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BIOLOGICAL ASPECTS OF THREATENED PSEPHELLUS ERIVANENSIS (ASTERACEAE) IN THE CONTEXT OF EX-SITU CONSERVATION

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Psephellus erivanensis Lipsky (Asteraceae) is a threatened knapweed species of the Armenian flora, endemic to the Atropatene floristic sub-province of the Armeno-Iranian floristic province. According to the results of the conducted study, *P. erivanensis* is identified as a polycarpic rhizomatous hemicryptophyte with perennial rosettes and annual leafy elongated generative shoots. The diploid cytotype has been found for the species to be 2n=32, the karyotype is symmetric, consisting of 2 pairs of submetacentric and 14 pairs of metacentric chromosomes, 0.77-1.54 μm in size. The average pollen fertility of *P. erivanensis* is quite high and is in the range of 93-99%, which indicates a high seed set, contributing to the species' reproduction. Plants introduced in the Yerevan Botanical Garden have a full development cycle, mature seed formation, and vegetative self-renewal ability, in comparison with natural ones, are distinguished by higher total humidity, intensity of transpiration and photosynthesis, and a decrease in water deficit. The species is recommended for ex-situ conservation through living plant collection creation and, considering its ornamental value, for utilization in arid landscaping schemes. The article is illustrated with a map of the species distribution in Armenia, original photographs, and tables.

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Keywords: *Psephellus erivanensis;* conservation; eco-physiology; morphology; reproductive features; Armenia

جنبه‌های بیولوژیکی حفاظت در خارج از رویشگاه اصلی گونه در معرض خطر Psephellus erivanensis Lipsky (Asteraceae)

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گونه Psephellus erivanensis Lipsky (Asteraceae) یکی از گونه‌های در معرض خطر در فلور ارمنستان است که انحصاری زیرحوزه آتروپاتان از حوزه ارمنی– ایرانی است. براساس نتایج این مطالعه گونه Psephellus erivanensis گیاهی علفی چندساله ریزوم‌دار با برگ‌های طوقه‌ای چندساله و شاخه‌های گل‌دهنده بلند برگ‌دار است. گیاهی دیپلوییید با شماره کروموزومی 2n=32 و کاریوتایپ متقارن متشکل از دو جفت کروموزوم ساب متاسانتریک و چهارده جفت کروموزوم متاسانتریک به طول ۰/۷۷–۱/۵۴ میکرون است. متوسط میزان باروری آن کاملاً بالا بوده و در محدوده ۰/۹۹–۰/۹۳ است که نمایانگر میزان بالای تولید دانه در ارتباط با تجدیدحیات گونه است. گیاهان کاشته شده در باغ گیاه‌شناسی ایروان

دارای یک سیکل کامل رشد، تولید دانه، توان بازسازی رویشی در مقایسه با نمونه‌های وحشی هستند و هم‌چنین میران تبخیر و فتوسنتز در گیاه افزایش یافته و کمبود آب کاهش می‌یابد. برای این گونه، حفاظت در خارج از رویشگاه اصلی از طریق کاشت در کلکسیون‌های زنده و هم‌چنین استفاده از آن در طراحی فضاهای سبز در مناطق خشک و نیمه بیابانی توصیه می‌گردد. نقشه پراکندگی جغرافیایی گونه، تصاویر از رویشگاه طبیعی و قسمت‌های مختف گیاه ارایه می‌گردد.

INTRODUCTION

The flora of Armenia is rich and diverse in species composition and useful plant resources. Around 3800 species of vascular plants of 160 families and 913 genera grow in Armenia with a total area of about 30,000 km2 (Fifth National Report to the Convention on Biological Diversity, 2015). The formation of such plant diversity in a small area was influenced by the complex geological structure of Armenia, high altitudinal variation (375–4090 m a.s.l.), soil and climate variability, location at the junction of different floristic provinces such as moderately humid Caucasian, arid Central Anatolian and Armenian-Iranian (Bagdasaryan 1958; Balyan 1969; Takhtajan 1978).

Approximately 14% (452 species) of the flora of Armenia is listed in the Red Book of Plants of the RA (Tamanyan, 2010). A significant number of threatened species are found in the Ararat Valley of Armenia. Due to increased pressures on vegetation, climate change, and the transformation of habitats, many plant species that are adapted to a specific range of environmental factors become scarce or disappear. In the last decades, the spaces within natural vegetation suffered a decline on the territory of Ararat Valley. Habitats of sagebrush, halophyte, psammophyte, and gypsiferous-clayish semideserts are under particular anthropogenic impact. As a result, some species that occurred in the recent past in abundance, have survived only in small, rare fragments in natural semidesert vegetation and are presented by populations with low numbers of individuals. Among them are a large number of xerophytic ornamental species adapted to growing in a sharply continental climate of the semidesert zone.

