

Biology of *Begonia* sect. *Wageneria* (Klotzsch) A.DC. under cultivation conditions (*ex situ*)

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Abstract. Morphological structure, features of growth and development of *Begonia* species of the *Wageneria* section (*B. convolvulacea*, *B. glabra*, *B. fagifolia*) under *ex situ* conditions were studied. The architectural model and structure of inflorescences, as well as the dynamics of shoot growth and flowering, are established and described. Recommendations for the optimal cultivation of the *Wageneria* section begonias in greenhouses and rooms are presented. The main factor affecting the success of cultivation and decorative effect is the air temperature; the optimal one is +20-30 °C. *Begonia convolvulacea* and *B. glabra* proved to be the most resistant to various cultivation conditions.

1 Introduction

Begonia is a mega-genus with about 2500 species [1]. In 1954, Klotzsch described the *Wageneria* section, which included 16 species [2]. Until recently, it was believed that this section has 7 species [3]. Currently, the section contains 6 species, since *B. smilacina* A.DC. has been recognized as a synonym of *B. glabra* Aubl. [4]. Three species of the *Wageneria* section are cultivated in the CSBG SB RAS collection: *B. convolvulacea* (Klotzsch) A.DC., *B. glabra*, and *B. fagifolia* Fisch. ex Otto. The description of *B. glabra* was first published in 1775 by Jean Baptiste Aublet [5]. *B. convolvulacea* was first discovered by the German naturalist Frederick Sello in 1853 and the following year introduced to the Schönbrunn gardens in Vienna [6]. The plant was described in 1854 under the basionym *Wageneria convolvulacea* by Johann Friedrich Klotzsch [2]. The botanical description of *B. convolvulacea* was first given by Alphonse de Candolle in *Flora Brasiliensis*, 1861 [7]. In 1936, German botanists Christoph Otto and David Dietrich published a description of *B. fagifolia* [8].

The main characteristics of the *Wageneria* section are as follows: plants lianescent, anthers dehiscent with laterally positioned, longitudinal slits; styles free, placenta per locule; seed with a “crown” (micropylar or chalazal end inflated) [9].

The begonias of the *Wageneria* section are native to South and Central America. *B. glabra* has the widest range, from Mexico to Brazil, *B. convolvulacea* found throughout Brazil. *B. fagifolia* has a more limited range. It is found in Brazil, growing only in the coastal Atlantic forest, southeast and northeast (Rio de Janeiro, in the north of Espirito Santo and in the south of Bahia) [10].

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In the Atlantic forest *Begonia* species occupy different biotypes, such as marshes, sunlight places and wet soil, rain and dry forests, altitude vegetation and xerophytes vegetation [11, 12]. *B. convolvulacea*, *B. glabra*, and *B. fagifolia* prefer to grow as epiphytes or hemiepiphytes and are usually found in trees, in shaded and light places. They can sometimes be seen on rocky cliffs [10]. *B. glabra* grows not only on trees, but also along the edges of paths [13].

All of these begonias are widely used in landscaping in America and Europe [6]. In Siberia, these species are still rare; most often they are found in private collections. In order to promote the wider cultivation of these species, a more detailed study of their biological characteristics is necessary. Thus, the study of the morphological structure, and features of the growth and development of species *ex situ* became the goal of our study. The results obtained allowed to develop recommendations for optimal cultivation begonias of the *Wagneria* section.

2 Material and methods

The studies were carried out in the Central Siberian Botanical Garden of the Siberian Branch of the Russian Academy of Sciences (CSBG SB RAS, Novosibirsk, Russia) over 20 growing seasons (2000-2021). Plant samples are obtained from the V.L. Komarov Botanical Institute of the Russian Academy of Sciences, Saint Petersburg (*B. convolvulacea*, 1980; *B. fagifolia*, 2000) and from the N.V. Tsitsin Main Botanical Garden of the Russian Academy of Sciences, Moscow (*B. glabra*, 1999).

The climate of Novosibirsk is continental; its essential feature is the rapid heating of the air in the spring and its intense cooling in autumn. The average onthly daytime air temperature in August is +16° C, the minimum is +10° C. In September, the values of these indicators decrease, respectively, to +10° C and +2° C [14]. At subzero air temperatures during the cold period, begonias can be grown indoors.

