

**A new subspecies of *Reseda microcarpa* from Iran**

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**Massoud Ranjbar:** Prof., Department of Biology, Herbarium Division, Bu-Ali Sina University, Hamedan, Iran**Mahtab Asgari Nematian**✉: PhD Student, Department of Biology, Herbarium Division, Bu-Ali Sina University, Hamedan, Iran (mahtabasgari5@gmail.com)**Abstract**

*Reseda microcarpa* subsp. *zanjanica* is described as a new subspecies from Zanjan province (NW Iran). Morphological and micromorphological characteristics (flowers, leaves, inflorescences, fruits, seeds, and pollen grains), habitat features (ecological conditions that influenced the growth of this taxon such as altitudes and growing beds), distribution, taxonomic notes, and conservation status (IUCN Red List categories and criteria) are provided and compared for new subspecies and *R. microcarpa* subsp. *microcarpa*. Moreover, statistical analysis by multi-variate statistical analyses software (MVSP) segregated both the taxa based on morphological and micromorphological characteristics (quantitative and qualitative) with Principal Components Analysis (PCA). All characteristics formed three groups (group B: plant height and inflorescence length, group C: polar pollen axis and minimum and the average of colpus measurements, and group A: includes the rest studied morphological and micromorphological characteristics) except one characteristic (i.e. maximum size of colpus measurements) and two groups had high value for segregation of both taxa based on the statistical analysis (group C for *R. microcarpa* subsp. *microcarpa*, and group B for the new subspecies). Although, characteristic group A was valuable in the position of both taxa, the maximum size of colpus had the lowest value.

**Keywords:** Habitat, new subspecies, micromorphology, *Resedaceae*, taxonomy, Zanjan province**معرفی زیرگونه جدیدی از گونه *Reseda microcarpa* از ایران\***

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مسعود رنجبر: استاد گروه زیست‌شناسی، دانشکده علوم، دانشگاه بوعلی سینا، همدان، ایران

مهتاب اسگری نعمتیان✉: دانشجوی دکتری گروه زیست‌شناسی، دانشکده علوم، دانشگاه بوعلی سینا، همدان، ایران (mahtabasgari5@gmail.com)

**خلاصه**

*Reseda microcarpa* subsp. *zanjanica* Ranjbar & Asgari متعلق به تیره ورث (*Resedaceae*) به عنوان زیرگونه جدید از استان زنجان معرفی می‌شود. ویژگی‌های ریخت‌شناسی و ریزریخت‌شناسی شامل گل، برگ، گل‌آذین، دانه و دانه‌گرده، بوم‌شناختی شامل ارتفاع و بستر رشد، پراکنش، آرایه‌شناختی و وضعیت حفاظت برای زیرگونه جدید (با توجه به فهرست IUCN) بررسی و با زیرگونه *R. microcarpa* subsp. *microcarpa* مقایسه گردید. به علاوه، بررسی آماری حاصل از کلیه صفات کمی و کیفی ریخت‌شناسی و ریزریخت‌شناسی با استفاده از نرم‌افزار MVSP و با روش تجزیه مولفه‌های اصلی (PCA)، تفکیک این دو آرایه را تایید نمود. همه صفات به جز اندازه بیشینه شیار دانه‌گرده در سه گروه (صفات B شامل ارتفاع گیاه و طول گل‌آذین، گروه صفات C شامل اندازه محور قطبی دانه‌گرده و اندازه کمینه و میانگین شیار دانه‌گرده و گروه A شامل بقیه صفات ریخت‌شناسی و ریزریخت‌شناسی) قرار گرفتند و دو گروه از صفات، دارای ارزش آرایه‌شناختی بیشتر در جدایی دو آرایه فوق بودند (گروه C برای *R. microcarpa* subsp. *microcarpa* و گروه B برای زیرگونه جدید). اگر چه صفات گروه A در تعیین موقعیت هر دو آرایه با ارزش بود، اما اندازه بیشینه شیار دانه‌گرده کمترین ارزش را داشت.

