

## RESEARCH PAPER

# Ecological perspectives of endemic Flora of Adjara (Georgia)

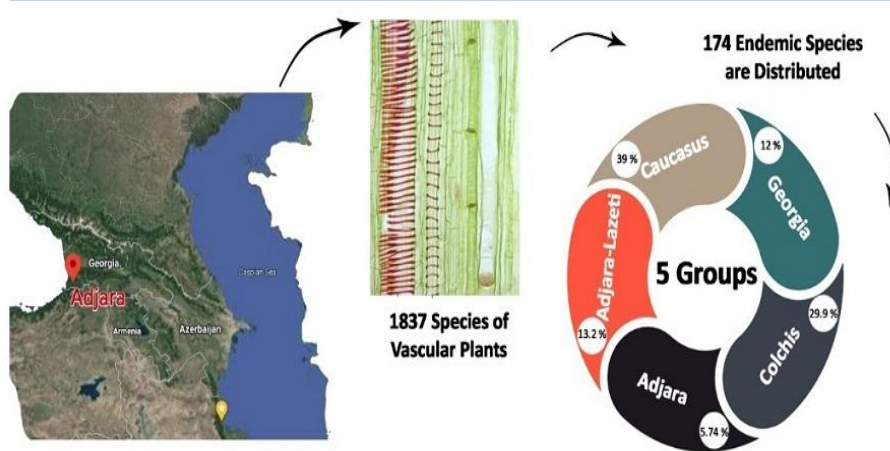
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## Highlights Graphical Abstract

- The Subject of the research was endemics distributed in the floristic region of Ajara (Georgia).
- 1837 species of vascular plants are distributed in Ajara's floristic region, with 174 endemic into five different ecological groups.
- The highest percentage comes from Caucasian endemic plants.



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## Abstract

In Ajara's floristic region of Georgia, 1837 species of vascular plants are distributed, of which 174 are endemic and divided into 5 groups of the Caucasus, Cholchis, Ajara-Lazeti, Georgia, and Ajara by geographic structure. According to life forms, 136 species are perennial grasses, 6 species are biennial, 6 annuals, 11 trees, 13 bushes, and two timbered lianas. They are distributed in the diverse ecological environment as coastal sand and dunes, coastal lowlands, freshwater ponds, in peatbogs, on the humid, shaded slopes of the coast, in thermophilous and mesophilous broadleaf forests, Cholchismesophilous shrubs, hemixerophilic biotopes of cliffs, screes of the forests, biotopes of subalpine forest-valleys, and alpine valleys. Species endemic to cholchis are mainly distributed on shaded slopes and in the thermophilic-mesophilic forest belt, which must be a habitat of endemic origin for Colchis. Most of the endemics species of Adjara and Adjara-Lazeti (28%) are associated with floristic complexes of cliffs, scree, and supposedly, together with the cliffs, rocky outcrops, gorges, and another littoral-ecological environment, that can be considered as one of the ecotopes of the endemic flora of Adjara and Adjara-Lazeti.

