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# ABŞERON BÖLGESİNDE YETİŞTİRİLEN *Passiflora edulis* L. TÜRÜNÜN YAPRAKLARININ MORFOMETRİK PARAMETRELERİNİN DEĞİŞİMİ

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## ÖZ

Bitki gelişimi sırasında, yapraklar boyut, şekil ve geometrik boyutlardaki farklılıklar dahil olmak üzere çeşitli ontogenetik değişiklikler gösterebilmektedir. İncelenen morfolojik özelliklerin türler ve popülasyonlarda önemli farklılıklar gösterdiği belirlenmiştir. *Passiflora* cinsinin *P.edulis* türü büyüdükçe ve geliştikçe heteroblastik önemli değişikliklere uğramaktadır. Genç ve olgun yaprakların vejetatif fazları arasında morfolojik farklılıklar bulunmuştur. Azerbaycan'da tanıtılan en umut verici türlerden biri olan *ex situ* ve *in situ* koşullarda yetiştirilen *P.edulis* L.'nin yapraklarının morfolojik polimorfizmi matematiksel olarak incelenmiş ve analiz edilmiştir. Yaprak alanı *ex situ* koşullar altında 145.9 cm² ve *in situ* koşullar altında 115,5 cm²' olarak saptanmıştır. *Ex situ* koşullar altında yaprağın çevresi 378.49 cm iken, *in situ* koşullar altında yetiştirilen bitkilerde bu parametre 366.5 cm olarak bulunmuştur. *Ex situ* koşullarda yetiştirilen örneklerde yaprakların morfolojik özellikleri *in situ* koşullara göre daha yüksek bulunmuştur. Ancak, *in situ* koşullarda geliştirilen bitkilerde yaprak çevresine ek olarak diğer morfolojik özelliklerde gözlenen çeşitlilik ve varyasyon katsayısı *ex situ* yetiştirilenlere göre daha yüksek bulunmuştur. Bu *in situ* koşullara kıyasla *ex situ* koşullar altında abiyotik faktörlerin daha yüksek stabilitesinden kaynaklanmıştır. Yüksek varyans *P.edulis* türlerinin yüksek adaptasyon yetenekleri ile ilişkilidir.

**Anahtar Kelimeler:** İntrodüksiyon, varyasyon, morfometrik analiz, heteroblasti, popülasyon

## VARIATION OF MORPHOMETRIC PARAMETERS OF *Passiflora edulis* L. SPECIES LEAVES, FIRST INTRODUCED TO ABSHERON

## ABSTRACT

During plant development, leaves undergo various ontogenetic changes, including differences in size, shape and geometric dimensions. An in depth study of morphological traits showed differences in species and populations according to adaptive traits. The *P.edulis* species of the *Passiflora* genus undergoes heteroblastic significant changes as it grows and develops, showing a morphological distinction between young and mature vegetative phases. Morphological polymorphism of the leaves of *Passiflora edulis* L., one of the most promising species introduced to Azerbaijan and grown under *ex situ* and *in situ* conditions, was studied and analyzed mathematically. The leaf area was 145.9 cm² under *ex situ* conditions and amounted to 115.5 cm² under *in situ* conditions; The perimeter of the leaf under *ex situ* conditions was 378.49 cm, while in plants grown under *in situ* conditions this parameter was 366.5 cm. The morphological characteristics of the leaves were found to be higher in the samples grown under *ex situ* conditions compared to the *in situ* conditions. However, in addition to the leaf perimeter, diversity observed in other morphological traits and the coefficient of variation were higher in plants developed under *in situ* conditions compared to those grown *ex situ*. This is attributed to the greater stability of abiotic factors under *ex situ* conditions compared to *in situ* conditions. The high variance indicates the high adaptability of the *P.edulis* species.

**Keywords:** Introduction, variation, morphometric analysis, heteroblast, population

## INTRODUCTION

*Passiflora edulis* (Marakuya) is a native of South America and can grow in both tropical and subtropical climates. *Passiflora* having creeping and climbing lianas belongs to the family *Passifloraceae* of the order Violes. It has about 500 species that grow naturally in tropical America, Asia and Australia [19].