Psephellus erivanensis Lipsky (= *Centaurea erivanensis* (Lipsky) Bordz.), subgenus *Xanthopsis* (DC.) Tzvel., Asteraceae, was first described from the gypsiferous semidesert habitats of the Ararat Valley of Armenia in the environs of the city Yerevan by V. Lipsky, who characterized the plant, noted its ornamental effect, calling it "a very beautiful plant" (Lipsky 1902). *Psephellus erivanensis* is included in the Red Book of Plants of RA under the Vulnerable Species category (VU) based on geographic condition criteria [B 1 ab (i, ii, iii) + B2 ab (i, ii, iii), (Tamanyan & al., 2010)] and in the IUCN Red List of Threatened Species (https://www.iucnredlist.org/species/200387/2655530). The main limiting factors posing a threat to the species are identified exogenous factors such as loss, fragmentation, and degradation of natural habitats. A part of the *P. erivanensis* population is protected in the "Erebuni" and "Khosrov Forest" State Reserves of the RA. With the aim of conservation and reproduction of the gene pool, appropriate conditions for its clonal micropropagation have been elaborated (Nersesyan & al. 2019).

One of the current trends for the protection of threatened plant species is their conservation under ex-situ conditions (Sharrock 2012). Great importance is given to scientific research and ex-situ conservation of living plants documented collections in the Botanical Gardens (Heywood 2017; Mounce & al. 2017). For many years, the conservation of living plants and the models of main types of plant communities have been carried out at the exhibition Plot “Flora and Vegetation of Armenia” of the Yerevan Botanical Garden NAS RA (Akopian 2010; Akopian & al. 2017). The most characteristic taxonomic composition is selected for each community modeled in the plot. Priority is given to threatened or insufficiently studied species of the native flora, and species of economic or ornamental value. Ornamental threatened plant cultivation under ex-situ conditions and involvement in the practice of landscaping can serve as an effective measure for their conservation (Younis & al. 2010; Colombo & al. 2020). However, many wild plants with ornamental potential are not used due to insufficient botanical information, lack of data on morphological, phenological, and reproductive characteristics, and adaptive capacity to new conditions, necessary for the development of conservation strategies.

Initially, *P. erivanensis* was introduced to the living collection of the "Flora and Vegetation of Armenia" Plot of the Yerevan Botanical Garden in 1958-1961 and afterwards was periodically cultivated there (Mirzoeva, Akhverdov 1959, archival notes of living collection observations). The studies were continued in its natural habitats in the Ararat Valley of Armenia and under ex-situ conditions in the Yerevan Botanical Garden in

2016-2017 and 2021-2023. The study of the biological characteristics of threatened plant species is one of the fundamental aspects of developing a strategy for their conservation both in nature and under ex-situ conditions. However, the biological features of the threatened species *P. erivanenesis* have not previously been studied in detail. The presented work aims to study the morphological, phenological, reproductive, and some ecological and physiological characteristics of this species in semidesert habitats of the Ararat Valley and under ex-situ conditions in the Yerevan Botanical Garden. The present investigation contributes to the knowledge of knapweed *P. erivanensis*, one of the threatened species of the flora of Armenia, preserved in small fragments of semidesert natural habitats of the Ararat Valley, subject to increasing anthropogenic influence. The data obtained can be used for ex-situ conservation of this species in living plant collections and ornamental landscaping schemes in arid areas.

MATERIALS AND METHODS

Specimens growing in natural populations of the Ararat Valley and in the living collection of the Yerevan Botanical Garden NAS RA, and specimens from the Herbarium (ERE) of the A. Takhtajan Institute of Botany NAS RA were used as materials for the study. Observations in nature were carried out during expeditions on gypsum-bearing clay-gravelly hills of the Ararat Valley, located along the middle course of the Araks River at an altitude of 800-1000 m a.s.l. The climatic indicators in the Ararat Valley are close to those in the Yerevan Botanical Garden NAS RA located in the zone of stony wormwood semidesert at an altitude of 1200 m a.s.l. The annual precipitation is 300-365 mm, the average annual temperature is + 11˚C, the average air temperature is 24-26˚C in summer and –5(–8) ˚C in winter, average annual relative air humidity is 59%. The absolute minimum temperature in the Yerevan Botanical Garden is 2-3˚C lower than in the Ararat Valley. The soils are brown, heavy loamy, carbonate, and medium stony, the subsoil is underlain by tuff. A separate exhibition "Flora of gypsiferous semidesert" was created in the Yerevan Botanical Garden (Akopian & al. 2017), where the local soil was replaced by clay soil rich in sulfates and containing gypsum crystals. For the cultivation of *P. erivanensis*, samples transplanted from natural habitats and grown from seeds collected in nature were used. To identify the edaphic adaptation, it was also grown on the local soil of the Yerevan Botanical Garden. During summer, the rainless periods of seasonal development, plants were provided with moderate watering.

The studies on life form, ontogenetic, and seasonal development were done by the generally accepted methods of morphology and phenology. Phenological observations and measurements were carried out during all phases of ontogenesis from seed germination to fruiting. The results of the introduction experiment were evaluated according to Bylov and Karpisonova (1978). The morphological features of plant samples were studied using an MBC-9 stereo microscope. Photos of plants and habitats were taken with a Nikon D3400 digital camera. GPS data imported to GIS were used for mapping.