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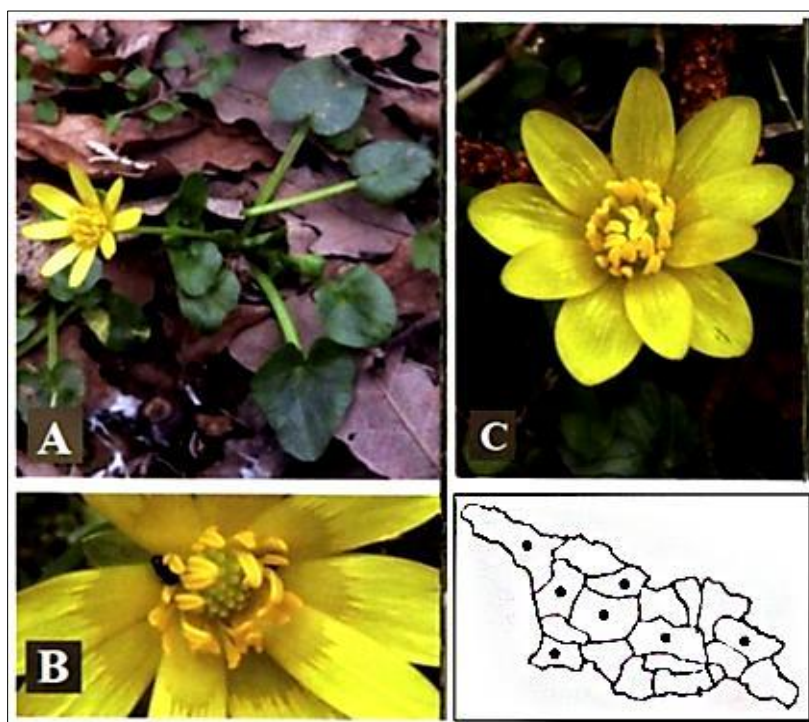
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## 1. Introduction

The floristic region of Ajara is located in the south-western part of Georgia. The southern border of it coincides with the state frontier between Turkey and Georgia and goes along the Shavsheti ridge. From the north, it borders with the Meskheti ridge, from the east to Arsiani ridge, and from the west to the black sea. It is located at 0-2993 m above the sea level with a humid, subtropical climate, rare habitats, and landscapes, a special flora structure based on the autochthonous Mediterranean flora of the Tertiary period (Manvelidze, 2008). The warm and humid climate and the ecological environment's diversity lead to abundance and variety of vegetation cover not encountered in Georgia's other territory (Cipollini et al., 2017; Poythress and Affolter, 2018).

The floristic region of Ajara is the most prominent refuge in the Caucasus. during the ice age of the tertiary and quaternary periods, heat-loving species are sheltered here; therefore, Adjara is also distinguished by a diversity of relict endemic taxa of the tertiary and quaternary periods, floristic complexes created from relict endemics, and rare relict ecosystems that are dominant in Adjarian flora (Li et al., 2017; Nalini and Prakash, 2017; Shrestha et al., 2016; Surat and Yaman, 2017). 1837 species represent Adjarian flora that among them, 174 are endemic. Their geographical structure is divided into five groups as, Caucasus, Georgia, Cholchis, Ajara-Lazeti, and Ajara (Preston and Hill, 1997). They unite in 150 genera from 50 families and makeup 9.4% of Ajara's whole flora. Among them 68 species are endemic to Caucasus (39%), 52 to Cholchis (29.9%), 23 to Ajara-Lazeti (13.2%), 21 to Georgia (12%) and 10 to Ajara (5.74%) (Memiadze 2009). By life forms, 136 species are perennial grasses, 6 species are biennial, 6 annual, 11 trees, 13 bushes, and 2 are timbered lianas. Endemics of different species are distributed in different ecotopes (Eckstein et al., 2018). The distribution of endemic species in the flora of Adjara by habitat and increase in altitude above the sea level is as follows:

1. At an altitude of 0-25 m above sea level, endemic species associated with ecotopes of coastal sands and dunes are *Ficaria calthifolia* (Fig. 1), *Ficaria Popovii* var. *adzharica*, *Ficus colchica*, *Hedera colchica*, and *Rubus caucasicus*. Plants endemic to peat swamps are *Rhamphicarpa medwedewii*, *Hibiscus ponticus*, *Rhynchospora caucasica*, and *Nymphaea colchica*. By origin, they are related to the Borealuar Flora Complexes. *Rhamphicarpa medwedewii* is endemic to Georgia and grows on Kobuleti's lowland, is under the threat of extinction, and included in the Red list of threatened species of Georgia (Elizbarashvili et al., 2018; Lachashvili et al., 2017).



