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Patterns of distribution and survival of European yew (*Taxus baccata* L.) in an alpine tree line ecotone in the Greater Caucasus (Georgia)

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ABSTRACT

Four disjunction sites with European yew (*T. baccata*) were included in this study (Fig. 1). All of them are represented in the western part of the Greater Caucasus Range (GCR). Considerable interest was directed towards two sites in the alpine tree line ecotone. Another two sites included low or mid-elevation locations.

The present paper is the first attempt towards data analysis on yew elevation variability across the Greater Caucasus, including treeline ecotone. An effort has been made to reveal survival strategy of yew under pessimal conditions. The sharp geomorphology of high mountainous limestone habitat; harsh climatic conditions long-term impact of severe disturbances due to temperature extremes, solar radiation, cold winds, and other topo climatic conditions; related to both - individual and community stands of yew were considered. All these fluctuating abiotic disorders affect the anatomy, physiology and behavioral peculiarities of relict yew; in particular the vegetative propagation ability of krummholz stand of yew. Our aim here was to strengthen the environmental awareness among the local people through this study, vis-a-vis enlighten the incredible natural sites of the GCR, which contain remarkable endemic and relict flora.

Introduction

Species of genus *Taxus* L. (Taxaceae) occur throughout temperate zone of the Northern Hemisphere. Most botanists believe that genus encompasses seven closely related species [1]. Genus *Taxus* is a relict conifer. It appeared during the transition between the Cretaceous and the Tertiary, 66 million years ago [2]. Taxaceae radiated from the southwest China. In the Tertiary period Asian species complex diverged within various geographic clades including European yew lineage [3].

European or English yew is a relict of moderate tertiary climatic countries [1].

According to the paleontological findings, the plant is accepted as the oldest tree genus in Europe. The oldest fossil record dates to the Miocene (about 23 mya) [4]. Its latitudinal distribution encloses 63°N-30°N [5]. It is native to most of Europe, northern Africa (the Atlas Mountains), Asia Minor, the Caucasus and northern Iran [6,7].

In temperate Eurasia changes in the abiotic factors of the Neogene have profoundly affected the regional species distribution. For example, the mid-Miocene-Pliocene global climate oscillation and further complications in the Alpine-Himalayan orogenic belt, have served as the reason of advancing aridity. The climate eventually became unsuitable for the growth of *T. baccata*. This event has led to disjunction in the yew populations and has shaped in general its modern-day latitudinal and altitudinal distribution trend. The additional fragmentations in the range of yew have occurred due to further deteriorations in the climate during the Quaternary multiple glacial periods as well as anthropogenic factors (various human disturbances) in the Holocene [8].

Within the range yew's dispersal ability is limited by low temperatures in the north and by long drought in the south. It has a very wide soil tolerance but is vulnerable to waterlogging [1,6].

Altitudinal distribution increases from north to south with moisture demand. Currently, similar to other species of *Taxus*, European yew is highly shade tolerant, but can withstand full exposure to the sun [1,9]. In mountainous areas yew prefers north-western or north-eastern shade slopes, close to maritime-coastal climates, where it occurs under canopy of deciduous or mixed forests [1,10].

During climate warming within the Pleistocene/Holocene boundary, despite its poor dispersal ability, species of *Taxus* have followed a speedy distribution in northwest Europe and simultaneously in the high mountainous altitudes [11].

As the Holocene started with rapid climate warming, the yew spread to the southern fringes of Europe and Asia Minor. During the Last Glacial Maximum (about 25 thousand years ago), a bottleneck for thermophilous dendroflora, yew continued to live in refugial areas of the Amanus and Taurus Mts of southern Turkey. During the later climate warming *T. baccata* began to migrate from southern Turkey and

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probably between 9000–7000 BCE crossed Anatolia and reached the Caucasus (the Black Sea shores and the Caucasus Mts) [12]. In the present interglacial period, *Taxus* was more abundant in the first half of the Holocene, and, therefore, must have played more important role in the hardwood and softwood forest communities [10].

Today, one of the most important reasons in the decline of *T. baccata* is human impact (widespread deforestation, habitat fragmentation, etc.). 'Such activities have transformed the forest landscape and affected vegetation dynamics, especially of shade-tolerant and late-successional species like yew' [13].

