesis, are frost-resist-

ant and characterized by ordinary growth and development rhythm – they fruit regularly and give self-seed.

2. The species that regularly flower but are characterized by periodical, instable fruiting: *Araucaria anguistifolia* (Bertol.) Kuntze, *Keteleeria fortunei* (A. Murray bis) Carriere, *Cedrus libanii* A. Rich., *Taxus baccata* L., *Camellia reticulata* Lindley, *Thuja standischii* (Gordon) Carriere, *Pinus pinea* L., *Abies sachalinensis* (F.Schmidt) Mast., *Picea glauca* (Moench) Voss., *Pinus armandii* Franch.,

3. Newly introduced species growing in the closed soil conditions and special ecological conditions that have not reached the propagation age yet: *Araucaria cunninghamii* Aitonex A.Cunn, *Abies balsamae* (L.) Mill, *Abies holophylla* Maxim., *Abies veitchii* Lindl., *Afrocarpus mannii* (Hook. f.) C. N. Page, *Torreya californica* Torr., *Cercis canadensis* L., *Bauhinia purpurea* L., *Picea rubens* Sarg. and *Robinia hispida* L.These species are characterized by regular rhythm of vegetative development.

The reproduction/propagation (with seed and vegetative) peculiarities and properties were studied in the open and closed soil conditions. Seed collecting was conducted from the half-century and centenary specimens of fruiting species in the local collection also, within the frames of the international seed exchange programs between the botanical gardens worldwide. The optimal qualities of seed ripeness, collecting terms and dates, storage and pre-sowing preparation measures (stratification) were identified. Sowing was conducted in two variants: 1) sowing of newly-gathered seeds in autumn; 2) sowing of stratified seeds taken in autumn – in early spring. Newly-gathered seeds were sowed in the orangery conditions on specially prepared substrates in autumn, the stratified ones – in spring.

As a result of autumn sowing of newly-gathered and cleaned seeds the species have been selected that are characterized by good energy of shooting; the percentage of the obtained sowing fluctuates between 60 - 95% depending on seed quality, gathering terms, sow depth (small-size seed on the surface level, relatively larger ones – in depth), substrates, etc. Their shooting quality fluctuates in the following way: *Metasequoia glyptostroboides* - 95%, *Abies nordmaniana* - 85%, *Cupressus quadalupensis* - 90%, *Torreya grandis* - 95%, *Cephalotaxus fortune* - 80%, *Pseudolarix amabilis* - 95%, *Cedrus deodara* - 70%, *Liquidambar styraciflua* - 60%, *Ginkgo biloba* - 95%, *Platycladus (Thuja) orientalis* - 90%, *Lespedesa floribunda* - 75%, *Pinus pinaster* - 60%, *P. roxburghii* - 85%, *P. wallichiana* - 60%, *P. taeda* - 60%, *Diospyros lotus* - 70%, *Pinus bungeana* - 65%.

We got good harvest as a result of 90-day-long cold stratification (+5^0) of autumnally gathered and cleaned seeds: *Thuja standischii - 40%, Torreya grandis - 90%, Ginkgo biloba - 95%,* as a result of spring (IV) sow of stratified seeds. By this time *Thuja standischii* are in juvenile stage whereas *Torreya grandis* and *Ginkgo biloba* are in virginal stage.

In the conditions of closed soil, the state of the following newly introduced species of seeds and live plants obtained through the exchange programs between botanical gardens – *Araucaria cunninghamii, Abies balsamea, Abies holophylla, Abies veitchii, Afrocarpus mannii, Araucaria araucana, Torreya californica, Cercis canadensis, Bauhinia purpurea, Robinia hispida, Picea rubens* – is satisfactory. Their evaluation will be possible after further observation (Table 1).

The optimal terms and effective methods of vegetative propagation were determined and elaborated on the following species: *Buxus colchica*, *Chamaecyparis formosensis*, *Pterocarya pterocarpa*, *Taxus baccata.* The results of the vegetative reproduction showed that rooting of the species – *Chamaecyparis formosensis* – grafted in early autumn on a special substrate (2 portions of sand and 1 portion of coniferous humus) comprises almost 1 year period (6 months for development of callus tissue, 4 months for root formation) and constitute 50 - 60%.