Eco-physiological studies of water regime, the intensity of transpiration, and photosynthesis were conducted by Sheremetyev (2005); Salnikov & Maslov (2014). All of the measurements were done in the period between 11:00 and 13:00. Each measurement was done with 3 repetitions and in 3 options (7-10 shoots were chosen for each sample). Received data are the average results of the performed analysis which were subjected to statistical development. The water deficiency was calculated by the following formula:

$$WSD = (Ws - Wf) \times 100) / (Ws - Wd), (\%)$$

Ws – leaf mass after complete saturation with water, mg; Wf – fresh weight of leaves, mg; Wd – leaf dry weight, mg.

The fresh sample was promptly weighed and dried under 150ºC to determine the total water content. The following formula calculated the total water content:

$$X = \frac{P_1 - P_2}{P_1} \times 100$$

X is the total water content, % from the wet weight, P_1 is the wet weight of the leaf before drying, in grams, P_2, is the dry weight of the leaf sample, in grams, 100 - is for expressing the total water content in the leaf from the wet weight in percentages.

The intensity of photosynthesis was determined by the change in the dry weight of the leaf sample. The intensity of photosynthesis in mg/dm^2, per hour, is expressed by dividing the amount of synthesized dry material by the period between the measurements. The following formula measures the intensity of photosynthesis:

$$P = \frac{P_2 - P_1 \times 1 \times 100}{23.55} \text{ mg/dm}^2\text{, hour}$$

Karyological investigations were made on the mitotic metaphases of the meristematic cells from the root tips of germinated seeds. The root tips were pretreated in 0.4% colchicine solution and fixed in fluid 3:1 alcohol and glacial acetic acid, after hydrolysis in HCl they stained in Schiff reagent and were squashed on a glass slide with 45% acetic acid. The preparations were placed in butyl alcohol and then in xylene for 5 minutes, and were placed in Canadian balsam. Slides were examined under a light microscope AmScope Photomicroscope using an oil immersion objective (×100).

Pollen fertility was determined by staining with acetocarmine on temporary preparations (Pausheva 1980). The fertility of each collected sample was tested in 5 replicates of 100 pollen grains. For data comparison, the arithmetic mean $\mathbf{S_x}$ was calculated according to the $\mathbf{S_x = \Sigma\ (x\text{-}x) \times k}$, where the absolute value was subtracted from the arithmetic average number of fertile grains and the sum was multiplied by k, that is the number of replicates. In our case, the number of replicates corresponded to the number 0.1253 (Wolf 1966). The preparations were examined under a light microscope at a magnification of 350 times. Pollen fertility is relatively constant and practically does not change over time, so both fresh and dry material from the ERE Herbarium were used. The pollen material of *P. erivanensis* was collected from the ERE Herbarium (Table 1).

Table 1. *Psephellus erivanensis* specimens used for pollen study.

Specimen number	**Locality**
ERE 86998	Armenia, between villages Vokhchaberd and Zovashen, in the vicinity of the dam. 15.V.1965. Leg. V. Avetisyan, A. Mekhakyan, V. Manakyan
ERE 133896	Armenia, Abovyan region, village Zovashen, near Azatreservoir. 14.VI.1985. Leg. E. Gabrielian
ERE 134257	Armenia, Ararat region, in the vicinity of the village Surenavan, Urts Range, Khakhokhi-Dzor gorge. 16.VII.1985. Leg. E. Gabrielian, G. Fayvush
ERE 132588	Armenia, Ararat region, crest of the Urts Range, mountain steppe. 13.VIII.1985. Leg. E. Gabrielian, G. Fayvush
ERE 132590 ERE 132591	Armenia, "Erebuni" Reserve, on dry clay slopes. 25.VII.1986. Leg. E. Gabrielian
ERE 161711	Armenia, Kotayk, Abovyan region, Jrvezh Forest Park, western border, western slopes, gypsum-bearing clays, 1500-1600 m a.s.l.. 08.VII.2001. Leg. V. Manakyan
ERE 182958	Armenia, Kotayk district, "Erebuni" Reserve, dry stony slopes, 1300 m a.s.l., 40.09ºN, 44.37º E. 08.VII.2011. Leg. A. Nersesyan, I. Gabrielyan

RESULTS

The xeromorphic perennial *P. erivanensis* is one of the characteristic plants of the Ararat Valley gypsiferous semidesert. Communities of the gypsophytes are very scattered and consist mainly of subshrubs and perennials (Fig.1). Within gypsophilic vegetation, *P. erivanensis* grows with *Acantholimon karelinii, Acanthophyllum mucronatum, Amberboa moschata, Dorema glabrum, Lactuca takhtadzhianii, Reamuria alternifolia, Reseda microcarpa, Rindera lanata, Salsola cana, S. tomentosa, Stachys inflata, Zygophyllum atriplicoides,* and some others.