**واژه‌های کلیدی:** آرایه‌شناختی، استان زنجان، تیره ورث، ریزریخت‌شناسی، زیرگونه جدید، زیستگاه

## Introduction

The family *Resedaceae* has six genera and 85 species in the southwestern Asia (Takhtajan 1969, Cronquist 1988, Martín-Bravo *et al.* 2007). There are three tribes in the family classified based on morphological characteristics (including *Astrocarpeae* Müll. Arg., *Cayluseae* Müll. Arg., and *Resedeae* Müll. Arg.) (Martín-Bravo *et al.* 2007). Tribe *Resedeae* was further divided into two subtribes viz., *Randoninae* (including *Randonia*), and *Resedinae* (including *Ochradenus*, *Oligomeris*, and *Reseda*) (Martín-Bravo *et al.* 2007). All taxa of *Reseda* L. are important in the conservation of biodiversity and are mainly being found in the arid to semiarid regions in Iran (Abdallah & De Wit 1978, Abdallah *et al.* 1982). The genus *Reseda* includes 12 species, eight subspecies, and four varieties in the Flora Iranica areas (Abdallah *et al.* 1982). Flora of Iran, and the flora of U.S.S.R. have mentioned about this genus with 10 and 11 species, respectively (Komarov 1939, Nowroozi 1993). Based on the molecular phylogenetic studies (Martín-Bravo *et al.* 2007, Martín-Bravo & Jiménez-Mejías 2009), the monophyly of the family *Resedaceae* and their tribes were accepted. Although, the monophyly of some genera such as *Caylusea* and *Sesamoides* was supported by Martín-Bravo *et al.* (2007), *Reseda* along with *Ochradenus*, *Oligomeris*, and *Randonia* constructed a paraphyletic core group (*l.c.*).

Some morphological characteristics such as size and shape of leaves, pedicels length, indumentum of leaves, stem, fruit, shape, and size of superior, lateral, and anterior petals were found important in the species and subspecies delimitation of *Reseda* (Martín-Bravo *et al.* 2007, Çilden *et al.* 2018). In this way, micromorphological characteristics had taxonomical values such as: seed size and pollen shape (Çilden *et al.* 2018). Lately, two comprehensive research had been done based on micromorphological characteristics with valuable taxonomical issues (Asgari Nematian & Ranjbar 2021, Çilden & Yildirimli 2021). Results of seed micromorphological characteristics were in agreement with the

subgenera and sectional rank of the taxa of this genus (Çilden & Yildirimli 2021). The members of *Reseda* were placed in six pollen types and eight subtypes based on exine ornamentation that can be used to identify the species of this genus (Asgari Nematian & Ranjbar 2021).

During the present fieldwork, some *Reseda* specimens were collected which were not possible to identify them using the Flora Iranica (Abdallah *et al.* 1982), Flora of Iran (Nowroozi 1993), Flora of U.S.S.R. (Komarov 1939), and taxonomic revision of the family *Resedaceae* (Abdallah & De Wit 1978). Our observation was compared with *Reseda microcarpa* Müll. Arg., after using important taxonomical characteristics such as seed and pollen grain micromorphology, anatomical characteristics, and ecological features; our results showed that, the studied (collected) taxa was different from *R. microcarpa* hence proposed as a new subspecies. The aim of the study, therefore, is to describe a new subspecies of *R. microcarpa* which is native to NW Iran (near Zanjan province).

## Materials and Methods

During growing seasons (2018–19, the plant specimens were collected from Tabriz-Zanjan freeway (NW Iran) and morphological characters were examined in herbarium material of *Reseda microcarpa* deposited at Conservatoire et Jardin botaniques de 'la Ville de Genève (G), and additional collections at Bu-Ali Sina University (BASU), The Natural History Museum (BM), Royal Botanic Garden Edinburgh (E), Komarov Botanical Institute, Saint Petersburg (LE), Muséum National d'Histoire Naturelle, and Paris (P) herbaria (Fig. 1). The characters of leaves, stems, and pedicels were examined by stereomicroscope (Olympus CX 41). For the present investigation, the indumentum of the stems, leaves, and fruits were mounted on brass stubs. Seeds and pollen grains were also mounted on stubs and coated by gold in a sputter coater (KYKY SBC). The micrographs were taken by electron microscopy (JEOL JSM-840A: JEOL Ltd., Tokyo, Japan) in Bu-Ali Sina University. Finally, the micromorphological characteristics were observed

