Ontogenesis of species of the genus *Berberis* L.

*Elnara Salahova*¹, *Mehriban Qafarova*¹, *Irada Mammadova*¹, *Afaq Bagirli*¹, and *Nuray Qadirova*¹

¹Institute of Dendrology, Baku AZ1044 Azerbaijan

**Abstract.** Recently, climate change, reduction of species diversity, and food problems are among the problems that worry the whole world. Plants play an important role in solving these problems. For this purpose, we introduce various food, medical, and industrial plants. One of the plants with different fields of application is the species belonging to the genus *Berberis* L. For this purpose, the bioecology of *Berberis* L. species was studied to regulate the ecological balance. To study the introduction and adaptation of *Berberis* L. species to the Absheron conditions on a scientific basis, it is important to evaluate the biological and morphological features of these species at individual stages of development. During the introduction of barberry species, it is very important to study the biology of individual development of each species. Ontogeny - the individual development of the species - covers the period from the zygote to the natural death of the species. Information about the morphological characteristics of the species is obtained in the developmental stages of ontogenesis.

1 **Introduction**

The study of plant morphogenesis is the most main gauge of adaptation to the soil-climate conditions of the area where it was introduced. The morphological characteristics of the species we studied in Absheron conditions have not been studied. Therefore, in our research work, the sowing of the seeds of those species, the morphology of the seedlings obtained from them, and the dynamic development in the I-III vegetation years were more thoroughly investigated in our research works.

Taking this into account, the morphological characteristics of the sprouts of the species were described during our research. For this purpose, the developmental stages are divided into the following periods and stages: embryonic period, embryonic stage, juvenile stage, virginal stage, reproductive stage, senile period [15].

2 **Materials and Methods**

Nine species of the *Berberis* L. genus belonging to the *Berberidaceae* Juss. family were used as the study objects: *Berberis vulgaris* L. (Common barberry), *Berberis iberica* Stev & Fisch. Ex DC. (Georgian barberry), *B. densifolia* Rusby. (Densifolia barberry),

*Corresponding author: salahova.elnara@bk.ru*
The study of the initial stages of ontogenesis in plants was carried out by I.G. Serebryakov [11] was carried out according to the method. The morphology and growth of the root system were studied in 1-3-year-old plants using the method of "complete digging out and washing of roots" according to V.A. Kolesnikova [7]. Morphological traits of fruits and seeds were studied by the method of I.A. Ivanov and N.M. Dudik [5].

3 Results and Discussion

Describing the morphology of the sprouts, the following indicators were determined: the beginning of seed germination, the development of the later part of the embryo, the dynamics of hypocotyl development, the opening and full formation of the first leaves, the development of the spindle root system, the development of the epicotyl, the formation and opening of the first pair of true leaves, their shape, and size.

To study the ontogeny of barberry species, in 2014-2015, the seeds were sown in the first 10 days of March in a specially prepared nutrient medium (pots) in open conditions. For this purpose, local and imported seeds were used (Table 1). The first sprouts were observed at an air temperature of 18-20°C and soil humidity of 60-65%. Germination was recorded 31-43 days after sowing. The germination type is terrestrial, hypocotyl. *Berberis vulgaris* L., *B. heteropoda* Schrenk., *B. densifolia* Rusby., *B. thunbergii* DC germinate faster in seeds sown at the same time, and *B. julianae* C.K. Schneid species (10-14.04.2015), and later *B. levis* Franch. and *B. koreana* Palib. (18-22.04.2015) species were observed.

The research has shown that seed germination and seedling development in *Berberis* L. species are very alike so it is difficult to detach seedlings from each other by morphological features; hypocotyl, shape, color, and stem are formed at this stage. The first leaves and juvenile leaves differ only in size.

At the embryonic phase, the seeds give above-ground sprouts. When seeds germinate, an embryonic rhizome is first formed. After the formation of the root of the sprout, a hypocotyl and 2 short first leaves appear on the soil surface. Regardless of the species, the epicotyl is very weakly developed in barberry species. After 10-15 days, first-order lateral roots begin to form.