This tree species is under threat, and has become locally extinct or reduced to individual trees or small populations over the past 4000 years in many parts of its range. This trend is continuing [1,14]. Hence, in the majority of countries, *T. baccata* is included in the Red Data Books and is accepted as a problem in nature conservation [5].

Within the temperate forests, yew is found usually either as solitary trees or scattered at most in small groups. Dense, pure woodlands consisting of *T. baccata* can be found rarely, in refugial sites, under mild maritime climate [1].

In the Caucasus, European yew is clear example of its location in woodland communities and, at the same time, it is obviously manifested in its spatial patterns of distribution through different sequence types of altitudinal vegetation belts, significantly in the GCR.

During this study only elevation distribution pattern has been taken into account. The aim of the present study was to improve our understanding on the range of distribution limit of *T. baccata* by its maximum elevation, i.e. in the treeline ecotone of the Greater Caucasus, to reveal a pathway related to survival ability of yew in harsh ecological environment.

Material and methods

In order to enlighten the altitudinal expansion of European yew (Table 1), attention was focused on the range of relict tree in southern Caucasus, significantly in Georgia. In this region, in the GCR yew sequentially occurs almost at all elevation types of vegetation from lowlands and foothills up to treeline zone (2200 m a.s.l.) of the Greater Caucasus. Data was used from: (1) literature sources and (2) from latest personal observations (2014–2016).

Results and discussions

Among four mountain systems of the Caucasus Isthmus – the Greater Caucasus, Lesser Caucasus, Talysh Mountains and Javakheti-Armenian Uplands (part of the Armenian Highland) – yew populations exist in the first three systems. Although, in all altitudinal zonations, including treeline ecotone, yew is sporadically represented only in the GCR.

The Greater Caucasus, one of the greatest ranges in western Eurasia is presented as climatic barrier between Eastern Europe and West Asia, stretching latitudinally for over 1000 km [15]. Southern macroslope of the range consists of majority of characteristic landscapes of the Caucasus Isthmus [16]. Yew tolerates a wide range of soils, but most notably it prefers calcareous soils with a high lime content. Limestone massifs of the GCR are of the Jurassic and Cretaceous origin and with their powerfully thick deposits of limestone are remarkable by active karstic processes [17,18]. Western part of the southern slopes of the GCR, under the influence of the moderating activity of the Black Sea, are remarkable with its warm, humid climate at the lower elevations. However, the latter changes to cool, humid climate towards the mid-elevations and to a moderately cold and extremely humid climate at the highest altitudinal zone should be taken into consideration [16].

Calcareous substrate harbours a high biodiversity. Plant species richness peaks on calcareous habitats [19–22]. Patterns of high level of neo- and paleoendemism on species and genera levels ('calcareous riddle') in calcicolous flora of the GCR has always been of interest for the Caucasian botanists [23–25]. The same holds true for the phytogeography of calcicolous alpine species [26].

Available data of the sites, as it mentioned already, was used in this study from four disjunction areas of Transcaucasia (the GCR) with considerable attention to two subalpine treeline ecotones. Another two low or comparatively lower altitudinal vegetation sites have been well studied previously by several botanists and foresters.

Below are identified two sites where yew forms either old-growth monodominant forest formation (Taxetum) (Fig. 1.4., Batsara; Fig. 4., Batsara) or is successfully associated (co-occurring) with evergreen shrub/tree, Colchic box-tree (*Buxus colchicum*) or some deciduous trees in canopy (e.g., *Fagus orientalis,* also *Carpinus betulus, Tilia dasystyla* subsp. *caucasica*) (Fig. 1.1., Sochi). Two other sites are found in treeline ecotone (Fig. 1.2., Okhhachkue; 1.3., Khvamli).

There are 130 known yew stands in the Western Caucasus (one of the highest recorded data in the North Hemisphere) [12], of which Sochi yew stand in southwestern Caucasus encompasses 301 ha, and Khosta yew-box grove envelopes 190 ha, ranging from 40 to 520 m a.s.l [27–30] (Fig. 1.1.). Until today two sites have been protected due to above mentioned moderate, oceanic climate. Sochi-Khosta yew and yew-box-tree stands are considered to have remained relatively unchanged since the mid-Tertiary (about 30 mya). Magnificant giant yew reaches a height of 30 m and is 1 m in girth, and height of Colchic box-tree goes up to 18 m and diameter is up to 50 cm. This forest is under protection of UNESCO as an object of the World Heritage [5,28].