and compared. We followed Punt *et al.* (2007) for the terminology of pollen grain characteristics. Principal Component Analysis (PCA) by MVSP software was used for the taxa (as PCA case scores), using all quantitative and qualitative morphological characteristics (as PCA variable loadings) (Kovach 1999). The conservation status of *R. microcarpa* was evaluated according to IUCN Red List categories and criteria (IUCN 2019).

## Results and Discussion

*Reseda microcarpa* subsp. *zanjanica* Ranjbar & Asgari subsp. nov. (Figs 2–3)

Type: Iran: Zanjan province, Tabriz-Zanjan freeway, 90 km to Zanjan, 37° 06' 58" N 47° 53' 23" E, 1200 m, 26.5.2019, Ranjbar & Asgari 45832 (holotype: BASU; isotype: IRAN 77785).

*Reseda microcarpa* subsp. *zanjanica* Ranjbar & Asgari differs from *R. microcarpa* Müll. Arg. subsp. *microcarpa* in height of plant (60–65 cm), having elliptic to ovate leaves with 10–15 mm wide; pedicel length 8–10 mm and 10–12 mm in flowering and fruiting stages, respectively; longer inflorescence, different corolla size and petals numbers, 18–19 stamens, with orange anthers; red-brown seeds and shiny with smooth to slightly rugose surface; and prolate-spheroidal pollen grains, with reticulate-striate exine (Tables 1 & 2). More characteristic features of the plant is as follows:

Plant perennial, 60–65 cm high. Stem branched, erect, undulate, muricate with linear striation. Leaves 35–40 × 10–15 mm, entire, elliptic to ovate, leaf surface undulate, muricate, with colliculate striate and irregular cuticular folds with stomata. Inflorescence raceme, 25–35 cm long, loose. Bracts 4.5–5 × 0.5 mm, erect, linear, deciduous, glabrous. Pedicel 8–10 mm in flower and 10–12 mm in fruit, ribbed. Flowers bisexual, perianth 6(–7)-merous. Calyx 4–5 × 0.5–0.7 mm in flowering stage, persistent, slightly accrescent, oblong to oblong-spathulate, margins glabrous, widely pallid. Petals 7, 2.5–3 × 1.5–2 mm. The limb of superior petals trisects, often lateral lobes reduced, flabellate, usually smaller than an appendage; central lobe oblong, obtuse; lateral lobes

narrower, sometimes all or laterals ones appearing as dents. Lateral petals sometimes smaller than others. Anterior petals smallest; limb usually simple, sometimes lateral lobe(s) represented by dents. Disc 1.5–2 × 1 mm, minutely papillose, glabrescent. Stamens 18–19, filament 2–2.2 mm, glabrous. Anthers 2–2.1 mm, oblong, orange. Ovary ovoid-ellipsoid, with three carpels and styles. Capsules erect, with thickened pedicels, stipitate, obovoid to globular, 3-angled, walls (deeply) sulcate, mouth contracted, teeth minute, with cuticular folds, undulate indumentum and stomata. Seeds 1.21–1.31(–1.25 ± 0.05) × 1.09–1.21(1.16 ± 0.05) mm, 10–12 per capsule, reniform, red-brown and shiny when mature, testa rugose, seed surface smooth to slightly rugose (Figs 3–8).

