

Taxus baccata L. and *Zelkova carpinifolia* (Pall.) K.Koch - Rare and Endangered Species of Georgian Flora in Eastern Georgia

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Abstract

The article discusses the contemporary bioecological conditions of rare and endangered endemic and relict plants of narrow distribution included in the Red Book of Georgia: *Taxus baccata* L., and *Zelkova carpinifolia* (Pall.) K.Koch., under the conditions of Eastern Georgia. Their growth and development patterns, limiting factors, and distribution both in the wild and in cultivation have been studied.

The research has determined that over the past decades, due to the sharply increased anthropogenic impact on natural ecosystems and the intensification of natural events, their number has been greatly decreased in their natural distribution area and they are threatened with extinction. Therefore, it is necessary to identify appropriate conservation methods.

Keywords: Relict; Endemic; *Taxus baccata* L.; *Zelkova carpinifolia* (Pall.) K.Koch.

1. Introduction

The flora of Georgia is rich in ancient relict, endemic, medicinal and ornamental plants. In recent years, against the backdrop of sharply increased climate change and anthropogenic impact, the distribution area of many rare and endangered plants has been shrinking every year, and the limiting factors for their development in nature have been increasing. The threat of extinction of endemic and relict plants of our flora and the change of natural landscapes is increasing, more and more species are at risk of extinction. Such endangered plants include the endemic and relict plants of Georgia, *Taxus baccata* L. and *Zelkova carpinifolia* (Pall.) K.Koch., which are preserved today, in small groves or individual trees, which are protected or declared as natural monuments and are included in the Red Book and Red List of Georgia as vulnerable (VU) species.

Their status can only be improved through specific conservation actions. Therefore, it is of great importance to study the current bioecological condition of these species, which will allow us to identify ways to conserve them as a species on the verge of extinction.

2. Sources and methods

The aim of our research was to study the growth and development patterns and modern bioecological state of rare and endangered endemic and relict plants of Georgia: *Taxus baccata* L. and *Zelkova carpinifolia* (Pall.) K.Koch, and to identify limiting factors under the conditions of Eastern Georgia.

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For this purpose, the study was conducted on the target species *Taxus baccata* L. and *Zelkova carpinifolia* (Pall.) K.Koch, which are widespread in nature and culture in the regions of Eastern Georgia, namely Inner Kakheti. The peculiarities of their growth and development, the periods of bud opening, the beginning and end of cambium activity in 1-3-year-old shoots, the process of shoot lignification, the rate and time of growth in height have been studied according to the methodological guidelines by A. Tsitsvidze, E. Lobzhanidze and Yatsenko-Khmelevsky [1],[2],[3].

3. Results and discussion

Taxus baccata L. is an evergreen, coniferous tree or shrub, growing to 25-32 m tall, with a diameter of 1.5-2.5 m. It is characterized by a long life. Some of its representatives live to be 2000-3000 years old. It is shade and drought tolerant, characterized by slow growth. Its annual increase in height rarely exceeds 20 cm.

It is characterized by a dense rounded cylindrical or pyramidal crown, and develops branches from the base. It easily tolerates pruning, is a valuable ornamental plant, and is actively used in ornamental gardening [4], [5].

Young branches are green and angular. Older branches and trunk are covered with thin reddish-brown bark, which falls off in elongated plates. The wood of *Taxus baccata* L. is yellowish-red in color, lacks resin canals, which distinguishes it from other conifers. The wood of *Taxus baccata* L. is very beautiful, hard and does not rot for a long time, therefore it is also called "decay-resistant wood". It is actively used in carpentry and furniture production.

The needles of *Taxus baccata* L. are lanceolate-linear in shape, 1.5-3 cm long and 2 mm wide, arranged in two rows in one plane. The lifespan of the needles is 8-10 years.

Taxus baccata L. - a dioecious plant, blooms in early spring, in March. The seeds are oval, pointed, hard-skinned and completely enclosed in a red fleshy aril. The seeds ripen in the same year. *Taxus baccata* seeds are mainly spread by birds. The seeds and needles of *Taxus baccata* are poisonous. They contain alkaloids – taxine, myloseine, and the glycoside taxicatin.

In recent years, it has been actively used in medicine, in the treatment of asthma, bronchitis, rheumatism, as well as in cardiology. It is characterized by strong antibacterial properties. The substances released into the air by the plant from its needles kill surrounding microorganisms.