Another, mixed – Oriental beech forest with yew (Fageta-taxceto) is found in the East Georgia (Kakheti district), as already mentioned, it occurs in the Batsara River Gorge (the Alazani River's left tributary). In

Table 1
The altitudinal range of *Taxus baccata* in different countries of temperate Eurasia.

Countries/Regions	Elevations	Authors
South Slovakia	660–1000 m a.s.l.	Thomas & Polwart, 2003
Alps	1100–1400 m a.s.l.	„——————————“
Iran	1400 m a.s.l.	„——————————“
Turkey	1400–1900 m a.s.l.	„——————————“
Pyrenees	1400–1650 m a.s.l.	„——————————“
Southern Spain	1600–1900 m a.s.l.	„——————————“
Carpathians	1660 m a.s.l.	„——————————“
Sardinia	1700 m a.s.l.	„——————————“
Macedonia	1800 m a.s.l.	„——————————“
Central Greece	1950 m a.s.l.	„——————————“
Northern Africa	2000–2500 m a.s.l.	„——————————“
The Greater Caucasus Range (GCR)	1900 m a.s.l.	Tvauri, 2006
GCR	2000 m a.s.l.	Sukhachev, 1934
GCR	2050 m a.s.l.	Thomas & Polwart, 2003
GCR (Okhachkue, W. Georgia)	2200 m a.s.l.	Gegechkori, 2015
GCR (Khvamli, W. Georgia)	1950 m a.s.l.	„——————————“, 2016

Fig. 1. The main sites of the woodlands of yew (*Taxus baccata*) (1,4), prostrate shrubland (3) and individual shrub (2) in the treeline of the calcareous area of the Greater Caucasus (South Caucasus).

this area, relatively pure stand of *T. baccata* has still remained preserved in the Batsara Reserve, forming one of the most extensive and best virgin stands in the world [10,28,31]. Within the territory of this reserve 220.000 specimens of yew trees extend from 900 m up to 1350 m and locally even up to 1500 m. Majority of trees can reach about 100 years of age. Approximately 13.000 trees are as old as 400–600 years, but some specimens are believed to be in the age of 1200–2000 years ([32], Kvachakidze1995 cited in Ref. [33]). The undergrowth and the herbal cover are lacking (Taxusumnudum), but rarely Taxusumfestucosum and Fageto-Taxusumfestucosum occur. There are some more thousand-year-old yew trees in the Batsara River Gorge [34–37] (Fig. 1.4.).

Oriental beech-yew tree community in Batsara Valley includes about 60 species of woody flora. Among noble hardwoods mention should be made of *Castanea sativa, Tilia begoniifolia, Fraxinus excelsior, Acer campastre*; in understory among others *Prunus* (*Laurocerasus*) *officinalis*; from vines *Hedera pastuchowii*, from riparian forests – *Alnus barbata*. These and other species give Batsara Valley the worldwide significance. To protect this area together with its unique monospecies stands of yew, the Batsara Natural Reserve was established in 1935 [31,38]. Ichuaidze [39] has reported high seedling mortality under a fully closed canopy, where shading is excessive and light levels too low.

The studies on the distribution of European yew on calcareous highlands of the GCR is highly interesting. This project is carried out under the research framework of maximum distribution patterns of canopy builder deciduous and coniferous trees in the forest/treeline ecotone of the western part of the Greater Caucasus. The research goal includes upward distribution of yew in different ways: (1) determination of extreme elevations of solitary individuals; (2) the same condition for prostrate yew shrubland, and (3) determination of some anatomical, ecological, and peculiarities of vegetative reproduction of yew in the subalpine area.

Taxus baccata in the Caucasus extends within the limits of forest distributions in high-mountains (2,200 m) (pers. observ.), as a krummholz shrub, during long lasting winter, hence during the long period of vegetation dormancy, it is protected by heavy and thick snow cover. Therefore, it grows as semi-prostrate shrub. In response to these harsh environmental conditions it can withstand the extreme physical pressures, but because of insufficient warmth it shows zero sexual reproduction, therefore, does not produce characteristic cones (arils) with ripen berries (Vorobyova 1982 cited in Ref. [33]).