*Passiflora edulis* is one of the 500 species belonging to the genus *Passiflora* and a tropical fruit crop known as passion fruit [9, 6]. It has been used by Asian peoples as a medicinal plant to treat anxiety, depression and insomnia [16]. There are species in the world belonging to the genus *Passiflora* that are used in different forms (ornamental, medicinal, edible fruits) [23]. *Passiflora caerulea* is widely used in landscape architecture as an ornamental plant in Azerbaijan. In the pharmaceutical industry, *Passiflora incarnata* L. species has been used for many years as a sedative and antidepressant drug

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[15]. Most of these species are native to the United States and South America, including Argentina, Brazil, Colombia and Paraguay. On the Asian continent, it grows naturally in Australia and China. In Brazil, 89 species of *Passiflora* are endemic and therefore, it is considered the home of biodiversity [5].

An optimal environmental condition is the main stimulus for the normal growth and development of the organism. In this regard, three factors should be noted: temperature, humidity (moisture) and wind speed. It is these three factors that characterize the microclimate conditions of the area and the creeping plants grown in the area have a special role in their regulation [13].

*Passiflora edulis* L. is a species with leaves arranged in a leaf mosaic pattern without overshadowing one another. A characteristic feature of leaf mosaic is to ensure that the same amount of light falls on the leaves on the same plane. The mosaic arrangement of the leaves can be seen in almost all lianas. The different shapes and sizes of the leaf blades and stalks, the angle of their alignment in the ortostih, the split leaf blade, etc. allow active photosynthesis by maximum use of light rays [24].

In the same sprout, the leaves have different structures and can form a three-layered formation. Those in the lower part of the sprout are the bottom leaves, the middle leaves are more active in photosynthesis and those around a flower group are called top leaves. When describing the leaves, the focus is on the middle leaves. Because the middle leaves contain all the general features of the leaves in the habitus of the plant [24].

The variation observed in leaf morphology is a key indicator of plant adaptation to different environmental conditions. To assess the diversity in the population of the *Passiflora edulis* L. species belonging to the *Passiflora* genus of the *Passifloraceae* family, we analyzed the variation of the morphological and functional characteristics of the leaves in the areas where the species was introduced. For this purpose, leaf samples were taken from *ex situ* and *in situ* populations of the *P.edulis* L. species introduced in the experimental field of the Institute of Dendrology of ANAS in 2018.

*Passiflora edulis* is a heteroblastic species [7]. Heteroblastic means the presence of different leaf shapes on a plant [20, 25]. The transition from the juvenile to the mature stage is manifested by changes in leaf morphology over time as the growth meristem, commonly known as the heteroblasty (apical). These morphological changes are connected to changes in plant hormones and the chemical composition of the leaf [21].

The color of the cultivated *Passiflora* species (passion fruit) fruits changes from orange to purple depending on the species. They are full of seeds, which are surrounded by a gelatinous mass and used in the preparation of fruit juices, cocktails, sweets, ice cream and fruit salads. Brazil is the most important producer of this fruit with 317,000 tons on 35,000 hectares [2]. Fruit, which is also very important from a health point of view, is a natural sedative. *Passiflora* fruit (Marakuya) is also rich in nutrients, vitamins C, B1, B2, B5, calcium, phosphorus and protein [22].

Many researchers studied the leaf diversity of *Passiflora* species [26]. Various conclusions were drawn in these studies. Goebel K. (1908) stated that heteroblasty occurs because the process of photosynthesis in plants during the development of newly formed leaves does not fully provide the plant with nutrients [11]. Some researchers report that in the populations of the *Passiflora* species, all the first leaves are similar and that heteroblastic changes occur in the structure of the subsequent leaves. Gilbert (1982) concluded that in *Passiflora*, heteroblasty is a mechanism for escaping Heliconius butterflies that used leaves to lay eggs [10].

*P.edulis* was first introduced to Azerbaijan by us. The introduction was successful, phenological observations were made at all stages of ontogenesis. We aimed to study the diversity observed in the leaves of *P.edulis* L species under *ex situ* and *in situ* conditions and to assess the adaptive potential of the species.

## MATERIALS AND METHODS

We started the first introduction of *Passiflora* species in Azerbaijan in 2018 using seeds imported from Florida and Thailand. *Passiflora* species can be propagated by seeds, cuttings and offshoots [4, 23]. During the season, all stages of ontogenesis were studied, phenological observations were made by various methods. *P.edulis* adapted well to Absheron conditions.

The Absheron Peninsula, where the study was conducted, is located at 40°77' and 40°37' north latitude and 49°30'-50°22' south longitude. The length of the peninsula is 80 km from north to west, the widest width is 27 km, the middle part is 22 km. The total area of the peninsula is 2050 km². The climate of Absheron is included in the subtropical climate zone with dry and very hot summers, warm and mild autumns and short winters [10].

