Morpho-physiological features of *Stephanotis floribunda* in conditions of greenhouse culture

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Abstract. *Stephanotis floribunda* Brongn. is an ornamental pot-plant characterized with intensive growth, profuse flowering, stability in interior conditions. We studied the growth and developmental rhythm of the shoot system of the experimental plant, investigated its biomorphological features, compared the physiological and biochemical characteristics of the assimilating organs of *Stephanotis floribunda* during the growing season in phases: budding, mass flowering, flowering end, single flowering, slow growth and relative peace. The system of stephanotis shoots is characterized by a plagiotropic growth direction and all its vegetative-generative areas are structurally homogeneous. Due to its ability to take root in each node, the structural unit – metamer – retains autonomy and is able to restore the entire individual. The indicators of the pigment composition throughout the whole observation period indicate the stability of the photosynthetic system, and confirm the significant adaptation potential of *Stephanotis floribunda* in protected ground conditions.

1. Introduction

The cultivated species of Stephanotis (*Stephanotis* Thouars.) is one of 16 representatives of the genus of Madagascar origin, has the ability to grow intensively, abundantly flowering and is resistant to indoor conditions [1]. When studying the mechanisms of adaptation of Stephanotis to low illumination values in interiors, the photostability and undemanding nature of the greenhouse plant was revealed to light of different intensity [2, 3]. This determines its practical importance as a decorative, potting culture for indoor landscaping of premises for various purposes.

1.1. The study objective

The study objective is to investigate the morphological-physiological peculiarities of *Stephanotis floribunda* in greenhouse culture.

1.2. The corresponding tasks

The corresponding tasks are to study the features of the rhythm of growth and development of stephanotis; to study the biomorphological features of the experimental plant; to compare the physiological and biochemical characteristics of the assimilating organs of *Stephanotis floribunda* during the growing season in the phases: budding, massive flowering, the end of flowering, single flowering, growth retardation and post dormancy.
2. Materials and methods

2.1. Plant material

The object of the study - *Stephanotis floriferous* - *Stephanotis floribunda* Brongn., belongs to the Lastovnev family – *Asclepiadaceae* Borkh., the life form of which is a climbing vine, reaching from 2 to more than 5 m in length. Leaves are opposite, oval or oblong-oval, rounded at the base, with a short tip at the top, entire, dense, dark green, glossy. The flowers are white, tubular, and fragrant, which attracts pollinating insects. It is the morphological features in the structure of the anthers of the stephanotis flower that gave rise to the classification to the tribe – *Marsdenieae* to the subfamily – *Asclepiadoideae* [4-6].

The experimental plant was placed in the interior near the window of the south-eastern exposition, observations were carried out for two years (2018–2020). Characteristics of the microclimatic parameters of the room: temperature - 20 - 23 °C; humidity - 30-35%; E, illumination of 400-5000 lx. depending on cloud cover.

2.2. Botanical research

Observations on the growth and development of an experimental plant in the interior were carried out in line with the method of E.S. Smirnova [7]. We have adopted an escape of one morphological order (single-order escape) for the structural unit of the runaway system and an elementary unit of a single-order escape is a metamer (a node carrying two leaves and an adjacent internode). Plant measurements were carried out at the frequency of one every 5-10 days. In order to obtain a dynamic picture of the development of the plant we took into account several indicators: the linear dimensions of the annual growth of shoots, the magnitude of the linear growth of internodes and the size of the leaves by months.

2.3. Biochemical studies

The dynamics of the content of photosynthetic pigments – chlorophyll $a$($C_a$), chlorophyll $b$($C_b$), carotenoids ($C_{car}$) and flavonoid ($F$) ratios (chlorophyll $a/b$, chlorophyll / carotenoids) in the leaves of stephanotis was studied under closed ground conditions during the growing season [8]. Stephanotis leaves for analysis were collected during the growing season in phases: budding, massive flowering, end of flowering, single flowering, growth retardation and post dormancy. The average sample consisted of fragments of the central part of the leaves from shoots of different orders, with no damage, in the amount of 6–8 pcs. The leaves were collected 1 time per month (from the 20th to the 25th of each month) in the morning. The content of photosynthetic pigments was determined in 3-fold biological replicates on SF-56 spectrophotometer (LOMO-Microsystems, Russia), according to the method of E. V. Barkovsky [9]. The presence of pigments was calculated in mg / g of dry matter. Fresh leaves were extracted with 96% ethanol to determine the content of chlorophylls and carotenoids.

Statistical data processing was carried out using the software package «Excel MS Office-2016»; «Statistica 10». The analysis of the correspondence of the data distribution to the law of normal distribution was made on the basis of Shapiro – Wilk criterion.

3. Results and discussion

The success of indoor culture of representatives of tropical and subtropical flora is due to knowledge of their morphogenesis and ecology. The environmental parameters of the environment (temperature, humidity, illumination) were monitored using a combined instrument «TKA-PKM model 41».