My personal observations in the Caucasus show that except frequently dense populations, individual yew trees are more widespread, mostly in lime-rich substrate of the Greater Caucasus. Typically it grows up to 20–25 m height, trunks are 1.5 m in diameter. Usually it is represented in maximum elevations of 1,800 m a.s.l. (e.g., on Mingaria Mts, Samegrelo, W. Georgia), as a low straight-trunk trees(8–10 m tall) (Fig. 5., Mingaria).

Okhachkue (Samegrelo) highland site with the spectacular karst landscape well expresses the altitudinal sequences of forestline and treeline ecotones, followed by markedly indicated subalpine-alpine tall- and low-herb communities (Fig. 1.2., Fig. 2a-d).

One of the most striking arboreal plants in Okhachkue limestone outcrops (2,200 m a.s.l) is solitary specimen of *T. baccata* (Fig. 2b,d). It grows as a low shrub (about 1 m tall) (Fig. 2b). It seems, this is its maximum altitude distribution in the Caucasus. In Okhachkue this subprostrate shrub tends to grow on the shaded north-facing exposure, on moderate steep slopes. This is a common habitat of the Caucasian rhododendron represented as an elfin stand (Fig. 2c). Within a matrix of dense *Rhododendron caucasicum*, solitary specimens of yew co-occur with other scattered arboreal individuals, notably dwarf and crooked-trunk forms of *Fagus orientalis,* and with normally (almost straight-trunk) growing *Sorbus caucasigena* (Fig. 2c). Underwood is represented with poor specimens of *Vaccinium arctostaphylos*, patchy dwarf shrubs consisting of *V. myrtillus* and *Salix apoda*. The herb layer usually consists of Colchic subalpine tall-forb vegetation. Among tall herbs, the most frequent species are *Heracleum egrissicum, Pyrethrum macrophyllum, Senecio macrophyllus*; other herbs consist of *Carex pontica, Geranium gymnocaulon*, *Anemone fasciculata*, *Ranunculus abchasicus, Nardus glabriculmis*, etc. At the end of summer *Crocus scharoianii* begins to blossom, which in the beginning of autumn bursts into bloom.

It is interesting that not far from plant community with yew (about 1 km) in Okhachkue, in slightly lower altitude (2,100 m a.s.l.) dwarf form of *Viburnum lantana* occurs. Subalpine zone of the Great Caucaus represents probably its one of the highest occurrence in the mountain ranges in the Caucasus. According to Kharazishvili and Memiadze [40] in the Lesser Caucasus (Adjara) it is also found at 2100 m a.s.l.

Khvamli (also known as Khomli) is an enormous limestone massif located in Racha-Lechkhumi, one of the most striking regions of West Georgia (Fig. 1.3., Fig. 3a-d). The highest point of the Khvamli massif is

Fig. 2. (a). Limestone massif (Okhachkue) with characteristic karstic landscape, the typical habitat of the alpine calcicolous endemics, W. Georgia (2,300 m a.s.l.) (photo 2015). (b) author with individual yew specimen in the Caucasian rhododendron thickets (Okhachkue); (c) the typical habitat of the solitary specimen of *T. baccata* represented by *Rhododendron caucasicum* stand (d) herbarium specimens of yew (Okhachkue).

2002 m a.s.l. The massif dominates over the region's landscape, influencing even the local climate. On the other hand, Khvamli is endless source of legends and mythology [18,41]. In Khvamli area the populated cites and agricultural habitats created by humans occupy a small area, hence the natural vegetation continues to play a dominant role. There are many sites with canyon-like gorges and steep slopes, which are very difficult to reach, therefore, almost pristine forests and meadows are widespread (Fig. 3a).

The most widespread forest formation is the woodland with beech (*Fagus orientalis*) (Fig. 3a). Near the timberline the beech forest is enriched with open acerwood, high mountain maple (*Acer trautvetteri*)*, which is represented either by majestic specimens, or small subalpine trees and trees with twisted trunks. Frequently the steep slopes and rocky terrain are colonized by stands of birch with boreal roots of origin – *Betula litwinowii*. The highest elevations (1750–1900 m) with a cold to cold-temperate climate consist of forests composed of mountainous taiga, i.e. native acidophilous conifers: Oriental spruce (*Picea orientalis*) and Caucasian fir (*Abies nordmanniana*). Both – deciduous and coniferous forest communities are very characteristic on the limestone regions of the GCR.

Local forestline, consisting of spruce/firwood community, gives way upwards to treeless alpine vegetation-a markedly expressed ecotone of the acidiphilous timberline (krummholz) enriched with calcicolous relict endemic shrubs.