We studied *Begonia* plants in various conditions: in greenhouses (tropical and subtropical) and interiors (office rooms). In the greenhouse with a tropical climate, plants were grown at a temperature of +20-35° C, humidity 50-90 %, illumination 2000-5000 Lx. In a greenhouse with a subtropical climate, the air temperature during the year varied from +5 to 35° C, air humidity was 30-70 %, illumination 1000-5000 Lx. Some plants were taken outdoors after the average daily air temperature was set at +10° C (second decade of May) and returned back in the greenhouse after the leaves had completely died off (second half of August).

To assess the adaptive capabilities and prospects of cultivation of the *Wagneria* section begonias, we recorded the main indicators, such as: morphological traits and types of shoot growth, seasonal rhythms of plant growth and flowering, completeness of ontogenesis, the ability of plants to vegetative and seed reproduction [15, 16]. The decorative properties of plants were also evaluated.

3 Results

The most significant structural feature of begonias shoot system is the continuous monopodial growth of the axes and the axillary position of the inflorescences. In begonias of the *Wagneria* section all vegetative shoots are plagiotropic. So, all the studied species belong to the monopodial plagiotropic long-metameric architectural model [17]. Vegetative shoots of the studied begonias are uniformly leafy along the entire length, creeping along the surface of the soil and rooting in the nodes, with a raised tip (Fig. 1 a). They can be

attached to a support (wood, stones, artificial pillars and grates) with the help of adventitious roots and creep on the surface of the soil without support.

The length of begonia shoots cultivated *ex situ* is limited to 2-3 meters by the space of the greenhouse (Table 1). When grown in pots, plant growth is limited by the size of the pots. The length of the shoots in nature varies, reaching, for example, 15 m in *B. glabra*.

Table 1. Main characteristics of begonias of the *Wagneria* section

	Place	<i>Begonia species</i>		
		<i>B. convolvulacea</i>	<i>B. glabra</i>	<i>B. fagifolia</i>
Flowering period, month	Nature ¹	V–IX* I–III, V, VI–X**	I–XII**	VII–IX*
	I ²	I–III, V, VII, IX	I–X	V–VII
	II	IV–V, VII–VIII	II–IX	VI
	III	II, V, VI, VIII	I–IX	VI
Length of the peduncle, cm	Nature	14–56* 6,8–53,8**	17–22* 13,5–35**	20–27* 20–70**
	I	6–10	5–7	3–4*, 3–5**
	II	3–8	2–5	1–2
	III	5–10	3–4	1–3
Number of flowers per one inflorescence, pcs.	Nature	70–200**	50–100**	–
	I	50–150	40–90	200–250
	II	30–60	30–60	150–200
	III	30–70	30–70	150–180
Length of the main shoot, m	Nature	2–8**	3–7*, 2–15**	3–4*, 3–5**
	I	2–3	2–3	2–3
	II	1,5–2	1,5–2	1–2
	III	1,5–2	1,5–2	0,5–1
Length of internodes, cm	Nature	3,5–18*, 3–17**	2,2–7,5 *	2*, 4–4,7**
	I	5–7	4–5	1–2
	II	5–6	3–4	1–2
	III	5–6	2–4	0,5–1
Size of the sheet blade, cm	Nature	6–11 × 7–25,5* 5,5–25×9–29**	7,5–10,5 × 5,5–7* 5–18×2,5–13**	7–11,2 × 2–4,5* 7–8×5,6–6,8**
	I	6–10×9–12	4–11×2,5–7	5–6×2,5–6
	II	3,5–5×8–10	6–8×2–9	3–6×2–4

	III	4,5–6×8–11	3–9×2–7	3–6×2–5
Length of the petiole, cm	Nature	2,8–18* 3,7–29,5**	1,2–2,5* 1,1–9**	1,1–3* 1,7–2**
	I	5–7	2–5	1–1,5
	II	1–3	1–4	1–1,2
	III	1–3	1–3	1–1,3

¹According to the literature data: Kollmann, 2012 [10]*; Gregório 2016 [13]**

²*Ex situ* growing conditions: I – tropical greenhouses, II – subtropical greenhouses, III – rooms