Psephellus erivanensis is a polymorphic species, which is characterized by variability in some morphological features, for example in the shape and pubescence of the leaves, involucre shape, size, color, character of the involucre appendages serrations, by the degree of seeds asymmetry, the length and shape of the inner pappus elements. Based on such distinguishing features as the size of the capitulum and the degree of the involucre appendages serration, two subspecies have been described for it, viz. subsp. *erivanensis* and subsp. *holargyrea* (Bornm. & Woronow) Gabrieljan (Gabrieljan 1988). With numerous large silvery capitula, subsp. *holargyrea* have more pronounced ornamental qualities **(**Fig. 2**)** and is different from subsp. *erivanensis*, with a small capitulum, which is also found in the phryganoid and mountain steppe vegetation. Being near the city of Yerevan and adjacent villages and limited to a specific gypsiferous habitat, *P. erivanensis* subsp. *holargyrea* populations are more threatened.

Fig. 1. Gypsiferous semidesert landscapes of the Ararat Valley.

Fig. 2. *Psephellus erivanensis* subsp. *holargyrea* in the flowering stage.

In Armenia it occurs in the Yerevan floristic region, at an altitude of 800-2000 m a.s.l. on dry clayey gypsum-bearing or slightly saline slopes, in sagebrush semidesert, mountain steppe, among the phryganoid vegetation of the Ararat Valley (Yerevan, Shorakhbyur, Zovashen, Geghadir, "Erebuni" State Reserve) and in the low-mountain zone of the Urts Range (Fig. 3). *Psephellus erivanensis* is an endemic to the Atropatene floristic sub-province of the Armeno-Iranian floristic province. Besides Armenia, it is found in Nakhichevan and East Anatolia.

Morphological and phenological characteristics

By H. Raunkier's classification (1934), *P. erivanensis* belongs to hemicryptophytes. The duration of its growing season is about 8.5 months from early spring to late autumn. The achenes, in the natural conditions and sown open-ground in the Yerevan Botanical Garden in autumn, germinate after winter stratification in mid-March of the following year. The achene is 4.5–6×2–3 mm, oblong-asymmetric, longitudinally striated, greenish-light brown, sparsely hairy, later glabrous, lateral hilum with clearly visible elaiosome and a short ciliated double, persistent pappus **(**Fig. 4a**).**

Germination is epigeal. Seedlings are greyish-green with flat, oblong, or broadly-obovate cotyledons, 1.0×0.7(0.8) cm, fleshy, glabrous, the first two leaves are opposite, densely pubescent (Fig.4b, c). Cotyledons persist for about two months after germination. The radicle reaches 12–15 cm long, and most of the lateral rootlets are branched out in the upper soil layer. Hypocotyl is 2.0–2.5 cm long, and epicotyl and subsequent internodes are almost not developed. Each next leaf develops with an interval about of 8–10 days.

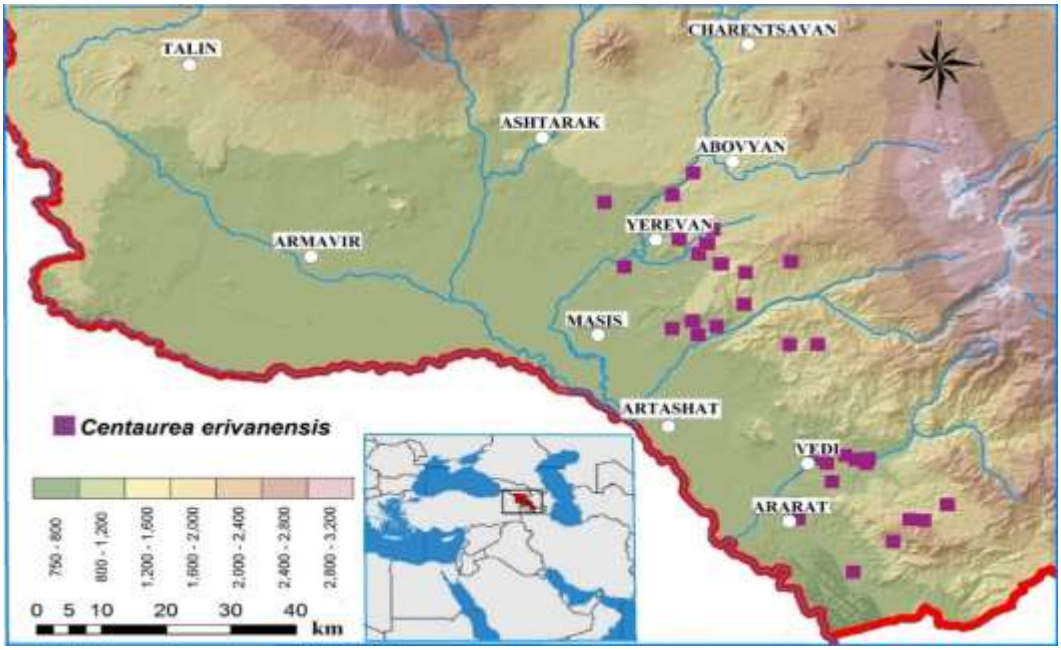

Fig. 3. Distribution map of *Psephellus erivanensis* in Armenia.