- Micromorphology of stems, leaves, and fruits

In *R. microcarpa* subsp. *zanjanica*, epidermis cells of the stem are undulate-muricate with linear striation of varying, 36–73 × 120–186 µm with a unique shape (Fig. 4 D-F) while this characteristic is 25–35 µm in height and 50–300 µm in width with a unique shape in *R. microcarpa* subsp. *microcarpa* (Fig. 4 A-C). The upper leaf side of *R. microcarpa* subsp. *zanjanica* was undulate-muricate to colliculate-striate with irregular cuticular folds. The muricate diameter was also variable in size (48.32–56.60 × 102.99–178.92 µm) (Fig. 5 D-F). Besides, the upper side of leaves form moderately muricate with irregular cuticular folds in *R. microcarpa* subsp. *microcarpa* and the muricates diameter were various with 25–50 µm height and 50–150 µm width, and spherical apex (Fig. 5 A-C). In *R. microcarpa* subsp. *microcarpa*, the capsules are 5–6 × 4–4.5 mm, pendulous in mature, obovoid-cylindric to obovoid-subglobose, glabrous, constricted below the teeth and narrow at the base (stipitate), with wide mouth, capsule teeth 1–1.5 mm, smooth indumentum and stomata (Fig. 7 A-C). Therefore, the micromorphological characters of stems, leaves, and fruits are valuable for separating the new subspecies from the type subspecies.

- Distribution and ecology

*Reseda microcarpa* subsp. *microcarpa* is distributed in Armenia, Azerbaijan, Turkey, and Iran

(Komarov 1939, Abdallah *et al.* 1982, Nowroozi 1993). This taxon is distributed mainly in northwestern Iran (Fig. 9), 700–1200 m elevations, and usually grows on stony loams or schist, on calcareous rocks, as well as on calcareous schist. Its conservation status could be categorized as Least Concern (LC), according to IUCN Red List criteria (IUCN 2019). However, the distribution range of *R. microcarpa* subsp. *zanjanica* is restricted in NW of Iran where it grows on dry and clay slopes, 1200 m (Figs 3F & 9). It is known only from the type locality until now. The total distribution area of the subspecies is approximately 1 km<sup>2</sup> and population density seems to be quite low. The new subspecies has been proposed as Critically Endangered (CR) B2ab (ii, iii) according to the IUCN Red List criteria (IUCN 2019). Based on the above ecological information, this new subspecies is distributed in higher elevations rather than the type subspecies. Although, *R. microcarpa* subsp. *microcarpa* generally prefers stony loams or schist (Abdallah & De Wit 1978, Komarov 1939), the new subspecies grows in more difficult ecological conditions.

#### - Seed coat and pollen grains micromorphology

Micromorphological characteristics of pollen grains in *R. microcarpa* subsp. *zanjanica* are different from the type subspecies in their shape, size, and exine ornamentation (Table 2). Prolate spheroidal pollen grains are found in the new subspecies; however, they are mainly prolate in the type subspecies (Fig. 8 E & G, Table 2). Exine ornamentation as a major micromorphological characteristic in new subspecies was reticulate-striate, while reticulate-fossulate exine ornamentation was seen in *R. microcarpa* subsp. *microcarpa* (Fig. 8 F & H, Table 2). The other micromorphological characteristics, such as polar and equatorial axes, P/E ratio, the range of number and size of lumina and muri were different between two subspecies of *R. microcarpa* (Table 2).

Seed micromorphology provides further differences in the identification of new subspecies. Rugose seed coat

sculpture was seen in new subspecies that was different from the type subspecies (tuberculate coat sculpture) (Fig. 8, Table 2). Other seed qualitative characteristics such as color and state of the surface were valuable in differentiation of both taxa. In this way, quantitative seed characteristics had a taxonomical value (length and width of seed and length/width ratio) (Table 2).

#### - Statistical analysis

The results of Principal Components Analysis (PCA) include eigenvalues, percentages, and cumulative percentages for both axes, PCA case scores (studied taxa), and PCA variable loadings (all qualitative and quantitative studied characteristics) are shown in table 2 and figure 10. According to this, two subspecies of *R. microcarpa* were placed in different positions (negative and positive in axis 2 for *microcarpa* subsp. *microcarpa* and *R. microcarpa* subsp. *zanjanica*, respectively) (Fig. 10 A, Table 2).