The begonias of the *Wagneria* section cultivated in tropical greenhouse do not have a distinct dormant period. In February, begonias begin intensive growth, but its rate varies in different species: the fastest growth of shoots is observed in *B. glabra*. In April, the growth of shoots slows down (Fig. 2). The growth dynamics in *B. convolvulacea* and especially in *B. fagifolia* is smoother, so they these species can be attributed to the group of constantly growing plants. When cultivating begonias in interiors, such growth patterns are preserved. In greenhouse with a subtropical climate, the growth of begonias slows down when the temperature drops to +5-10° C in winter. Shoots with short internodes are formed at this time. The shortest internodes, 0.5 cm long, are formed in *B. fagifolia* (Table 1).

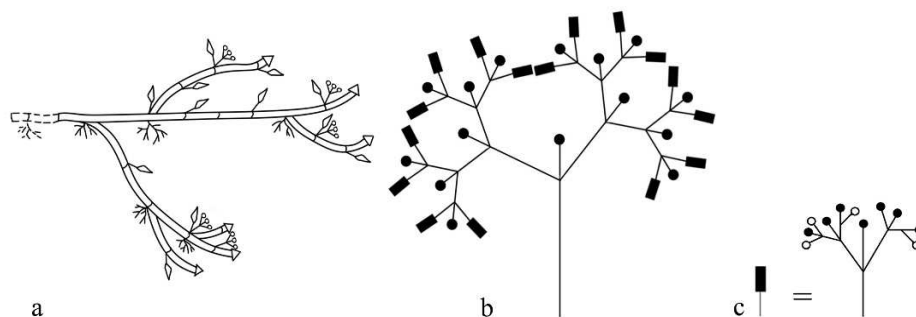


Fig. 1. Structure of the shoot systems in *Begonia* section *Wagneria*: monopodial plagiotropic long-metameric architectural model (a); scheme of dichasial inflorescence (b) with its terminal part (c).

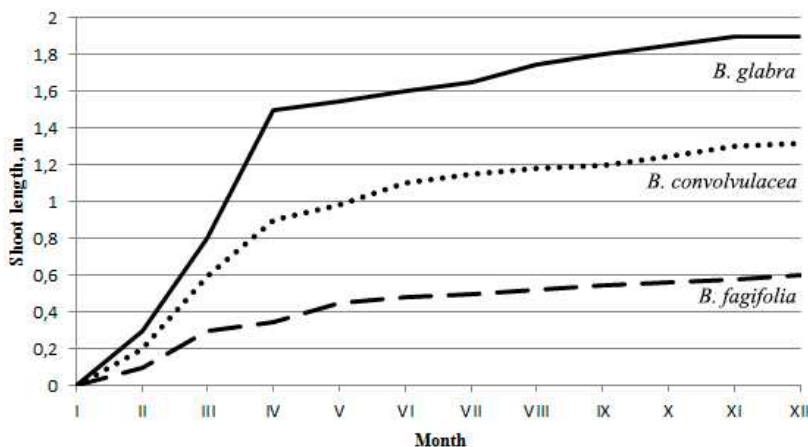


Fig. 2. Dynamics of the shoot growth in *Begonia* species cultivated in a tropical greenhouse.

The leaf blades of the studied begonia species differ significantly, both in shape (Fig. 3) and size. The latter depends on the growing conditions: at low temperatures (less than +10° C) and insufficient humidity (less than 20 %), smaller leaves are formed (Table 1). In *B. fagifolia*, unlike other species, the leaves are covered with long hairs. The shape and color of the leaves, as well as the texture of the surface are significant indicators of the decorative appearance of the species.