Morphological type *Stephanotis floribunda* Brongn.is a pleidyasian long-melane climbing vine plant. All the vegetative metamers of this plant are structurally uniform and expressed by a single quality: a node with a normally developed (or rudimentary) leaf and an adjacent short (or elongated) interstitial site. Neither the kidney scales nor the specialized kidney renewal in Stephanotis are revealed. No modifications of the leaf are identified.

Thus, each single-order vegetative shoot consists of identical metamers, and, consequently, the entire vegetative sphere of stephanotis consists of shoots that are completely homogeneous in structure.
order shoots are vegetative-generative and differ only in the number of metameres. Each single-order stephanotis shoot grows at the top of the stem as the shoot grows older, the tip dries out, and the nearest axillary bud (or several at the same time) continues branching the plants, i.e. overturning in the shoot system occurs as a result of the death of the top of the shoot, and flowers or inflorescences are always located axially. As a true tropical plant, stephanotis grows and blooms almost all year round. However, in the interior conditions, it can be seen that these processes are slow and stretched (table 1).

Table 1. Characteristics of Stephanotis floribunda Brongn. Growing season.

| Month | № shoot | Phase of plant development | Sizes, cm | Growth |
|-------|---------|----------------------------|-----------|--------|
|       |         |                            | Leafstalk | Leaf plate | leaves, pcs | shoot, cm |
|       |         |                            | length    | width     |          |          |
| III   | 2       | Active growth              | 2.1±0.5   | 8.1±1.6   | 5.5±1.0  | –        | –        |
|       | 3       |                            | 1.5±0.5   | 4.5±0.5   |          |          |
|       | 1       |                            | 1.5±0.5   | 4.5±0.5   |          |          |
| IV    | 2       | Active growth              | 1.9±0.6   | 8.8±1.1   | 6.1±0.7  | 4.5±1.5  | 11.5±3.5 |
|       | 3       |                            | 6.3±2.4   | 9.0±3.0   |          |          |
|       | 1       |                            | 2.7±1.2   | 12.8±3.8  |          |          |
| V     | 2       | Budding                    | 2.1±0.7   | 8.1±1.5   | 4.6±0.7  | 3.3±0.8  | 10.0±2.1 |
|       | 3       |                            | 3.8±1.4   | 8.3±2.7   |          |          |
|       | 1       |                            | 7.4±0.4   | 20.1±0.4  |          |          |
| VI    | 2       | Massflowering              | 1.5±0.5   | 8.8±1.3   | 4.8±0.6  | 7.3±0.5  | 25.5±3.2 |
|       | 3       |                            | 2.0±0.4   | 12.1±0.3  |          |          |
|       | 1       |                            | 9.1±1.4   | 5.7±0.3   | 3.3±0.5  | 4.0±0.3  |
| VII   | 2       | Endflowering, budding      | 1.7±0.4   | 10.9±0.4  | 5.8±0.3  | 7.3±1.2  | 28.3±7.3 |
|       | 3       |                            | 5.3±0.3   | 2.8±0.3   | 4.0±0.6  | 4.9±0.4  |
|       | 1       |                            | 9.1±1.4   | 5.7±0.3   | 1.3±0.3  | 4.0±0.3  |
| VIII  | 2       | Single flowering           | 3.0±0.3   | 10.9±0.4  | 5.8±0.3  | 8.3±0.5  | 37.3±9.7 |
|       | 3       |                            | 5.3±0.3   | 2.8±0.3   | 1.7±0.3  | 18.7±7.2 |
|       | 1       |                            | 9.4±0.8   | 5.9±0.4   | –        | 9.5±1.5  |
| IX    | 2       | Plant growth retardation   | 3.0±0.3   | 10.9±0.4  | 5.8±0.3  | 4.5±1.5  | 9.0±1.9  |
|       | 3       |                            | 5.3±0.3   | 2.8±0.3   | 0.8±0.2  | 4.5±1.5  |
|       | 1       |                            | 2.5±0.3   | 8.3±0.3   | 5.3±0.3  | –        | 17.0±3.0 |
| X     | 2       | Plant growth retardation   | –         | 8.0±0.4   | 4.4±0.4  | 5.0±1.5  | 6.5±2.9  |
|       | 3       |                            | –         | 8.5±1.4   | 4.4±0.6  | 4.0±0.2  | 6.7±1.8  |
|       | 1       |                            | 5.8±1.8   | 7.8±2.1   | 5.3±0.7  | 3.0±0.2  | 17.0±3.0 |
| XI    | 2       | Single flowering, relative rest | –      | 10.5±1.5 | 4.5±0.5 | 3.0±0.2 | 3.3±0.9 |
|       | 3       |                            | –         | 8.5±1.4   | 4.4±0.6  | –        | –        |

«→» Lack of growth.