Based on the PCA variable loadings, three characteristic groups and one characteristic (maximum of colpus) were made. Characteristic group B included: minimum and maximum of plant height and inflorescence length measurements; characteristic group C included: all measurements of the polar axis and minimum and average measurements of colpus; and characteristic group A included the other quantitative and qualitative morphological characteristics (Fig. 10 B, Table 2).

The results of PCA analysis based on the studied taxa and their quantitative and qualitative morphological characteristics showed that, characteristic group B had a major role in the situation of the new subspecies in the biplot (Fig. 10 A). In contrast, characteristic group C had a major role in the situation of the subspecies type (Fig. 10 A). Characteristic Cx (Maximum of colpus) had a minor role in the situation of both taxa (Fig. 10A). The rest of the characteristics in the central part of the biplot (characteristic group A) were important for the situation of both taxa (Fig. 10 A).

**Table 1.** Comparison of morphological characteristics in two subspecies of *Reseda microcarpa*

Character	<i>R. microcarpa</i> subsp. <i>microcarpa</i>	<i>R. microcarpa</i> subsp. <i>zanjanica</i>
Plant height (cm)	45–50	60–65
Leaves width (mm)	5–10	10–15
Leaves shape	Obovate-spathulate to oblong	Elliptic to ovate
Pedicle length in the flowering stage (mm)	2–3	8–10
Pedicle length in the fruiting stage (mm)	3–5	10–12
Pedicle length in comparison to fruit	Shorter than capsule	Longer than capsule
Inflorescence length (cm)	15–25	25–35
Sepals size (mm)	2 × 0.5	4–5 × 1.5
Petals number	6	7
Petals size (mm)	2–2.5 × 1–1.5	2.5–3 × 1.5–2.5
Superior petal size (mm)	2.2 × 1.5	3 × 2.5
Lateral and anterior petal size (mm)	2 × 1	3 × 2
Stamen number	14–16	18–19
Color of anther	Cream to white	Orange

**Table 2.** Comparison of micromorphological characteristics in two subspecies of *Reseda microcarpa*

Character	<i>R. microcarpa</i> subsp. <i>microcarpa</i>	<i>R. microcarpa</i> subsp. <i>zanjanica</i>
Seed color	Dark-brown and dull	Red-brown and shiny
Seed surface	Warty	Smooth to slightly rugose
Seed length (mm)	1.25(1.35 ± 0.14)1.49	1.21(1.25 ± 0.05)1.31
Seed width (mm)	1.28(1.38 ± 0.06)1.43	1.09(1.16 ± 0.05)1.21
Ratio L/W	1.27	1.18
Seed coat pattern sculpture	Tuberculate	Rugose
Polar pollen axis (µm)	27.32(28.56 ± 0.95)30.09	17.72(19.14 ± 0.75)20.25
Equatorial pollen axis (µm)	13.70(14.36 ± 0.69)15.32	16.12(17.96 ± 0.98)19.29
P/E	1.80	1.09
Pollen shape	Prolate	Prolate-spheroidal
Colpus (µm)	19.73(23.36 ± 1.80)	8.82(11.25 ± 1.65)13.98
Muri width (µm)	0.14(0.18 ± 0.02)0.26	0.11(0.16 ± 0.02)0.21
Lumina diameter (µm)	0.22(0.32 ± 0.07)0.46	0.17(0.33 ± 0.10)0.50
Exine sculpturing	Reticulate-fossulate	Reticulate-striate

**Table 3.** The quantitative and qualitative morphological characteristics analyzed by principal components analysis between *Reseda microcarpa* subsp. *microcarpa* and *R. microcarpa* subsp. *zanjanica*

		Principal component analysis	
		Axis 1	Axis 2
Eigen values		0	793.366
Percentage		0	100
Cumulative percentage		100	100
Characteristic group	PCA variable loadings	Axis 1	Axis 2
B	Phi (Minimum of plant height)	0.124	0.377
B	Phx (Maximum of plant height)	0.124	0.377
A	Lwi (Minimum of leaves width)	0.041	0.126
A	Lwx (Maximum of leaves width)	0.041	0.126
A	Ls (Leaves shape)	0.008	0.025
A	Pli (Minimum of pedicel length in the flowering state)	0.008	0.025
A	Plx (Maximum of pedicel length in the flowering state)	0.017	0.05
A	Pfi (Minimum of pedicel length in the fruiting state)	0.058	0.176
A	Pfx (Maximum of pedicel length in the fruiting state)	0.058	0.176
A	Pc (Pedicel length in comparison to fruit)	0.008	0.025