**Fig. 1.** Distribution of *Ficaria calthifolia* in Georgia, (A): Tbilisi, kus-Tba; (B): Adjara, Botanical garden of Batumi and (C): Adjara, Merisi (Natural History Book Service).

2. At 25-50 m above sea level, endemics associated with freshwater ponds are *Trapa colchica*, *Trapa Maleevi*, *Nymphaea colchica*. All three are included in the Red list of threatened species of Georgia (Red Book 1982).

3. At the altitude of 50-200 m above sea level, endemics distributed in ecotops of seaside humid, shady slopes and forest are *Galanthus woronowii*, *Galanthus rizechinsis*, *Scilla monanthos*, *Ornithogalum woronowii*, *Iris lazica*, *Helleborus caucasicus*, *Cyclamen adzaricum*, *Primulamegasaefolia*, *Quercus dschorochensis*, *Hedera colchica*, *Symphytum ibericum*, *Symphytum caucasicum*, *Pachyphragmamacrophyllum*, *Buxus colchica*, *Swidakoeningii*, *Digitalis ferruginea*, *Euonimus leiophlea*, *Aristolochia pontica*, *Hedera colchica*, *Buxus colchica* and others.

4. At 200-500 m above sea level, endemic species associated with the belt of thermophilic-mesophilic broadleaf forests are: *Quercus dschorochensis*, *Osmanthus decorus*, *Hedera colchica*, *Symphytum caucasicum*, *Pachyphragma macrophyllum*, *Buxus colchica*, *Swida koenigii*, *Digitalis ferruginea*, *Euonimus leiophylla*, *Aristolochia pontica*, *Pyrus caucasica*, *Dryopteris alexeenkoana*, *Anthemis woronowii*, *Stachys macrophylla*, *Stachys trapezuntae*, *Paeonia macrophylla*, *Cirsium imereticum*, *Vicia antiqua*, *Heracleum cyclocarpum* and others. Endemic species associated with the biotopes of Cholchismesophilic shrubs are *Rhododendron ungerii*, *Rh. Smirnowii*, *Rh. Ponticum*, and *Epigea gaultherioides* (Manvelidze, 2010).

5. At the altitude of 500-1000 meters above sea level, endemic species characteristic for hemixerophilic biotopes of forest cliffs and scree that are: *Galanthus alpinus*, *Muscari alexandrae*, *Muscari sosnovskyi*, *Allium adzaricum*, *Allium gracilescens*, *Poa adzarica*, *Quercus pontica*, *Rubus woronowii*, *Astragalus adzharcicus*, *A. sommieri*, *Amaracus rotundifolius*, *Myosotis lazica*, *Symphytum caucasicum*, *Linaria adzharcicum*, *Crucianella colchica*, *Quercus dschorochensis*, *Myosotis lazica*, *Campanula pontica*, *Digitalis ferruginea*, *Euonimus leiophlea*, *Peucedanum calcareum*, *Echinops colchicus*, *Teucrium trapezundicum*, *Hedera colchica*, *Verbascum artovinense*, *Verbascum Edzetii*, *Myosotis radix – paralis*, *Scrophularia sosnovskyi*, *Galium subliferum*, *Seseli foliosum*, *Cirsium caput-medusae*, *Cirsium imereticum*, *Hieracium adzaricum*, *Taraxacum grossheimii*, and *Anthemis woronowii*, that this species in a way fill complexes of hemixerophilic forests.

6. At 1500-2000 meters above sea level, the following endemics are distributed in the scope of ecotope of subalpine forest and including *Acer trautvetteri*, *Salix kikodzeae*, *Salix caucasica*, *Valeriana colchica*, *Myosotis amoe*, *Eyphorbia austriaca*, and *Scrophularia chlorantha*. Species typical of subalpine forest-valleys are *Lilium ponticum*, *Lilium kesselringianum*, *Lilium szowitsianum*, *Betula medwedewii*, *Rhamnus imeretina*, *Rubus caucasicus*, *Pyrethum sorbifolium*, *Laserpitium affine*, *Sorbus subfusca*, and *Sorbus Colchica*.