To the beginning of June, the juvenile plants form rosettes with 9–12 leaves from 1.5 cm to 7 cm long, broadly lanceolate, finely serrate, slightly wavy along the edge, with petioles 3–4 cm long (Fig. 4d). Rosette-form primary shoot persists during the first year of plant development. An adventitious root is developed at the base of hypocotyl, which subsequently functions as a secondary tap root (Fig. 4e). The appearance of new leaves and the drying of the old leaves at the base of the rosette is observed until the end of autumn. During the autumn, axillary buds are formed at the base of rosette green leaves, from which new rosettes and annual generative shoots develop the following year. By winter, the rosette leaves do not fall, the plant goes through the winter with green leaves which remain until spring of next year, and then are replaced by new ones. In the second year, the transition of the plant to the early generative stage is observed. Flower buds are formed in the year of flowering. The phenological phases of budding, flowering, and the beginning of fruiting overlap each other. Budding continues from late May to July, flowering from June to early August. Annual generative shoots are erect, elongated, densely leafy, 35–40 cm long, with capitula by 3–7 pieces arranged at the top and the side-branchlets (Fig. 4f). Capitula are broadly ovate, with 30–32 shiny silver or yellowish involucres and a few partly protruding whitish-cream florets. Involucre 15–22×12–16 mm, short-cylindrical or ovate. Bracts of involucre multiseriate, imbricate, ovate, 8–9 mm long, glabrous, leathery, with membranous appendage. Appendages of the involucral bracts are silvery, membranous, broad or narrowly ovate, shiny, white or yellowish, suddenly pointed at the apex, and serrate-toothed along the edge. Marginal florets are tubular, with staminodes hidden in the pharynx, sterile or completely absent, median flowers are tubular, hermaphrodite; stamen filaments with very short papillae; stigma lobes blunt or slightly pointed. During the flowering period, the plant is very ornamental with silvery, shiny inflorescences. Cross-pollination by bees is noted.

Fruiting is usually observed from July to August–early September. In each capitulum, 1–3, rarely 4 seeds are formed. However, the development of a large number of generative shoots provides satisfactory seed productivity. The capitula easily falls off under a slight mechanical or wind gust influence, due to the strong fragility of the branchlets on which they are arranged. In natural habitats, after falling under the maternal plant they are dispersed by the wind, using anemogeochory, which is one of the characteristic ways of dry disseminules dispersal in arid areas. After the end of fruiting, generative shoots dry, the simultaneous appearance of new leaves in the center of the rosette, and renewal buds intensive development are observed. In subsequent years, as a result of perennial rosette growth, decumbent epigeogenic rhizome with scaly leaves and adventitious roots is formed at their base; the main root is not preserved.