The next phase is the juvenile stage. The characteristic feature of this stage is the formation of 1st, 2nd, and 3rd juvenile leaves. In May, a leaf rosette of 4, 5, and 6 leaves is formed (Figures 1, 2).

In favorable ecological and senotic conditions, the duration of the juvenile ontogenetic state in plants lasts from 5 months to 2 years.

In barberry species, the morphological structure gradually becomes more complex during the entire period of development, starting from the stages of ontogenesis.
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![Fig. 1. The appearance of 3-20-day-old seedlings of Berberis vulgaris L.](image)

The immature stage is observed in 2-year-old plants, the plant grows rapidly. At this stage, secondary branches are formed on the main branch. The second year of vegetation in all species, a bush is formed, and the plant passes into the stage of formation of a virginal or young vegetative structure.

The virginal stage is characterized by monopodial growth of the main axis and the development of shoots from axillary shoots. At the end of this stage, the completed growth of the root system [10].

![Fig. 2. Berberis Iberica Steve and Fish. Former DC. the formation of a rosette of leaves in a species](image)

Horizontally located additional roots are formed in the main part of the basal axis, and the root system is formed a mixed-type. In the ontogenetic state, a primary bush is formed. The duration of the virginal ontogenetic state is 2-3 years [2-4, 6].

<table>
<thead>
<tr>
<th>Species</th>
<th>The date of first leaves release to the soil surface</th>
<th>The date of first leaves shedding</th>
<th>First leaves duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berberis vulgaris L.</td>
<td>18.04. ±3</td>
<td>30.06.±3</td>
<td>73±3</td>
</tr>
<tr>
<td>B. iberica Stev &amp; Fisch. Ex DC.</td>
<td>22.04. ±2</td>
<td>15.06.±2</td>
<td>54±2</td>
</tr>
<tr>
<td>B. densifolia Rusby</td>
<td>17.04. ±2</td>
<td>20.06.±2</td>
<td>64±2</td>
</tr>
<tr>
<td>B. amurensis Rupr.</td>
<td>22.04. ±4</td>
<td>22.06.±3</td>
<td>61±3</td>
</tr>
<tr>
<td>B. levis Franch.</td>
<td>17.04. ±3</td>
<td>25.06.±3</td>
<td>69±3</td>
</tr>
<tr>
<td>B. thunbergii DC.</td>
<td>24.04. ±3</td>
<td>25.06.±2</td>
<td>62±2</td>
</tr>
<tr>
<td>B. julianae C.K.Schneid</td>
<td>18.04. ±3</td>
<td>25.06.±3</td>
<td>68±3</td>
</tr>
<tr>
<td>B. koreana Palib.</td>
<td>30.04. ±2</td>
<td>28.06.±3</td>
<td>59±2</td>
</tr>
<tr>
<td>B. heteropoda Schrenk.</td>
<td>24.04. ±2</td>
<td>30.06. ±3</td>
<td>67±2</td>
</tr>
</tbody>
</table>
In barberry species, the first leaves gradually turn yellow starting from the beginning of July and fall at the end. *Berberis julianae* C.K.Schneid (68±3), *B.levis* Franch. (69±3) and *B. vulgaris* L. (73±3 days) have the longest leaf lifespan, while *B. iberica* Stev & Fisch Former DC. and *B. koreana* Palib. (54±2 and 59±2 days) are relatively short. The remaining species occupy an intermediate position.

The next stage is the reproductive stage. Flowering and fruiting are observed at this phase. Depending on the species, this stage is observed at the age of 4-5 years in the *Berberis* L. species that we are researching. In the first year of flowering of a young generative plant, a group of flowers is formed in the area of growth of the previous year in the upper zone of the main axis. Flowers develop from apical meristems or axillary shoots. Flowers consist of perianth, sepals, petals, stamen, and pistils. The perianth consists of 6 leaflets located in the inner and outer circles. At the base of each leaf, there are two nectaries. Flowers are collected in the cluster flower group. Flower clusters of different shapes were observed on the species we studied: sparse, simple cluster

![Image](image_url)

**Fig. 3.** The appearance of fruit of *Berberis julianae* C.K.Schneid and *Berberis densifolia* Rusby.

(*Berberis vulgaris* L., *B.amurensis*), sparse, swinging cluster (*Berberis iberica* Stev & Fisch. Ex DC., *B.koreana*), dense, swinging cluster (*B.densifolia*), cluster adjacent to the leaf axils (*B.levis, B.julianae*), rare or sparse clusters (*B.thunbergii*), pile cluster with different stalks (*B.heteropoda*).