7. At 2000-2400 meters, endemic species characteristic of biotops of subalpine valleys are *Rhododendron caucasicum*, *Bellevalia paradoxa*, *Sorbus fedorovii*, *Aquilegia caucasica*, *Potentilla brachypetala*, *Fritillaria dzhabavae*, *Pserophellus shawsheticus*, *Euphorbia scripta*, *Pulsatilla aurea*, *Heracleum grossheimii*, *Laserpitium affine*, *Valeriana colchica*, *Inula magnifica*, *Grossheimia polyphylla*, *Cirsium aggregatum*, *Senecio platyphylloides* that they are very rare in nature.

8. At an altitude of 2400-2900 meters above sea level, endemic herb species common in alpine valleys are *Crepis pontica*, *Euphorbia scripta*, *Fritillaria dzhabavae*, *Scilla wingradowii*, *Bellevalia paradoxa*, *Primula pseudoelatiar*, *Milium schmidtianum*, *Helictotrichon adzharcicus*, *Koeleria albovii*, *Pulsatilla aurea*, *Potentilla brachypetala*, *Melampyrum alboffianum*, *Viola orthoceras*, *Nonea intermedia*, and *Psephallus adzharcicus*. By the number of species, the largest share (39%) comes from Caucasian endemics, center of distribution for the majority of which is subalpine belt (Ajara-Imereti, Arsiani, and Shavsheti ridges). This is natural since mountainous ecosystems are a center of origination for Caucasian endemic flora, and the most optimal conditions for their existence are found only in subalpine belt. Cholchis endemics, the percentage of which in Ajara is 29.9%, are distributed in the thermophilic-mesophilic belt that should be the center of origination for these endemics. Majority of endemic species of Ajara and Ajara-Lazeti – 28% are associated with cliff-scrub florist complexes, which can be found in every landscape unit and vertical belt. This confirms the assumption that rocks, remnants, and various lithological ecological environments are among the ecotopes of the formation of endemic species in Adjara. Also, endemic species to Ajara and Ajara-Lazeti, have mainly distributed in the gorge of the Ajaristkali River, especially in broad-leaved forest belts. Genera rich with species are Asteraceae with 28 species, Rosaceae (15),



Apiaceae (13), Liliaceae (13), Fabaceae (12), Scrophylariaceae (12), Ranunculaceae (10), Campanulaceae (7), Lamiaceae (7), Boraginaceae 6, Helleboraceae (5), Primulaceae (5), Caryophyllaceae (5), Poaceae (5), Aspidiaceae (4), Hypericaceae (4), Primulaceae (4), and finally Amaryllidaceae with 4 species (Patarkalashvili, 2017).

## 2. Materials and Methods

The research object was endemics distributed in Ajara's floristic region, studied in each floristic formation in association groups, and the belt range at 0-2993 m above sea level (Fig. 2). The primary method of the research was the expeditionary rout method. Plants were examined using Ajarian (Dmitrieva, 1959), Key to plants of Georgia (1964; 1969) and Georgian Flora (1971- 2014). Plants were given systematic status using systematic nomenclatures of Czerepanov (Czerepanov, 1995).