**Table 3** (contd)

B	Fli (Minimum of inflorescence length)	0.083	0.251
B	Flx (Maximum of inflorescence length)	0.083	0.251
A	Sw (Sepals width)	0.008	0.025
A	Sl (Sepals length)	0.025	0.075
A	Pn (Petals number)	0.008	0.025
A	Pw (Petals width)	0.008	0.025
A	Pl (Petals length)	0.004	0.013
A	Uw (Superior petal width)	0.008	0.025
A	Ul (Superior petal length)	0.007	0.02
A	Aw (Lateral and anterior petal width)	0.008	0.025
A	Al (Lateral and anterior petal length)	0.008	0.025
A	Si (Minimum of stamen number)	0.033	0.1
A	Sx (Maximum of stamen number)	0.025	0.075
A	Co (Color of anther)	0.008	0.025
A	So (Seed color)	0.008	0.025
A	Ss (Seed surface)	0.008	0.025
A	Sli (Minimum of seed length)	0	-0.001
A	Slm (Average of seed length)	-0.001	-0.003
A	SlS (Standard deviation of seed length)	-0.001	-0.002
A	Slx (Maximum of seed length)	-0.001	-0.005
A	Ewi (Minimum of seed width)	-0.002	-0.005
A	Ewm (Average of seed width)	-0.002	-0.006
A	Ews (Standard deviation of seed width)	0	0
A	Ewx (Maximum of seed width)	-0.002	-0.006
A	Lw (Ratio L/W)	-0.001	-0.002
A	Sc (Seed coat pattern sculpture)	0.008	0.025
C	Ppi (Minimum of polar pollen axis)	-0.08	-0.241
C	Ppm (Average of polar pollen axis)	-0.078	-0.236
A	Pps (Standard deviation of polar pollen axis)	-0.002	-0.005
C	Ppx (Maximum of polar pollen axis)	-0.082	-0.247
A	Epi (Minimum of equatorial pollen axis)	0.02	0.061
A	Epm (Average of equatorial pollen axis)	0.03	0.09
A	Eps (Standard deviation of equatorial pollen axis)	0.002	0.007
A	Epx (Maximum of equatorial pollen axis)	0.033	0.1
A	Pe (P/E ratio)	-0.006	-0.018
A	Ps (Pollen shape)	0.008	0.025
C	Ci (Colpus minimum)	-0.09	-0.274
C	Cm (Colpus average)	-0.1	-0.304
A	Cs (Colpus standard deviation)	-0.001	-0.005
-	Cx (Colpus maximum)	0.95	-0.314
A	Mi (Minimum of muri width)	0	-0.001
A	Mm (Average of muri width)	0	-0.001
A	Ms (Standard deviation of muri width)	0	0
A	Mx (Maximum of muri width)	0	-0.001
A	Li (Minimum of lumina diameter)	0	-0.001
A	Lm (Average of lumina diameter)	0	0
A	Ls (Standard deviation of lumina diameter)	0	0.001
A	Lx (Minimum of lumina diameter)	0	0.001
A	Ex (Exine sculpturing)	0	0.025
<b>PCA case scores</b>		<b>Axis 1</b>	<b>Axis 2</b>
<i>R. microcarpa</i> subsp. <i>microcarpa</i>		0	-19.917
<i>R. microcarpa</i> subsp. <i>zanjanica</i>		0	19.917