Khvamli is extreme eastern, marginal range of the endemic and relict *Woronovia-Carex* community, occupying the calcareous substrate [22]. Top of the Khvamli massif, alongside sharp dramatic gorges, side by side with well-developed karst areas (i.e. area dotted with karstic cavities), occurs a flat area, mini-plateau (62 × 36 m in size) (Fig. 3c). It is the mini-ecotone site, populated by homogenous dense stand (mat) of semi-prostrate (1-1, 5 m height) patch of *T. baccata* (Fig. 3c) with admixture of a few most smallest straight trunk specimens (~5–6 m height) (Fig. 3d), with open canopy. The latter ones, despite their straight stature change in physiognomy, are significantly decreasing in height, and extreme episodic frosts are likely to kill adult tree (Fig. 3d).

It should be underlined that such flat, gentle micro-habitat supports soil accumulation. The latter is a little bit deeper (about 20–25 cm depth) and more nutrient rich than surrounded primary rocks. The same niche of karst landforms provides an opportunity to remain till mid-summer of late-lying winter snow peck, which is an additional source of the soil moisture. In the same niche winter snow might protect prostrate yew mats from evaporation patterns originating from highland's fierce winds and frosts. Both phenomena produce potential positive mitigation effects against high radiation of open space highland and high temperatures during summer months. In this way, mini-plateau's topoclimate plays an important role, native vegetation is thus able to avoid desiccation stress and provide an establishment of semi-prostrate yew's stand.

Semi-prostrate yew, surrounding shrub life-forms of *Sorbus graeca, Juniperus* sp. vegetation as matted shrub, appears as dominating arboreal vegetation with high competition ability. Such a striking dense stand of yew is quite unusual growth of this coniferous tree in the