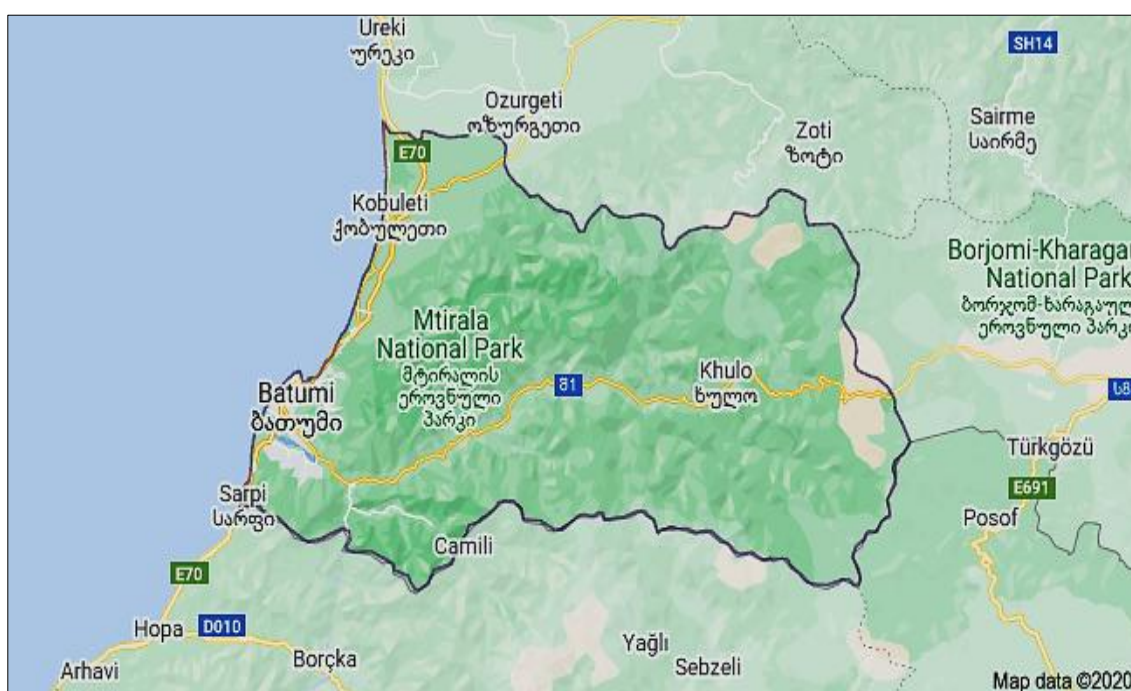


Fig. 2. The floristic region of Ajara is located in the south-western part of Georgia.

## 3. Results and Discussion

There are relict endemics of Tertiary and Quaternary periods distributed in the floristic region of Adjara. depending on the sea level's elevation, endemics are allocated on the existing ecotopes: On the four existing ecotopes existing at 0-50 meters above the sea level: seaside sands and dunes, peaty bogs, and coastal lowlands, 8 endemic species are distributed. At an altitude of 50-200 m above the sea level, in the ecotopes of coastal humid, shady slopes, 17 endemic species are common. 40 endemic species can be found in the forest; the majority of them are endemic to Cholchis and Ajara-Lazeti. At the 200-500 m above the sea level, 46 endemic species originating from Cholchis and Ajara-Lazeti are associated with thermophillic-mesophillic broadleaf forests. 3 species endemic to Ajara-lazeti associated with Cholchis mesophillic shrubs' biotype are: *Rhododendron ungeronii*, *Rhododendron Smirnowii*, and *Epigea gaultherioides*. These three species are under the threat of extinction and included in the "Red List" of Georgia – with the status of VU (Schachat et al., 2016).

At an altitude of 500-1000 m above the sea level, hemixerophyte ecotope of forest cliffs and screes outstanding for the enormous amount of endemics, where endemics of 57 species can be found. Most of them are endemic to Ajara-Lazeti, Georgia, and Cholchis, which partially fill complex hemixerophytic forest complexes. At 1500-2000 m above the sea level in the biotope of subalpine forest 8 Caucasian endemic timbered species are distributed for the subalpine forest-valley, 4 Caucasian shrubs, and 68 caucasian herb species are characteristic. For the biotops of subalpine valleys, 70 Caucasian endemic species are typical. Among the