To study the variability of morphological features of leaves, 100 leaves were collected from 10 plant samples, 10 leaves each [14]. Leaf samples collected

from mature forms should be used for the biometric analysis of leaves because samples from young offshoots and seedlings are very similar or even indistinguishable [3]. Six morphometric parameters (LL-leaf length, LW-leaf width, LSA-leaf surface area, LP-leaf perimeter, F-leaf shape coefficient and R-leaf length to width ratio (R=LL/LW)) were measured in the collected leaves using CI-202 Laser Area Meter (USA) (Figure 1). Measurements were carried out at the Institute of Dendrology of ANAS. The measurement results were mathematically analyzed [12].

Raw data are worthless until they are processed by computer systems for a specific purpose and turned into knowledge. The traditional method of transforming information into knowledge is based on classical analysis and interpretation. Compilation and mathematical analysis of the variation order according to the morphological features of the leaf, the centralization of the figures and their preparation for further analysis were implemented using the computer program Excel. To characterize the variation order, the comparison of the studied material with other materials can be carried out after determining the average mathematical parameters of the variation order ($\bar{x}$)

$$\bar{x} = \frac{\sum xf}{n} \qquad (1)$$

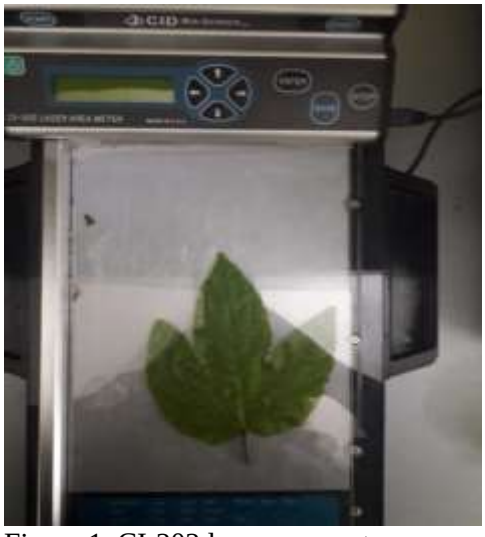

Figure 1. CI-202 laser area meter

The average mathematical index of morphological features characterizes the basis of modification variability. The average mathematical value differs the least from other dimensions in the variation order. The second parameter of the variation order, standard deviation (σ) was used to correctly characterize the variability. The standard deviation is calculated by the following formula:

$$\Im = \pm\sqrt{\frac{\left(x-\bar{x}\right)^2 f}{n-1}} \qquad (2)$$

The standard deviation shows, on average, how much each variation differs from the mathematical mean. Sigma (σ) is a measure of modification variability. The coefficient of variation is used to compare the variability observed in different traits in a population:

$$CV = \frac{\sigma}{\bar{X}} * 100\% \qquad (3)$$

## RESULTS AND DISCUSSION

Variation in leaf morphology is a key indicator of plant adaptation to environmental conditions. The structure and functions of a leaf can change due to evolution when it adapts to certain conditions. To assess the diversity in the population of the *Passiflora edulis* L. species, which is a member of the *Passiflora* genus belonging to the family *Passifloraceae*, we analyzed the variation of the leaf morphological characteristics in the areas where the species was introduced.

Higher morphological indices of the leaves were observed in plant samples grown under *ex situ* conditions compared to *in situ* conditions. Besides, heterophyllia the different structure of the leaves in the habitus of plants was more pronounced under *ex situ* conditions. Thus, under *ex situ* conditions, the leaves at the top are more split and subjected to sunlight compared to the leaves below, which in turn facilitates the adaptation of the introduced plant to local conditions.

Morphological traits of leaves were found to be higher in plant samples grown under *ex situ* conditions compared to those under *in situ* conditions. For example, the leaf area was 145.9 cm² under *ex situ* conditions and amounted to 115.5 cm² under *in situ* conditions; The perimeter of the leaf under *ex situ* conditions was 378.49 cm, while in plants grown under *in situ* conditions this parameter was 366.5 cm (Table). However, in addition to the leaf perimeter, diversity observed in other morphological traits and the coefficient of variation were higher in plants developed under *in situ* conditions compared to those grown *ex situ*. This is attributed to the greater stability of abiotic factors under *ex situ* conditions compared to *in situ* conditions. According to the perimeter of the leaf, the coefficient of variation under *ex situ* conditions was 35.58%, while under *in situ* conditions, it amounted to 12.63%. Based on the perimeter of the leaf, the coefficient of variation

under *ex situ* conditions was 35.58% and under *in situ* conditions it was 12.63%. The greatest variation in leaves was observed in the width to length ratio (R=LL/LW) (CV=112.9%) in plants grown *in situ* and the least variation was found in the same ratio of the plants grown *ex situ* (R=LL/LW) (CV=9.43%) (Table).