Table 1. Planting materials and reserve gene-pool of global status woody plants protected by IUCN "Red List" and Georgian "Red List" at Batumi Botanical Garden

N#	Species	Sample origin	Number	Size /cm/	IUCN and Georgian "Red List" Status
Family – Araucariaceae F. Neger.					
1	*Araucaria anguistifolia* (Bertol.) Kuntze	Loc. Repr.	3	50	CR
2	*Araucaria araucana* (Molina) K. Koch	Germany, Munich	1	12	EN
3	*Araucaria cunninghamii* Aiton ex A. Cunn	Ukraine, Kiev	1	40	VU
Family – Buxaceae Dumort.					
4	*Buxus colchica* Pojark.	Loc. Repr.	10	5-9	NT/VU
Family – Cephalotaxaceae F. Neger.					
5	*Cephalotaxus fortunei* Hook.	Loc. Repr.	12	22	LC
6	*Cephalotaxus sinensis* (Rehd. & E. H. Wilson) H. L. Li	Germany	3	28	LC
Family – Cupressaceae F. N. Neger.					
7	*Chamaecyparis formosensis* Matsum.	Loc. Repr.	23	30	EN
8	*Chamaecyparis lawsoniana* (A. Murray bis) Parl.	Loc. Repr.	10	47	NT
9	*Cryptomeria japonica* (Thunb. ex L.f.) D. Don	Loc. Repr.	13	32	NT
10	*Cupressus qudalupensis* S. Watson	Loc. Repr.	73	17	EN
11	*Metasequoia glyptostroboides* Hu & W. C.Cheng	Loc. Repr.	67	5-120	EN
12	*Taxodium mucronatum* Ten.	Loc. Repr.	4	60	LC
13	*Thuja standishii* (Gordon) Carriere	Loc. Repr.	4	8	NT
14	*Platycladus (Thuja)* orientalis L.	Loc. Repr.	23	22	NT
Family – Ebenaceae Gurke.					
15	*Diospyros lotus* L.	Loc. Repr.	7	16	LC
Family – Ginkgoaceae Endl.					
16	*Ginkgo biloba* L.	Loc. Repr.	42	32-55	EN
Family – Hamamelidaceae Lindl.					
17	*Liquidambar styraciflua* L.	Loc. Repr.	10	45	LC
Family – Juglandaceae L. O.					
18	*Pterocarya pterocarpa* (Michaux) Kunth ex Iljinsk	Loc. Repr.	12	23	LC/VU
Family – Leguminosae Lindl.					
19	*Cercis canadensis* L.	Russia, Pyatigorsk	1	32	LC
20	*Bauhinia purpurea* L.	France	2	75	LC
21	*Lespedeza floribunda* Bunge.	Loc. Repr.	22	60	LC
22	*Robinia hispida* L.	Czech Republic	1	20	LC
Family – Pinaceae Lindl.					
23	*Abies balsamea* (L.) Mill	Ukraine	1	6	LC
24	*Abies holophylla* Maxim.	Ukraine	5	11	LC
25	*Abies nordmaniana* (Steven) Spach	Loc. Repr.	40	3-6	LC
26	*Abies sachalinensis* (F. Schmidt) Mast.	Latvia	4	3	LC
27	*Abies veitchii* Lindl.	Ukraine	2	7	LC
28	*Cedrus deodara* (Lamb.) G. Don	Loc. Repr.	7	38	LC
29	*Cedrus libanii* A. Rich.	Loc. Repr.	6	32-50	VU
30	*Keteleeria fortune* (A. Murray bis) Carriere	Loc. Repr.	5	10-24	NT
31	*Picea glauca* (Moench) Voss.	Slovakia	30	3	LC
32	*Picea rubens* Sarg.	Germany, Munich. Botanical Garden	5	2	LC
33	*Pinus armandii* Franch.	Loc. Repr.	1	16	LC
34	*Pinus bungeana* Zucc. ex Endl.	Georgian National Botanical Garden	9	10	LC
35	*Pinus pinaster* Aiton	Loc. Repr.	3	25	LC
36	*Pinus pinea* L.	Georgian National Botanical Garden	8	30	LC
37	*Pinus roxburghii* Sarg.	Loc. Repr.	33	35	LC
38	*Pinus taeda* L.	Loc. Repr.	1	3	LC
39	*Pinus wallichiana* A. B. Jacks.	Loc. Repr.	16	18	LC
40	*Pseudolarix amabilis* (J. Nelson) Rehd	Loc. Repr.	16	24	VU
Family – Podocarpaceae Neger.					
41	*Afrocarpus mannii* (Hook. f.) C. N. Page	Ukraine, Kiev	1	41	VU
42	*Podocarpus macrophyllus* (Thunb.) Sweet	Loc. Repr.	12	9	LC
Family – Taxaceae Lindl.					
43	*Taxus baccata* L.	Loc. Repr.	15	5	LC/VU
44	*Torreya californica* Torr.	Austria	1	11	VU
45	*Torreya grandis* Fortune ex Lindl.	Loc. Repr.	30	15-18	LC
Family – Theaceae D. Don.					
46	*Camellia reticulata* Lindley	Loc. Repr.	1	5	VU