studied endemic species, ones with high amplitude of distribution are *Galanthus woronowii*, *Scilla monanthos*, *Ornithogalum woronowii*, *Ficaria popovii*, *Helleborus caucasicus*, *Cyclamen adzharicum*, *Primula megasaefolia*, *Quercus dschorochensis*, *Hedera colchica*, *Symphytum ibericum*, *Symphytum caucasicum*, *Myosotis lazica*, and *Pachyphragma macrophyllum*. They constitute highly decorative species and are involved in the external or domestic trading network (Varshaniidze, 2013). By the number of species, the highest share comes from the Caucasian endemics, centre for origination and distribution for most of which is subalpine belt, endemics of Cholchis are distributed in the thermophilic-mesophilic forest belt, that must be the biotope of their origination. Majority of the endemic species of Ajara and Ajara-Lazeti are associated with the florist complexes of cliff-sediments, therefore the littoral ecological environment is one of the ecotopes of the formation of endemic species of Adjara and Adjara-Lazeti (Gegechkori, 2018).

By the number of species, the largest share (39%) comes from Caucasian endemics, the centre of distribution for the majority of which is subalpine belt (Ajara - Imereti, Arsiani, and Shavsheti ridges). This is natural since mountainous ecosystems are a center of origination for Caucasian endemic flora, and the most optimal conditions for their existence are found only in subalpine belt. Cholchis endemics, the percentage of which in Ajara is 29.9%, are distributed in the thermophilic-mesophilic belt that should be the center of origination for these endemics. Majority of endemic species of Ajara and Ajara-lazeti 28% are associated with cliff-scrub florist complexes, which can be found in every landscape unit and vertical belt. This confirms the assumption that rocks, remnants, and various lithological ecological environments are among the ecotopes of the formation of endemic species in Adjara. Also, endemics to Ajara and Ajara-Lazeti are mostly distributed in the gorge of the Ajaristkali River, especially in broad-leaved forest belts. Genera rich with species are Asteraceae with 28 species, Rosaceae (15), Apiaceae (13), Liliaceae (13), Fabaceae (12), Scrophylariaceae (12), Ranunculaceae (10), Campanulaceae (7), Lamiaceae (7), Boraginaceae (6), Helleboraceae (6), Primulaceae (6), Caryophyllaceae (6), Poaceae (5), Aspidiaceae (4), Hypericaceae (4), Primulaceae (4), and Amaryllidaceae with 4 species. Among the studied endemic species, the broad scope of the distribution and ecologically promising that summarized in Table 1.

#### 4. Conclusion

In the florist region of Ajara 174 endemic species are distributed. According to Geographical structure, they are divided into five groups: Caucasus, Georgia, Cholchis, Ajara-Lazeti, and Ajara. They unite in 150 families of 50 families and compose 9.4% of Ajara's whole florist landscape. Genera rich with species are Asteraceae with 28 species, Rosaceae (15), Apiaceae (13), Liliaceae (13), Fabaceae (12), Scrophulariaceae (12), Ranunculaceae (10), Campanulaceae (7), Lamiaceae (7), Boraginaceae (6), Helleboraceae (5), Primulaceae (5), Caryophyllaceae (5), Poaceae (5), Aspidiaceae (4), Hypericaceae (4), Primulaceae (4), and Amaryllidaceae with four species.