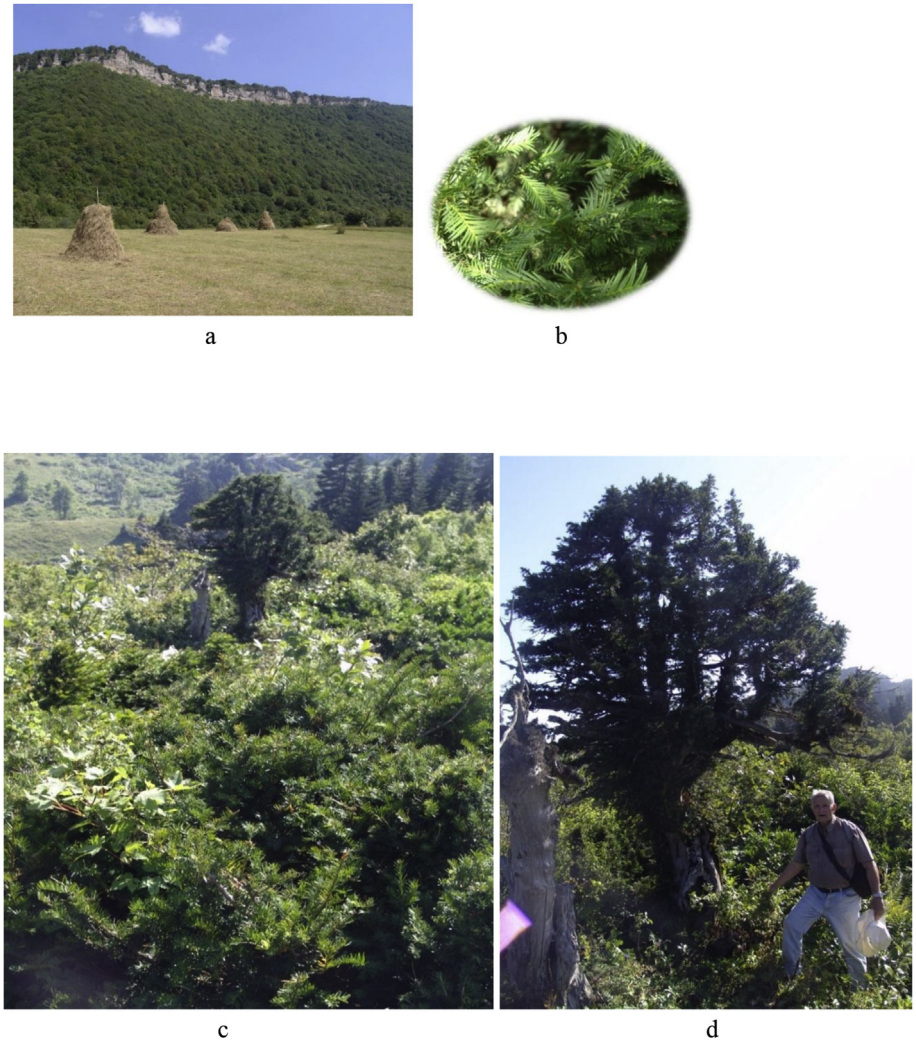

Fig. 3. (a) Racha-Lechkhumi (West Georgia), Khvamli limestone massif (1,400-2,200 m a.s.l.), general view (photo, 2016); (b) foliage of yew shown both (upper and under) surfaces; (c) the incredible homogenous clonal growth mat of *T.baccata* on the alpine timberline ecotone of the limestone mini-plateau. Clonal population of matted shrubland (1,950 m a.s.l.) (photo, 2016); (d) mature, straight-trunk specimens of yew, living (near to author) and dead (stump) one, occurring in the clonal growth mat of yew.

Caucasus.

In recent time *Acer trautwetteri* Medw. is treated as subspecies of *A. heldreichii* (*A. heldreichii* subsp. *trautvetteri* (Medw.) [42].

In local harsh environment yew shrub is inhabited by self-regeneration. It seems that native clonal population of yew descends from a single (or some) founder via vegetative propagation, remaining joint to the parent tree. This dense prickly mat helps to shelter new vegetative offsprings of local populations of dwarf yew (Fig. 3c).

In calcareous uplands (ecotone) of Khvamli, in this remote site for yew, the main abiotic disturbance patterns occur as harsh winds, also grazing (the timber of local woody plant populations have marginal value for human use), and browsing ungulate (e.g., roe-dear, livestock; pers. comment of native driver). Therefore, as it is broadly known, highland of the Greater Caucasus with limestone substrate gives rise to calcicole shrubs and unique herb flora. But subalpine belt of Khvamli with its prominent limestone topography, in treeless mini-plateau niche, without support of closed canopy of neighbouring forests is an unusual place which provides a home to extraordinary shrub populations of yew. So, shrubland dominated by English yew, according to scientific literature sources and personal observations is extremely restricted site in the Caucasus.

Accordingly, in order to find out solitary form (Okhachkue limestone massif, 2,200 m a.s.l.), so rare relict plant communities of yew Khvamli holds great scientific interest as valuable *in vivo* laboratory for scientific research. Hence, important goal for foresters, botanists and environmentalists is to research the causal sides of altitudinal distribution of yew across highland's ecotones (such as topography, elevation, macro- and microhabitats, exposure, etc.), biology (propagation), also possible shift in the marginal area of matted shrubland with harsh abiotic factors (heat sum, water availability, snow cover duration, destructive action of highland wind forces, etc.); to predict future changes (geographical range, population size) of this rare relict conifer during possible global warming (potential impacts of climate change).

This extraordinary small patch of yew stand on mainly skeleton-rich soils with other species of shrubs and herbs is a living monument, natural heritage which carries a feature of outstanding value of rarity (Fig. 3c).

On limestone substrate, including Racha-Lechkhumi, tall subalpine forb vegetation is described by R. Gagnidze [43]. These tall herbs, when they ascend gradually in elevation (subalpine belt), they become more dense.

Unique montane ecosystems of Khvamli with an exclusive agriculture (especially viticulture) of native people are one of the best-known in Georgia. Rock massif of Khvamli in Racha-Lechkhumi, with its floristic, faunistic, geological, paleontological, geomorphological features and, on the other hand, with its pictograms of zodiacal signs

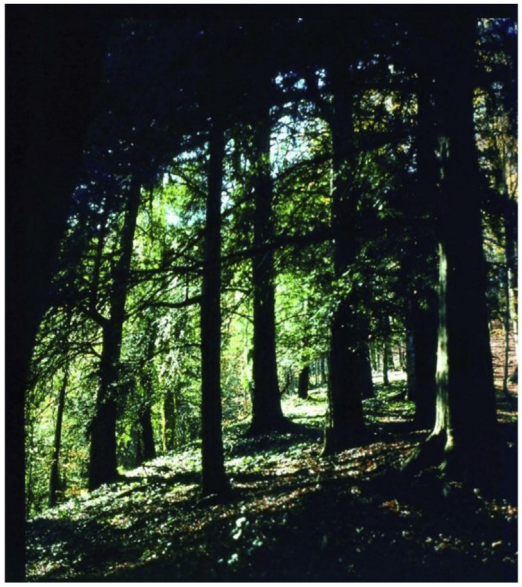

Fig. 4. Pure stand of mature specimens of *Taxus baccata* (Taxusum nudum) from Batsara (photo, 1989).