Table 2. Experiments of vegetative reproduction of species under study, with control variant and using bio-stimulators (%)

Species	H_2O Control	Variants of Treating with Bio-stimulators (Concentration %)				
		Indoleacetic acid (0.02%)	Indolebutyric acid (0.01%)	Lignitic humate (0.05%)	Potassium permanganate (0.1%)	Sucrose (5%)
Araucaria angustifolia	-	-	-	-	-	-
Buxus colchica	76	88	80	82	77	75
Chamaecyparis formosensis	88	90	88	85	73	75
Pterocarya pterocarpa	70	82	79	80	67	65
Taxus baccata	85	92	90	94	86	83

For the purpose of increase in rooting quality, the following bio-stimulators were used: indoleacetic acid (0.02%), indolebutyric acid (0.01%), lignitic humate (0.05%), potassium permanganate (0.1%), sucrose (5%). The efficiency of their action has been reflected on the following species: *Buxus colchica, Chamaecyparis formosensis, Pterocarya pterocarpa, Taxus baccata* (Table 2). The grafts treated with bio-stimulators have developed double length and twice as much second row roots, compared with the other samples. The study stated that in the process of callus and root development the age of a mother plant influences the rooting terms and the number of root development. Thus, we studied and analyzed the reproductive peculiarities of 46 species of 28 genera and 13 families of global status introduced woody plants protected by IUCN "Red List" and Georgian "Red List" that grow at Batumi Botanical Garden. According to the worldwide protection status in the orangery conditions the following planting materials were received: 4 samples of 2 Critically Endangered (CR) species, 186 samples of 5 Endangered (EN) species, 26 samples of 6 Vulnerable (VU) species, 65 samples of 6 Near Threatened (NT) species and 296 samples of 28 Least Concern (LC) species. Total planting and reserve gene-pool comprise 577 samples of 47 species, including 30 seed samples of local reproduction and 17 – delivered through the seed exchange programs between the botanical gardens worldwide.

In future the study of all species will continue from the scientific-methodological aspect for the purpose of their conservation in the collection of the Batumi Botanical Garden. We consider it necessary to elaborate an exposition project on the basis of *ex situ* conservation of the species protected by IUCN Red List, as a complex unit for the accomplishment of introductive, landscape, tour guiding and educational purposes.

ბოტანიკა

ბუნების კონსერვაციის საერთაშორისო კავშირის (IUCN) "წითელი ნუსხით" და საქართველოს "წითელი ნუსხით" დაცული გლობალური სტატუსის მერქნიან სახეობათა *ex situ* კონსერვაციული ბაზა ბათუმის ბოტანიკურ ბაღში

ვ. ჯაყელი*, მ. მეტრეველი**

* *ბათუმის ბოტანიკური ბაღი, ბათუმი*
***ბათუმის შოთა რუსთაველის სახელმწიფო უნივერსიტეტის ფიტოპათოლოგიისა და ბიომრავალფეროვნების ინსტიტუტი, ბათუმი*

(წარმოდგენილია აკადემიის წევრის ვ. პაპუნიძის მიერ)

გაანალიზებულია გლობალური სტატუსის IUCN "წითელი ნუსხის" და საქართველოს „წითელი ნუსხით" დაცული მერქნიან მცენარეთა ბათუმის ბოტანიკურ ბაღში მოზარდი 13 ოჯახის 28 გვარის 46 სახეობის ზოგიერთი ბიოეკოლოგიური თავისებურება: საქართველოს შავი ზღვის სანაპიროს ტენიან სუბტროპიკულ ნიადაგურ-კლიმატურ პირობებში მათი ზრდა-განვითარების, რეპროდუქციული განახლებისა და განვითარების შესაძლებლობები. აღნიშნულია ამ ფაქტორების მნიშვნელობა ახალ გარემოპირობებში დაცულობის სტატუსის მქონე სახეობების კონსერვაციული ბაზის შესაქმნელად. ამ დროისთვის მიღებულია 46 სახეობის სარგავი მასალა და სარეზერვო გენოფონდი. საკვლევ სახეობათა უმრავლესობა შესაძლებელია ჩართული იქნეს კონსერვაციული ბაზის სრულყოფისათვის ბათუმის ბოტანიკურ ბაღში.

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