All the studied species bloom cultivated *ex situ*. Inflorescences of *Begonia* are axillary, dichasial, with bracts and not reduced axes, bisexual, with male flowers basal and female flowers distal, protandrous [9, 18]. In begonias of the *Wagneria* section, dichasia are multi-tiered (Fig. 1 b), branching up to the 6-8th order, with a slight depletion of the branching of the higher orders, so terminal cyma may be monochasial (Fig. 1 c). The peduncles are arranged vertically; their height varies greatly and depends on the growing conditions (Table 1). The height of inflorescences *ex situ* is 2-7 cm in *B. glabra*, 3-10 cm in *B. convolvulacea*, and 1-3 cm in *B. fagifolia*. In nature, according to L.J.C. Kollmann [10] and B.S. Gregório [13], inflorescences can reach a large size, for example, up to 56 cm in *B. convolvulacea* (Table 1). The flowers are white, small, with petals 1-4 mm long; in begonias growing in nature, the petals can be to 7 mm (*B. fagifolia*). The number of flowers per inflorescence varies from 20 to 250 pcs., both in nature and in cultivation (Table 1). Due to the protandrous blooming, male and female flowers can be simultaneously in the same inflorescence only for a short time.

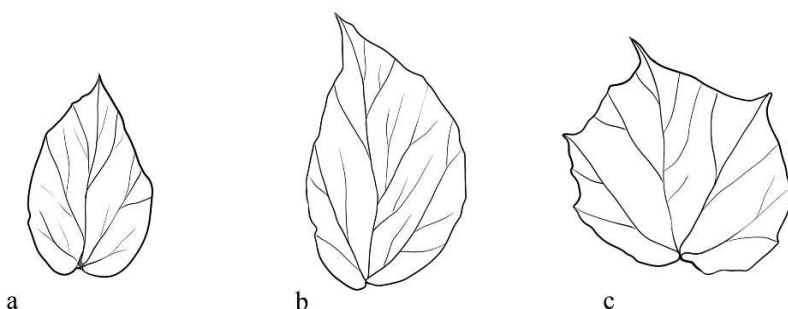


Fig. 3. Typical leaf blade shape of *Begonia*, section *Wagneria*: *B. fagifolia* (a), *B. glabra* (b), *B. convolvulacea* (c).

The duration and time of flowering differ in begonia species (Table 1). *B. glabra* does not have a pronounced flowering cessation from January to October under optimal growing conditions but the intensity of flowering varies during this period. *B. convolvulacea* blooms from January to October periodically: from January to March, and then in May, July, and September. *B. fagifolia* has the shortest flowering period which is from May to July. The intensity of flowering of all species decreases when the air temperature drops to +15° C. Flowering stop completely at +10° C.

Begonias of the *Wagneria* section are thermophilic plants. Their growth processes slow down when the air temperature drops to +10° C, and the leaves turn yellow at +5° C.

A drop in temperature below zero provokes the fall of all leaves and flowers. Therefore, these plants can be grown outdoors in Siberia only in summer. Pots with begonias are taken out of the greenhouse after the threat of frost has passed, that is, in the third decade of May. And they need to be brought back to the greenhouse in the third decade of August, when there is a chance of night frosts.

4 Discussion

Regular flowering, fruiting, and the formation of full-fledged seeds in begonias of the *Wagneria* section outside their natural range indicate their high adaptive potential. *B. convolvulacea* and *B. glabra* proved to be the most resistant to various cultivation conditions. *B. fagifolia* is more difficult adapting to deviations from the optimal growing regime. The main factor affecting the success of cultivation and the decorative effect is the temperature. The optimal temperature for growing begonias of the *Wagneria* section is +20-30° C. With a decrease in temperature, the growth of shoots is inhibited, shorter peduncles and smaller leaves are formed, the number of inflorescences and flowers decreases.

We recommend the studied species of begonias for growing indoors as groundcover and climbing plants. They usually have a lot of side shoots, so they are great for hanging in baskets or for making poles and trellises. Their decorative effect is mainly due to the dense rich green foliage. Research shows that people experience an unconscious calming response when looking at green foliage [19], also touching the surface of the leaves [20]. If you follow the necessary agrotechnical measures, you can achieve abundant flowering of these begonias in spring and summer.

In the conditions of Siberia, we recommend begonias of the *Wagneria* section for growing not only in greenhouses and winter gardens, but also in the rooms of various functional purposes. It was found that the volatile biologically active substances produced by *B. convolvulacea* reduce the microbial contamination of indoor air [21], so we recommended this species for the creation of phytomodules in kindergartens and schools. *B. convolvulacea* and *B. glabra* are suited for outdoor cultivation in hanging baskets which are placed in the garden from June to August, when there is no threat of frost.

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