Fig. 5. Samegrelo (West Georgia), limestone massif of Mingaria (1800m a.s.l.), the individual straight-trunk) yew (*Taxus baccata*) (photo, 2011).

carved into local caves is a great cultural heritage. So, this is a great natural and inspirational diversity in a relatively small area. For this reason, it is worthy of protection, being declared as National Park, still less Georgia has a long tradition of living and non-living nature's protection. From this viewpoint this country was the second after Russian Federation within the former Soviet Union.

Conclusion

Study area lies in the GCR, Georgia (Fig.1.2., Fig.1.3). As it is broadly known, altitudinal zonation with distribution of living organisms represents a nucleus concept in high mountain research. My investigations revealed wide ecological (altitudinal) amplitude of the European yew. It was highlighted that *T. baccata* is capable of growing as a prostrate shrub at higher elevations. Such kind of anatomical alteration occurs close to its elevational distribution limit, 2,200 m a.s.l. (Fig.1.2., Fig. 2a-d). Until now, for these sites of the Caucasus, such peculiarities of expanding range-edge patterns through natural layering of mountainous ecosystems were known, but for classic multizonal trees of primary (canopy) layer, for instance, species of *Fagus, Pinus*, *Abies*, *Picea* (Okhachkue limestone area). Such exceptional altitudinal distribution of yew is a first report in literature sources for the Caucasus.

According to already mentioned research, alpine ecotone is home to both life forms of yew - solitary and matted populations. Both krummholz life forms have high floristic value.

The same should be pointed out regarding extraordinary form of matted (i.e. dense elfin) populations of yew. Its vegetative radial growth was found with a great probability at the edge of this conifer's altitudinal distribution, about 1,900 m a.s.l. (Khvamli limestone massif) (Fig.1.3., Fig. 3c-d).

Ground of the subalpine/alpine ecotone of the GCR, where yew is found, is represented by lime-rich substrate.

Pattern of survival strategy of yew in treeline ecotone's hostile environment includes many aspects: (a) adaptations to already above-mentioned pessimal abiotic factors (soils, climate); (b) biotic factors (competition from more calcicole shrubs, grazing animals, human activity); (c) peculiarities of reproduction (asexual); (d) the spatial (ecological niche) strategy is completely accompanied with the highland's gentle topography (Khvamli massif). In this environment yew behaves similar to, for example, Oriental beech (elfin life form of tree). It seems that rarely occurring gentle (flat) landforms with its soil and moisture accumulation ability vs usually very complicated surface of highlands limestone relief of the GCR is the crucial driver for establishment of krummholz community of yew.

As was pointed out, from ecological point of view, yew is subcanopy tree or shrub, and survives according to its shade-tolerance ability. But occurrence in treeless alpine environment growing in full sun and other significant disturbances press it to face a complex difficulty by means of adapting to the impact of frequently fluctuated climate change. Apart from change of its normally growing and branching pattern toward dwarfism, yew in dramatically changed in environment, where English yew completely modifies its adaptation strategy. It should be stressed that in open space of alpine ecotone yew uses the favourable mitigation circumstances of self-shading effect. In this case, as solitary shrub (e.g., Okhachkue site), it finds shelter within very dense thickets of dominant evergreen Caucasian rhododendron scrubland (Fig. 2c). On the other hand, via clonal propagation yew establishes its large, pure, natural, genetically stable self-sustaining population colonies in flat micro-niche (Khvamli site) (Fig. 3c), therefore exhibiting its own ecological trends with the 'dense and moist' rhododendron scrubland effect. In competition from other shrubs and grassland vegetation with matted shrubland of yew, the former one is completely suppressed. Only in marginal area of the krummholz yew shrubland, some other rival highland shrubs (species of *Sorbus, Rhamnus, Juniperus*) are able to spread side by side either as separate shrubs or low population density groups due to unfavorable terrain.

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