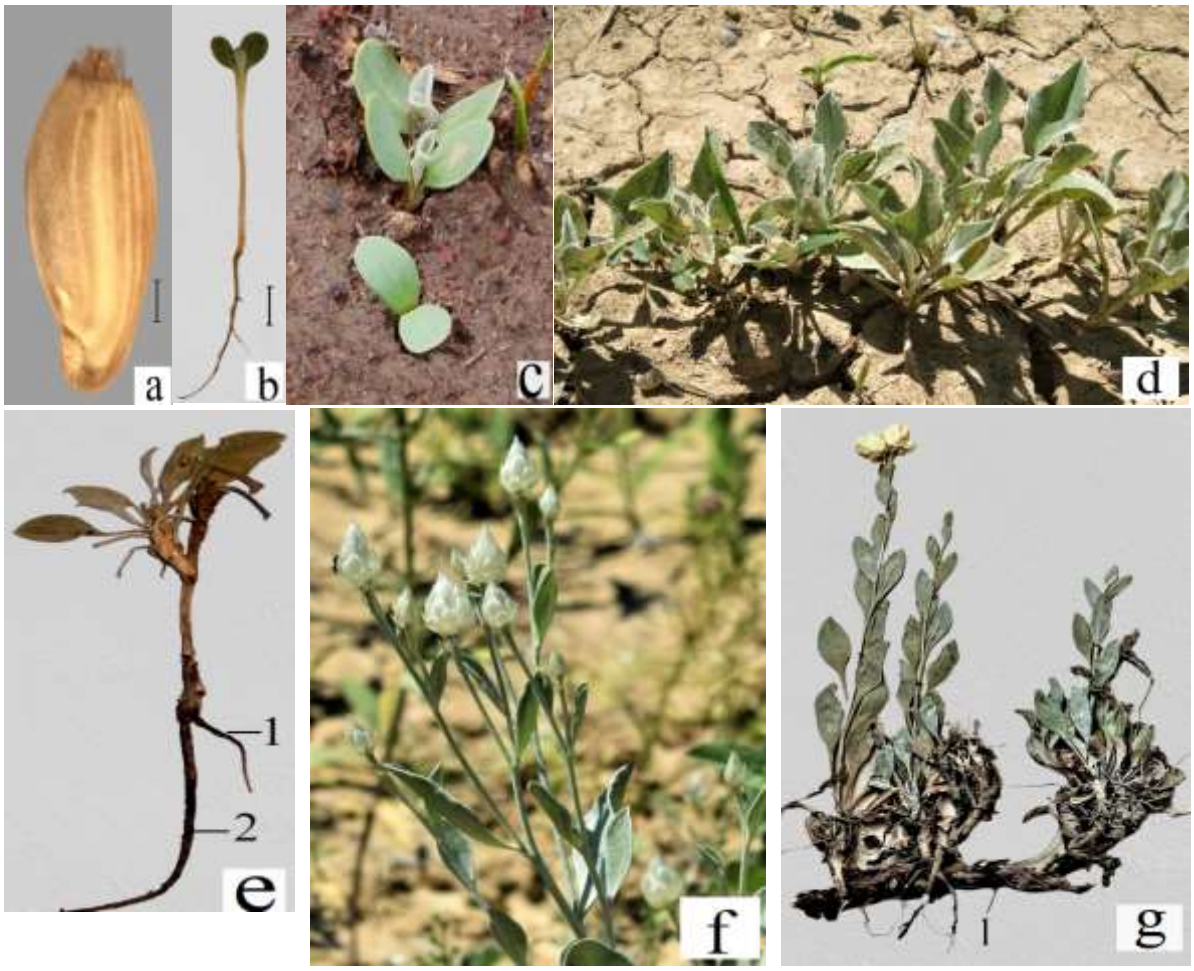

Fig. 4**.** *Psephellus erivanensis*. a, achene (scale bar 5 mm); b, seedling (scale bar 10 mm); c, seedling growth; d, juvenile plants; e, vegetative state of plant with rosette form shoots (1, adventitious root, 2, main taproot); f, flower buds; g, middle-age generative plant with plagiotropic rhizome.

The axillary buds are located in the nodes of the rhizome, from which the rhizome branches and the above-ground rosette shoots arise. *Psephellus erivanensis* has a shrublet-like habit, erect, 30–40 cm high. Stems are numerous, thick, with woody bases, appressed gray-pubescent, evenly leafy, usually branching from the base. Leaves (40)55×(10)20 mm, lanceolate to broadly lanceolate, oval or rhomboid, entire or serrated, sometimes partially slightly dissected, not fleshy, gray or white from dense adpressed pubescence, veins hardly noticeable; leaf blades smoothly pass into 30–40 mm long petioles. Plant structure consists of vegetative rosette-form shoots with renewal buds and with secondary roots developing at the base of the rosettes, annual leafy elongated generative shoots, and epigeogenic plagiotropic rhizome with adventitious roots (Fig. 4g).

Eco-physiological characteristics

Gypsophillous plants are endowed with features of specialization to extreme climatic and edaphic conditions of the Ararat Valley semideserts (Takhtajan & Fedorov 1972). Gypsum, by absorbing water, creates a possibility for perennial vegetation to exist in conditions of extreme physical dryness. In the structure of the stems and leaves of gypsophillous species, xeromorphic features, increasing their drought resistance, the ability of water storage, and reduction of transpiration are combined. Due to the high thermal stability of such plants, the intensity of photosynthesis in them does not fall, and water consumption is significantly reduced, which indicates a high efficiency of water use.

Table 2. The water regime, the intensity of transpiration, and photosynthesis indicators of *Psephellus erivanensis* in natural habitats and the Yerevan Botanical Garden.

Psephellus erivanensis	Total water % wet weight (M, m)	Water deficit % wet weight (M, m)	Transpiration intensity mg/g wet weight, hr	Photosynthesis intensity mg CO_2/dm^2-h
Gypsiferous semidesert of the Ararat valley, 900 m a.s.l.	42.0±1.04	44.7±0.91	146.3±0.96	2.02±0.87
Yerevan Botanical Garden, 1200 m a.s.l.	43.0±0.96	43.5±0,84	148.1±0.98	2.06±0.96

Some comparative physiological features of *P. erivanensis* were revealed in the natural conditions of the gypsiferous semidesert of the Ararat Valley and under ex-situ conditions in the Yerevan Botanical Garden. The parameters of the water regime of plants, the intensity of transpiration, and photosynthesis were determined (Table 2). Plants introduced in the Yerevan Botanical Garden, in comparison with natural ones, are distinguished by slightly higher total humidity and intensity of transpiration and photosynthesis, as well as a decrease in water deficit.

Karyological data

According to the literature data, the diploid cytotype is characteristic of *P. erivanensis* 2n=32, with basic chromosome number x=16 (Tonyan 1972). Our exploration result matches the previous count from Armenia. The karyologically studied samples collected during the expedition in the Ararat Valley revealed a diploid cytorace for this species 2n=2x=32. Voucher data: ERE 201491, Armenia, Ararat province, near village Getazat, the road to Mount Eranos, dry slopes, 920 m a.s.l., 40.0256° N, 44.3444° E. 01.VII.2022. Leg. J. Akopian, A. Ghukasyan, L. Martirosyan, A. Elbakyan. Det. J. Akopian.

The karyotype of *P. erivanensis* is symmetric, consisting of 2 pairs of submetacentric (I & III) and 14 pairs of metacentric very small chromosomes 0.77-1.54 µm in size. Symmetry index TF% = 49.87, total chromosome length is 34.01 µm. Karyotype formula is: 2n=32=4SM +28M (Fig. 5 A, B). Description of the karyotype for the taxon is given here for the first time.