In the spring-summer period, the growth of the axillary buds in the new lateral shoots of subsequent orders and the growth of leaves are noted. It follows from observations that the size of the sheet increases rapidly during the first week of its growth, then the size of the sheet becomes stable (8.5x5.5cm) and does not change its entire life. In any month, the active growth of one leaf lasts about two weeks, a single
leaf fall is observed throughout the entire growing season. In the process of development, the partly lignified stems of Stefanotis branch out evenly throughout and lose leaves at the bottom of the shoot over time. It is noted that in second-order shoots of branching, a growth of 2–2.5 times exceeds the growth of first-order shoots and 2.5–5 times of third-order shoots (figure 1).

![Figure 1. Estimation of the average value with a known variance.](image)

Stefanotis is characterized by massive formation of buds on the shoots of the last year and a single formation on the green shoots of the current year. The main position of the inflorescences on the shoot is from 3 to 10 knots, the inflorescence of 11, 12, 17 knots is single. From May to July, and sometimes August, all the new buds enter the flowering phase, and, accordingly, the flowering period lasts about 40-55 days. The period of flowering of one flower (from the opening of the corolla to wilting) is 14-29 days, the inflorescences are from 16 to 35 days. The flowers in the studied species are collected in 2-8 pieces in cymotircumbello inflorescences, which open alternately, wilting and falling off occur in the same sequence. There are from 25 to 45 flowers during the mass flowering on the plant. Fruit setting and seed ripening were not observed under our conditions.

The content of chl $a$ and $b$ in the leaves and the ratio of their sum to the content of car are reliable indicators of the physiological state of plants and indicators of stress. During the growing season the content of chl $(a + b)$ in the leaves of *Stephanotis floribunda* decreased from a maximum of 1.4 mg / g during the spring budding stage to 0.82 mg / g during the flowering phase, and a second maximum of 5.29 mg / g was observed (figure 1) during the summer budding period with a subsequent decrease in autumn to 1.28 mg / g and increased to 9.42 mg/g by December. This suggests an increase in metabolism in an experimental plant associated with reproductive processes. The relatively high ratio of chla / b in September 2.46 mg / g and December 2.89 mg/g, is an indicator of the lack of light in this period of time due to reduction of the daylight in the autumn-winter period. The dynamics of the ratio chl $(a + b)$ / car in the range from 6.36 mg / g to 10.58 mg / g indicates a satisfactory physiological state of Stephanotis during the entire vegetation period (figure 2).
Figure 2. Dynamics of the content of photosynthetic pigments in leaves of *Stephanotis floribunda*. 
**Note:** Phase I. Budding II. Massflowering III. End flowering IV. Single flowering V. Plant growth retardation VI. Single flowering, relative rest.

Flavonoids play a significant role in the adaptation of plants to adverse factors, since their quantitative content depends on many physical, chemical, biological and anthropogenic factors. The content of flavonoids in stephanotis leaves varied from 0.59 mg/g to 2.07 mg/g, while its increase was noted in the phase of spring budding. This is due to the accumulation of products of the secondary metabolism, due to the intensive growth of the plant after the winter period.

Thus, in accordance with the indicators of the pigment composition of *Stephanotis floribunda* throughout the entire observation period, one can speak about the stability of its photosynthetic system in greenhouse conditions.

As a result of comparing the obtained parameters of photosynthetic pigments (*C a*, *C b*, *C car*, *Fl*) by the Friedman ANOVA analysis of variance and the ratios (chlorophyll/carotenoids, chlorophyll *a/b*) by
the t-test for dependent samples, we can conclude that there are statistically significant differences between the groups, at P < 0.05 (figure 3).

4. Conclusion
In the greenhouse culture, the morphological type *Stephanotis floribunda* Brongn. is an apleidyan long-melané climbing vine plant. The shoot system is characterized by a plagiotropic growth direction and all its vegetative-generative areas are structurally homogeneous. Each single-order stephanotis shoot grows at the top of the stem, and the inflorescences are always located axially. Stefanotis is characterized by massive formation of buds on the shoots of the previous year and a single formation on the green shoots of the current year. Massive flowering occurs in spring and summer. The period of flowering of one flower is 14-21 days, the inflorescences from 16 to 35 days. The flowering of the whole plant lasts 40–55 days.

During the growing season, the maximum content of chlorophyll *a* and *b* in the leaves of *Stephanotis floribunda* is noted in the reproductive period of the experimental plant (budding phase 5.29 mg/g, flowering phase 9.42 mg/g). The ratio of chlorophylls *a*/*b* remains at the optimal level from 1.74 mg/g to 2.89 mg/g throughout the entire observation period, which may indicate the stability of the photosynthetic system, as well as indicate a significant adaptation potential of *Stephanotis floribunda* under the conditions of introduction. Dynamics of the ratio of chlorophyll / carotenoids ranging from 6.36 mg/g to 10.58 mg/g indicate a satisfactory physiological state of Stephanotis during the entire vegetation season.

Acknowledgement
The study was financially supported by the Department of Education and Youth Policy of the Khanty-Mansiysk Autonomous District - Ugra (order No. 1281 of 08.25.17).

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