Taxus baccata is resistant to pests and fungal diseases and is rarely damaged by insects. It grows well on relatively moist and loamy, humus-rich soils. However, as its distribution shows, it prefers calcareous soils. *Taxus baccata* is cold-tolerant, although it is widespread in relatively warm areas. Its mesophilic nature explains the fact that in the forests of Georgia, especially in the dry conditions of Eastern Georgia. It is widespread mainly on the northern slopes of the mountains.

Taxus baccata L. is a rare relict and is threatened with extinction. Small groves or individual trees are preserved, included in all regional Red Books, including the Red Book of Georgia and the Red List of Georgia, as well as the Red List of IUSN [4].

Taxus baccata L. is naturally distributed in Western Europe, Northern Africa, and the Caucasus. In the Caucasus region, apart from Georgia, it occurs in Armenia and Azerbaijan. In Georgia, it is distributed in almost all regions. It is relatively widespread in Eastern Georgia, particularly in Kakheti, in the Batsara Gorge at the headwaters of the Alazani River, where a reserve was established in 1935 for the protection of *Taxus baccata* L. forests.

The area of the reserve exceeds 3,000 ha. It contains unique stands of *Taxus baccata* L., distributed at elevations of 1,000–1,500 (up to 1,666) m above sea level. The *Taxus baccata* L. stand occupies an area of approximately 800 ha; such an extensive yew stand is not found anywhere else in the world. The majority of *Taxus baccata* trees in this area are mainly 500–1,000 years old. A total of approximately 220,000 *Taxus baccata* trees grow within the Batsara Reserve, including about 13,000 trees older than 100 years. Several specimens reach an age of 1,200–1,500 years, with heights of 25–30 m and trunk diameters of up to 150 cm. In the forest, *Taxus baccata* L. occurs in association with maple, hornbeam, beech, and other tree species.

In addition to the Batsari Nature Reserve, *Taxus baccata* L. is widespread in Georgia both as single trees and in groups, in urban landscaping and parks (in Tbilisi, Telavi, Tsinandali, Lagodekhi, Kvareli), in Tsinandali Park, 47 of its roots grow. Here, the height of one of its specimens is 9 meters, it has a very well-developed trunk, its lower branches are

bent and rooted to the ground, one plant occupies an area of 11 sq. m. *Taxus baccata* L. grows well in all regions of northern Georgia, both in open and shaded areas.

In spring, *Taxus baccata* L. first disperses pollen, then shoots begin to grow. The growth of *Taxus baccata* L. in height lasts on average 80-90 days. *Taxus baccata* L. begins vegetation in late March or early April, regardless of temperature changes.

In 2-3 year old shoots of *Taxus baccata* L, cambium activity begins 5-8 days after bud opening. The formation of wood cells lasted 125-145 days in 2017, and 130-136 days in 2025. In the stem, this process lasted 145-165 days in 2025, and 150-170 days in 2025. It is likely that the growth duration of *Taxus baccata* L. is affected by the recent droughts and snowless winters in Kakheti, which leads to a water deficit in the soil and adversely affect its growth.

The seed germination rate of *Taxus baccata* L. is 35–40%. The seeds mature in the same year and are dispersed by birds.

The next study plant, *Zelkova carpinifolia* (Pall.) K.Koch., is also a rare relict, characterized by valuable timber and faces the threat of extinction [6]. In Georgia, it is found in Kakheti, Imereti, Adjara, Guria, Samegrelo, Tbilisi, the Georgian National Botanical Garden, and Tsinandali Park.

Zelkova carpinifolia - a tall deciduous tree, 20-30 (35-40) m tall and up to 2-3 m in diameter. It is characterized by a powerful main axis root system, and due to its strong and deep root system, it withstands strong winds. It loves shade and moisture, grows in moist forests, on river banks and along valleys, in coastal plains and in the lower mountain belt. It is also found on stony soils, but on stony soils it is characterized by slow growth and takes the form of a bush.

It is characterized by oblong-ovate, pointed, serrated short-stalked leaves. Brownish, egg-shaped, paniced flowers. It blooms in March and bears fruit in September-October. It reproduces by seeds, root suckers, and root cuttings

Zelkova carpinifolia is characterized by thick, dense, gray-green bark and hard wood. Its wood is characterized by high technical value, which ranks among the first in terms of durability among woody plants.

Due to the high physical and mechanical properties of its wood, it is one of the most valuable plants. The wood of *Zelkova carpinifolia* can last for tens and hundreds of years without damage. It is also not easily damaged by pests. Therefore, it has a fairly wide range of uses and is a particularly valuable material in construction.

That is why it has been subjected to intense exploitation by the population over the years. As a result, the area of natural stands has significantly decreased, and the species has become threatened with extinction

Currently, *Zelkova carpinifolia* is listed in the Red List of Georgian as a Vulnerable (VU) species. Although it is facing the threat of extinction, its conservation and promotion of its reproduction can help it survive and spread widely.