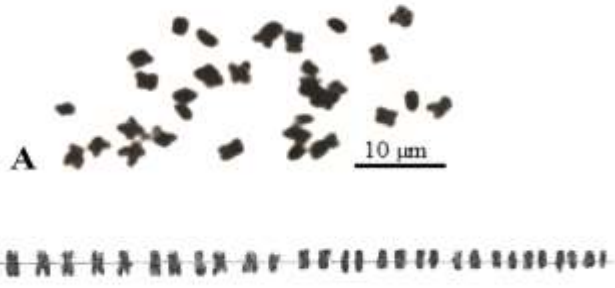

Fig. 5. A, Metaphase plate (2n = 32); B, Karyotype of *Psephellus erivanensis*.

Pollen fertility

For successful plant cultivation and seed production, information on pollen fertility is required, which can be determined using in vitro tests. Along with pollen fertility, the size of pollen grains plays an important role. According to the morphological heterogeneity of pollen, one can assume failures in microsporogenesis, which can lead to unsuccessful seed formation. It was revealed that the sizes of pollen grains of *P. erivanensis* tested from collections of different years differ little from each other (42.5-48.8 µm). The results show that the pollen fertility is quite high and is in the range of 93-99%, averaging 96.9±0.6% in both freshly collected samples and in herbariums collected from different populations of the plant (Fig. 6). This indicates that under favorable ex-situ conditions, there will be high seed set, which will contribute to the successful reproduction of the species to preserve the gene pool.

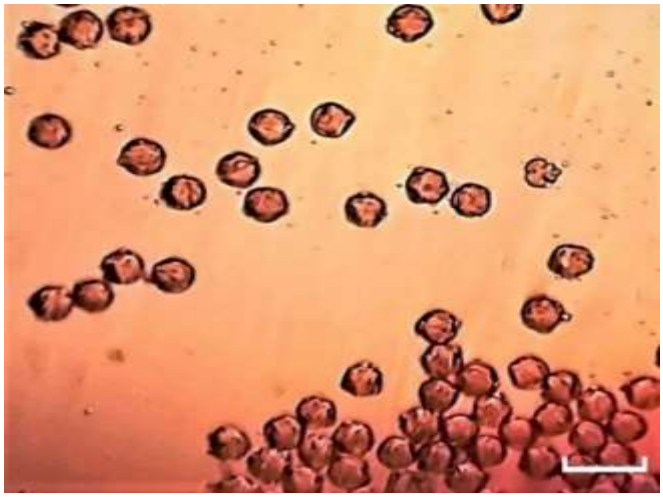

Fig. 6. *Psephellus erivanensis* pollen fertility (scale bar 100 μm).

DISCUSSION

Based on the data obtained from the introduction experience in the Yerevan Botanical Garden, *P. erivanensis* is recommended for ex-situ conservation through the establishment of living plant collections. The evaluation of the results of plant introduction is based on indicators of plant viability in culture, of the life cycle, stages of seasonal development and reproductive characteristics, and its resistance to biotic and abiotic factors of the growing environment.

Psephellus erivanensis is characterized as a xeromorphic polycarpic rhizomatous plant with two types of shoots, perennial rosettes, and annual leafy generative shoots. Under the conditions of introduction, they retain their natural phenorhythm stability, full cycle of seasonal growing, stable fruiting, mature seed formation, and vegetative self-renewal ability. There is no visible change in the general habits, in parameters of leaves, inflorescences, or the number of seeds in the capitulum. Under cultural conditions, propagation by seed sowing and artificial vegetative propagation through the division of the rhizome is possible. Self-seeding under cultural conditions is not noticed. Plants require traditional methods of cultivation, need moderate watering, and sufficient sunlight. Damage to the vegetative parts of plants by insects is not detected, however, insect damage to capitula and achenes occurs both in nature and in the conditions of introduction. Observations confirm the drought- and cold-resistance of *P. erivanensis*, adapted to the conditions of a sharply continental climate. The transplanted specimens with summer moderate watering develop normally both on the gypsum-containing soils and on the local soil of the Yerevan Botanical Garden. In contrast to the plants of natural habitats, the introduced plants show some higher total water content and intensity of transpiration and photosynthesis, decreasing the water deficit. Exploration results indicate *P. erivanensis's* satisfactory adaptation ability and the possibility of its cultivation and ex- situ conservation.

One of the main tasks of wild flora study is to identify its useful resources. The arid natural conditions of the Ararat Valley, where Yerevan, the capital of Armenia, and some other settlements are located, significantly limit the use of many flower crops for growing outdoors. Therefore, the drought-resistant wild ornamental species adapted to the local climate are of scientific and practical interest for the development of an assortment for arid landscaping. Based on the analysis of morphological, phenological, ornamental features and adaptive capabilities in cultural conditions, as the ability for generative, and vegetative renewal, we recommend the studied species as outdoor plants for ornamental landscaping. The introduction of *P. erivanensis* into the practice of ornamental landscaping can serve as one of the effective measures for its conservation. It can be successfully grown on gypsum-bearing, slightly salted, and loamy soils. When evaluating the ornamental qualities, such indicators as plant habit, leafiness, the shape and color of the leaves, the abundance of flowers, the color of capitula, the proportionality of plant parts, and others determined by aesthetic impressions were taken into account. Generative shoots both in the flowering and fruiting stages, and grayish-green leaves with a pubescent texture provide a long-term ornamental view of the plant. *Psephellus erivanensis* can be utilized in rockeries, for ornamental borders, in group plantings in flower beds against the background of lawns or open spaces, and as a cut flower for dry bouquets. It can be used for creating natural-style landscape compositions in the urban environment.