By the number of species, the highest percentage (39%) comes from Caucasian endemic plants. The majority of them are distributed on the forest margins of the subalpine belt, in forests, cliff-remnant- scree, valleys, shrubs, and alpine valleys. The majority of Cholchis endemics are distributed on the forest's slopes and different biotopes of the Cholchis thermophilic-mesophilic forest belt. The majority of endemics of Ajara and Ajara-Lazeti are associated with the florist complexes of cliff-remnant-scrub. Littoral ecological environment is one of the ecotops for the formation of endemic species of Ajara and Ajara-Lazeti. Some species showed the high amplitude of distribution involved in the country's domestic trading network among the studied endemic species that are *Galanthus woronowii*, *Scilla monanthos*, *Ornithogalum woronowii*, *Ficaria popovii*, *Helleborus caucasicus*, *Cyclamen adzharicum*, *Primula megasaefolia*, *Quercus dschorochensis*, *Hedera colchica*, *Symphytum ibericum*, *Symphytum caucasicum*, *Myosotis lazica*, and *Pachyphragma macrophyllum*. *Galanthus woronowii* and *Cyclamen adzharicum* are involved in external trading network of the country, like *Ficaria popovii*, *Helleborus caucasicus*, *Galanthus woronowii*, *Cyclamen adzharicum*, *Primula megasaefolia*, *Hedera colchica*, *Symphytum ibericum*, *Myosotis lazica*, and *Pachyphragma macrophyllum*.

**Table 1.** Distribution and ecological characterization of some studied endemic species.

Scientific name	Distribution and Ecological Characteristics
<i>Galanthus woronowii</i>	Herb, winter or early spring bloomer, aspect creator, highly decorative, medicinal, mesophilic species, and is endemic to Georgia. It distributed on shady slopes and broadleaf forest margins.
<i>Ornithogalum woronowii</i>	Herb, early spring bloomer, blossomes in February-April, is endemic to Ajara-Lazeti. It widely distributed in forest margins, on slopes, and open spaces of the forest and Forms aspects seen in the spring.
<i>Scilla monanthos</i>	Herb, highly decorative, yearly spring bloomer, aspect creator specie, endemic to Cholcis, widespread on forest margins and open spaces of forest.
<i>Ficaria popovii</i>	Endemic to Ajara, distributed on coastal lowlands and slopes, early spring bloomer, background creator, decorative specie. <i>Helleboruscaucasicus</i> is an evergreen herb, endemic to the Caucasus, highly decorative and medicinal plant distributed on roadside and forest slopes.
<i>Cyclamen adzharicum</i>	Herb, winter-early spring bloomer, highly decorative, medicinal, of an ephemeral nature, endemic to Ajara. Is distributed on seaside as well as in Ajarian inside-mountanousfoliaceous forests in the scope of 20-700 m above the sea level.
<i>Primula megaseifolia</i>	Herb, highly decorative, evergreen, early spring bloomer, endemic to Ajara-Lazeti. Is distributed in a scope of 400-1200 m above the sea level.
<i>Quercus dschorochensis</i>	15-20 m high deciduous tree, is endemic to Ajara-Lazeti. It is highly distributed in the lower and the middle belts of a forest.
<i>Hederacolchica</i>	Endemic to Cholchis, non-tier, evergreen timbered liana, is widely distributed in the entire forest belt.
<i>Symphytum ibericum</i>	Endemic to Georgia, perennial herb, decorative and medicinal plant. It is characterized with the wide distribution on the coastal slopes and forest margins.
<i>Symphytum caucasicum</i>	Endemic to Caucasus, herb specie, is widespread in an entire forest belt.
<i>Myosotislazica</i>	Highly decorative, herb specie endemic to Cholcis. It is broadly distributed in an entire forest belt.
<i>Pachyphragma macrophyllum</i>	Highly decorative herb endemic to Cholchis. It is characterized by wide distribution on the coastal slopes and in forests of the lower belt of a mountain and its margins.
Two Species <i>Galanthus woronowii</i> & <i>Cyclamen adzharicum</i>	Included in the Georgian foreign trade network.
Some other Species such as <i>Ficaria popovii</i> , <i>Helleborus caucasicus</i> , <i>Galanthus woronowii</i> , <i>Cyclamen adzharicum</i> , <i>Primula megasaefolia</i> , <i>Hedera colchica</i> , <i>Symphytum ibericum</i> , <i>Myosotis lazica</i> , and <i>Pachyphragma macrophyllum</i>	Possess high business potential and are involved in the domestic trading network of the country.

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