In Georgia, *Zelkova carpinifolia* grows at an altitude of 300-600 m above sea level. However, it feels better at an altitude of 100-400 m above sea level, where it is characterized by abundant fruiting. It lives for 500-600 years.

In Kakheti, *Zelkova carpinifolia* is found in the eastern part of Akhmeta Municipality, in the eastern foothills of the Caucasus, on an area of 240 hectares. In order to protect the *Zelkova carpinifolia* grove, the Babaneuri State Reserve was created in 1961, where *Zelkova carpinifolia* is found in quarters I, IV, V, VI of the reserve. In the Babaneuri reserve, one of the oldest trees is 25 meters high and 125 cm in diameter. This tree is called the “Leader of the Forest” of Babaneuri.

In the Babaneuri Nature Reserve, deciduous forests are mainly distributed on slopes and foothill plains. In addition to pure groves, the most common formations found here, in more or less mixed form, are:

Zelkova carpinifolia stand with a sedge cover, where the main forest-forming species is *Zelkova carpinifolia*, mixed with *Quercus iberica*, *Carpinus orientalis*, and shrubs *Ligustrum vulgare*, *Cornus mass*, *Grataegus pentagyna*. This formation contains a diverse herbaceous cover, where the main species is *Carex bushiorum*.

The next formation is hornbeam-conifer forest. The dominant species in this group is hornbeam (*Carpinus orientalis*), followed by zelkova (*Zelkova carpinifolia*). In this group, Georgian oak (*Quercus iberica*), field maple (*Acer campestre*), ash (*Fraxinus excelsior*) are found in isolated forms. Here, the understory is well developed, the main constituent species of which is Colchican box (*Buxus colchica*) [6].

Zelkova carpinifolia is heat-requiring, but quite frost-resistant. In its natural range, it can withstand -22°C and long frost periods (up to 140 days).

Zelkova carpinifolia begins to flower in April-May, depending on temperature, and lasts 2-3 weeks. Flowering and leaf unfolding occur simultaneously. Single trees begin to bear fruit at the age of 15-25 years, and in the forest at the age of 20-25 years. Its fruiting and seed quality depend significantly on climatic conditions, ecological factors, and the individual biological development of individual specimens. Under unfavorable climatic conditions (frequent and strong winds, drought, late frosts, etc.), seed yield and quality are very low.

Activation of cambial growth in the shoots of *Zelkova carpinifolia* begins in the second half of April and lasts for 150 days, until the first half of November. In the area of natural distribution (in the Babaneuri Reserve), this species is renewed both by seeds and by root shoots and root cuttings.

4. Conclusion

Thus, the study has revealed that both species *Taxus baccata* L. and *Zelkova carpinifolia* (Pall.) K.Koch. are characterized by good growth and development under the conditions of northeastern Georgia, both in their natural distribution area and in gardens and parks.

Taxus baccata L. can be propagated both by seed and vegetatively. The rootstock and the often cut trunk also give numerous shoots, and the lower branches of the tree root easily when in contact with the ground. It reproduces well by 1-2-year-old cuttings and layering, as well as by dormant buds, which is not typical for many conifers. In order to expand its area, it is advisable to cultivate plantations of *Taxus baccata* L., both from seeds and rooted cuttings. To increase the rooting rate of cuttings, it is advisable to use biostimulants.

In recent years, an expansion of the area of *Zelkova carpinifolia* has been observed in Kakheti, in particular in the Babaneuri State Reserve. It is characterized by good natural regeneration, new shoots are abundant in the zelkova forests, it penetrates into neighboring hornbeam and hornbeam stands. Its regeneration is particularly active in forest gaps, occurring mainly through root suckers, stump sprouts, and seeds.

Therefore, we can conclude that the renewal of *Zelkova carpinifolia* is taking place quite actively, even in areas where it was massively cut down.

In the future, it is desirable to pay more attention to the cultivation of *Taxus baccata* L. and *Zelkova carpinifolia* (Pall.) K.Koch. for various purposes, both in urban landscaping, as well as for landscaping gardens, squares and generally cities and other settlements, in the form of individual trees or groups, as well as for the cultivation of forest crops. This will contribute to the conservation of *Taxus baccata* L. and *Zelkova carpinifolia* (Pall.) K.Koch. as endangered species and the protection of the gene pool of these useful plants of the natural flora, which are facing destruction.

Compliance with ethical standards

Disclosure of conflict of interest

The author declares no conflicts of interest.

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