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REFERENCES

Akopian, J.A. 2010: Conservation of native plant diversity at the Yerevan Botanic Garden, Armenia. -Kew Bull. 65(4): 663-669.

Akopian, J., Hovakimyan, Zh., Paravyan, Z. 2017: Biomorphological features of some rare and endangered sandy and gypsy desert plant species of Armenia. -Biolog. Zhurn. Armenii 3(69): 39-46. Yerevan.

Bagdasaryan, A.B. 1958: Climate of the Armenian SSR. Yerevan. Publishing house Acad. Sciences Arm. SSR.

Balyan, S.P. 1969: Structural Geomorphology of the Armenian Highland and Surrounding Regions. Gabrielyan A.A. (ed). YSU Publishing House, 390 p. Yerevan.

Bylov, V.N., Karpisonova, R.A. 1978: Principles of creation and study of a collection of rare ornamental perennials. -Byull. Glavn. Bot. Sada 107: 77-82. Moscow.

Colombo, A.S., Berto, R., Ferrario, P., Toccolini, A., Larcher, F. 2020: Wildflowers in urban design:an exploratory research of preference in Italian adults. -Visions for Sustainability 15: 35-52. DOI: 10.13135/2384-8677/4599

Fifth National Report to the Convention on Biological Diversity. 2015: Ministry of Nature Protection. 106 p. Yerevan.

Gabrielyan, E.Ts. 1988: Review of species of the subgenus *Xanthopsis* (DC.) Tzvel. of the genus *Centaurea* L. (Asteraceae). -Novitates systematicae plantarum vascularium 25: 160-165. St. Petersburg.

Heywood, V.H. 2017: The future of plant conservation and the role of botanic gardens. -Plant Diversity 39(6): 309-313. DOI: 10.1016/j.pld.2017.12.002

Lipsky, V.I. 1902: *Psephellus erivanensis* Lipsky. -Proceedings of the Tiflis Botanical Garden 6(1): 64-65.

Mirzoeva, N.V., Akhverdov, A.A. 1959: Ornamental herbaceous plants of the flora of Armenia. -Bull. Bot. Sada Akad. Nauk Armyansk. SSR 17: 89-109. Yerevan.

Mounce, R., Smith, P. & Brockington, S. 2017: *Ex situ* conservation of plant diversity in the world's botanic gardens. -Nature Plants 3: 795-802. DOI: 10.1038/s41477-017-0019-3.

Nersesyan, A.A., Shcherbakova, Ye.N., Melkonyan, N.G., Danielyan, A.H. 2019: Ex situ conservation of *Centaurea erivanensis* (Asteraceae), *Cercis griffithii* (Caesalpiniaceae) and *Gypsophila takhtadzhanii* (Caryophyllaceae) by the method of clonal micropropagation. -Takhtajania 5: 76-79. Yerevan.

Pausheva, Z.P. 1980: Practicum on plant cytology. 304 p. Moscow.

Raunkiaer, C. 1934: The life forms of plants and statistical geography. Oxford, 632 p.

Salnikov, A.I., Maslov, I.L. 2014: Physiology and biochemistry of plants: practicum. Perm State Agricultural Academy, 300 p. Perm.

Sharrock, S. 2012: Global Strategy for Plant Conservation. A guide to the GSPC, all the targets, objectives, and facts. Published by Botanic Gardens Conservation International, Richmond, UK. 36 p.

Sheremetyev, S.N. 2005: Grasses on a soil moisture gradient. Partnership of scientific publications KMK, 271 p. Moscow.

Takhtajan, A.L., Fedorov, An.A. 1972: Flora of Yerevan (2nd edition). 394 p. Leningrad.

Takhtajan, A.L. 1978: Floristic regions of the world. 248 p. Leningrad.

Tamanyan, K., Fayvush, G., Nanagulyan, S., Danielyan, T. 2010: The Red Book of Plants of the Republic of Armenia. Higher Plants and Fungi (2nd edition). Ministry of Nature Protection of RA. 592 p. Yerevan.

Tonyan T.R. 1972: Correlation of some morphological features with ploidy in representatives of the subtribe *Centaureinea* Less. -Biolog. Journ. Armenii 25(11): 86-96. Yerevan.

Wolf, V.G. 1966: Statistical data processing. 254 p. Moscow.

Younis, A., Riaz, A., Saleem, S. and Hameed, M. 2010: Potential use of wildflowers in urban landscape. -Acta Hortic 881: 229–233. DOI: 10.17660/ActaHortic.2010.881.29