Although there was no sharp difference in the mean values of the length and width of the leaves in plants grown under *ex situ* and *in situ* conditions, a significant difference in the coefficients of variation of trait distributions was recorded. Thus, the distribution of leaf length in *P.edulis* plants grown in an open field was normal (CV=54.665%), while the distribution of leaf length in plants grown under greenhouse conditions was weak (CV=9.75%). A similar situation was observed regarding the width of the leaf: the distribution of the width of the leaf of the plants cultivated under natural conditions was normal (CV=93.94%), while the distribution of the width of the leaf of the plants grown under control conditions was average (CV=29.57%) (Table). Because of the stable ecological environment under closed conditions (control), no significant difference was observed in the change of traits and the coefficient of variation was lower compared to open conditions. Since the environmental factors are variable under *in situ* conditions, the self-preservation potential of the species appeared and a noticeable difference in the morphological traits is observed, which is manifested by a high value of the coefficient of variation.

Table. Morphological variations in *P.edulis* leaves grown under *ex situ* and *in situ* conditions

| Morphological Traits | | $\bar{x}$ | σ | CV(%) |
|---|---|---|---|---|
| Area ($cm^2$) | Ak | 145.9 | ±23.19 | 15.89 |
| | A | 115.5 | ±23.2 | 20.9 |
| Length (cm) | Lk | 23.496 | ±2.29 | 9.75 |
| | L | 23.6 | ±12.9 | 54.66 |
| Perimeter (cm) | Pk | 378.49 | ±134.65 | 35.58 |
| | P | 366.5 | ±46.3 | 12.63 |
| Width (cm) | Wk | 14.81 | ±4.38 | 29.57 |
| | W | 14.28 | ±5.2 | 93.94 |
| Ratio | Rk | 1.59 | ±0.15 | 9.43 |
| | R | 1.68 | ±1.9 | 112.9 |
| Factor | Fk | 0.04 | ±0.001 | |
| | F | 0.011 | 0.03 | 36.67 |

*Passiflora* species differ from trees and shrubs in many respects because of their creeping stems. They grow quickly, spread more in areas where trees and shrubs are difficult to grow and quickly "occupy" the area where they grow by developing in a vertical and horizontal direction.

The above-mentioned properties of creeping plants greatly expand the scope of their use. Thus, they protect the area from noise, harmful dust mixtures, strong winds, etc. and they are widely used in the improvement of microclimate conditions, biological re-cultivation of soils, medicine and the food industry.


Figure 2. *Passiflora edulis* L. A-the plant grown under *ex situ* conditions, B-the plant grown under *in situ* conditions

The role of *Passiflora* species with a creeping stem as a surface cover should be noted, especially in forestry and soil erosion protection.

According to our research, variations in the structure of *Passiflora edulis* leaves are often related to the growing conditions of the species. Like other organs, the variety of shapes of the leaves is due to the differentiation of growth, i.e. the diversity between the different rates of growth of the leaf in various directions. The high variability indicates the high adaptability of *P.edulis*.

Our country is one of the countries in the world with high economic potential, where many types of fruits can grow due to geographical location and ecological features. *Passiflora edulis* L. is a tropical fruit known in foreign countries as Marakuya. It is very popular and has different uses. This species, which attracts attention in the world due to its nutritional value and use in the field of pharmacy, can be easily cultivated in some regions of our country.

*Passiflora edulis* is a very important species for agriculture and is widely used commercially in the fruit industry. This is a new tropical species introduced in Azerbaijan and therefore, it is economically and scientifically important to start research by producing and adapting the species to appropriate environmental conditions. In our research, the adaptation of the species to different localizations: reaction to the environment where it grows, ability to bear fruit based on the indices of productivity and quality has been studied in depth.

Figure 3. Leaf heterophyllia in the *Passiflora edulis* species

The obtained results prove that the *P.edulis* species has a high adaptability potential. This suggests the possibility of cultivation of this species in large areas under Absheron conditions.

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