**Table 2.** Comparative study of fruits in *Berberis* L. species

<table>
<thead>
<tr>
<th>Species</th>
<th>Fruit</th>
<th>100 fruit mass (average), g</th>
<th>100 seed mass (average), g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Color</td>
<td>Shape</td>
<td>length, cm</td>
</tr>
<tr>
<td><strong>Berberis vulgaris</strong></td>
<td>scarlet</td>
<td>Oblong</td>
<td>0.8-1.1</td>
</tr>
<tr>
<td><em>B. iberica</em></td>
<td>scarlet</td>
<td>oblong</td>
<td>0.7-1.0</td>
</tr>
<tr>
<td><em>B.densifolia</em></td>
<td>red</td>
<td>ovoid or oblong</td>
<td>0.8-0.9</td>
</tr>
<tr>
<td><em>B.amurensis</em></td>
<td>bright red</td>
<td>elliptical</td>
<td>0.9-1.1</td>
</tr>
<tr>
<td><em>B. levis</em></td>
<td>violet</td>
<td>elliptical</td>
<td>0.5-0.7</td>
</tr>
</tbody>
</table>
In subsequent years, flowering and fruiting are passed on to the part that was the growth zone of the previous year. Single clusters and short branches form in the second year in place of the flower group formed in the first year in the first main axis zone [1, 8, 9, 14]. The initial bush grows monopodially; in parallel, axillary shoots increase and form. The 2nd and 3rd row vegetative branches arise from the lateral branches of the main axis [12, 13].

The color of the fruits varies from crimson to purple or shiny black (Fig 3). The length of the fruit varies between 0.5-0.7 and 0.9-1.2 cm depending on the species (Table 2).

The senile stage is the aging stage, which includes the period from the cessation of fruiting in the plant to the natural death of the plant. In barberry species, this period spans several decades or more.

### 4 Conclusion

I would like to express that several important results were achieved during the research. While studying the ontogeny of *Berberis* L. species, the morphology, growth and development, phenology, flowering, and fruiting of the seedlings of these species were also investigated.

The ontogenesis of species belonging to the genus *Berberis* L. consists of the following stages: embryonic stage, juvenil stage, virginity stage, reproductive stage, and old age period.

Embryonic stage rhizome, the first leaves, hypocotyl, and poorly developed epicotyl are formed. In the embryonic phase, the species are very similar to each other, differing only in size.

Juvenile leaves and leaf rosettes are observed in the juvenile stage. Juvenile phase lasts from 5 months to 2 years.

At the virginal stage, the root system is of a mixed type, and a primary bush is formed. This period lasts 2-3 years depending on the species.

Flowering and fruiting were observed in the reproductive phase. Depending on the species belonging to the *Berberis* L. genus, the flowering and fruiting phase begins at the age of 4-5 years. Flowers are collected in the cluster flower group. The color of the fruits varies from crimson to purple or shiny black. The length of the fruit varies between 0.5-0.7 and 0.9-1.2 cm depending on the species.

In barberry species, the senile stage spans several decades or more.

Studying the ontogeny of *Berberis* L. species helps to realize their application in different fields. Since *Berberis* L. species have a wide range of uses in medicine, landscaping, and industry, it is recommended to propagate these species in various areas.
Authors' contribution

Conceptualization, S.E.; Methodology, S.E.; Software, S.E.; Formal Analysis, S.E.; Investigation, S.E.; Resources, I.M and N.Q.; Writing – Original Draft Preparation, S.E.; Writing – Review & Editing, A.B.; Project Administration, M.Q.; Funding Acquisition, S.E.

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