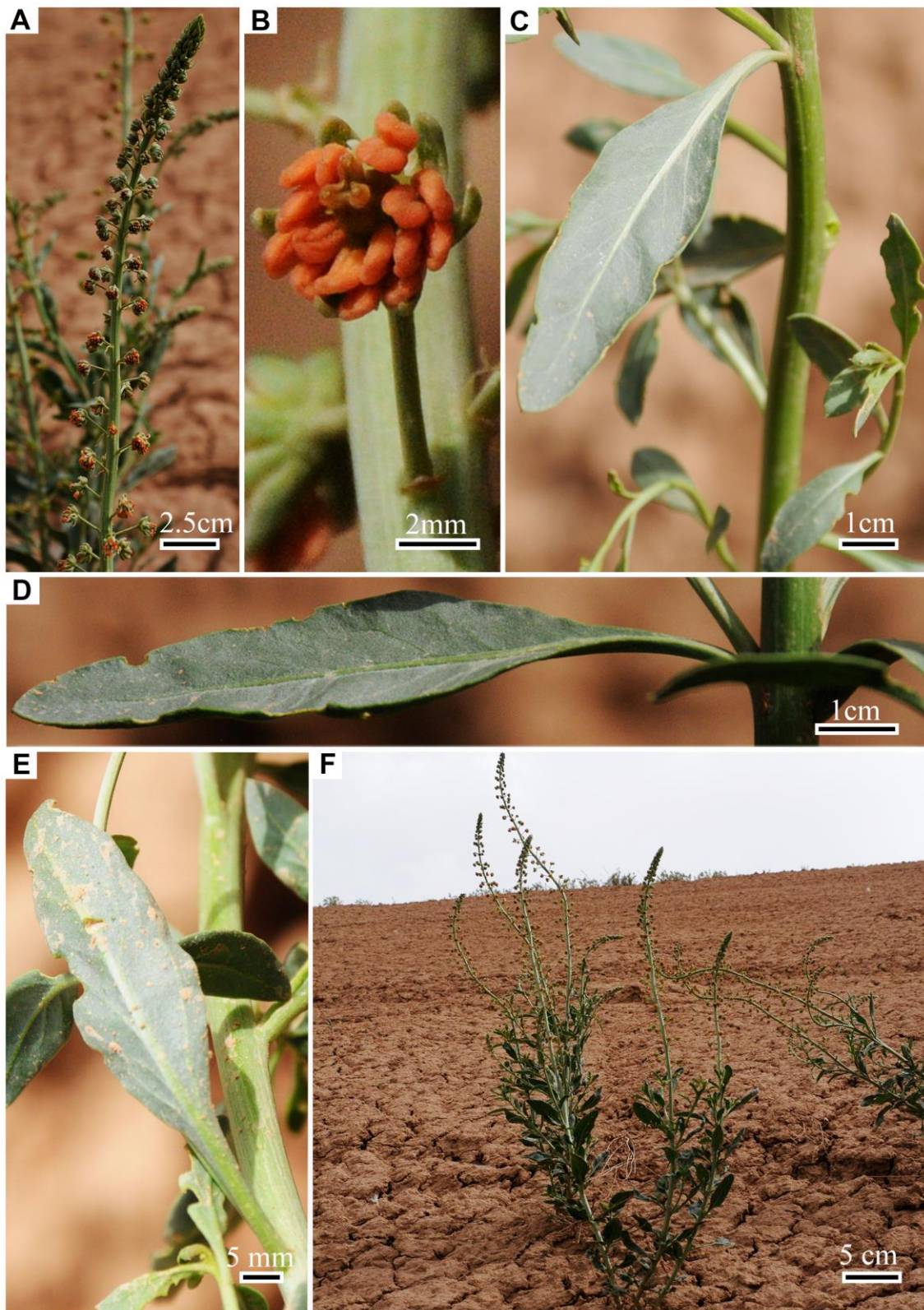


**Fig. 1.** A. Holotype of *Reseda microcarpa* subsp. *microcarpa* (Buhse s.n. G-BOISS), B. *R. microcarpa* subsp. *microcarpa* [s.n. (E), E00443286], C. *R. microcarpa* subsp. *microcarpa* [F.A. Buhse (LE), LE00013176], D. *R. microcarpa* subsp. *microcarpa* [Bunge s.n. (P), P02140961].

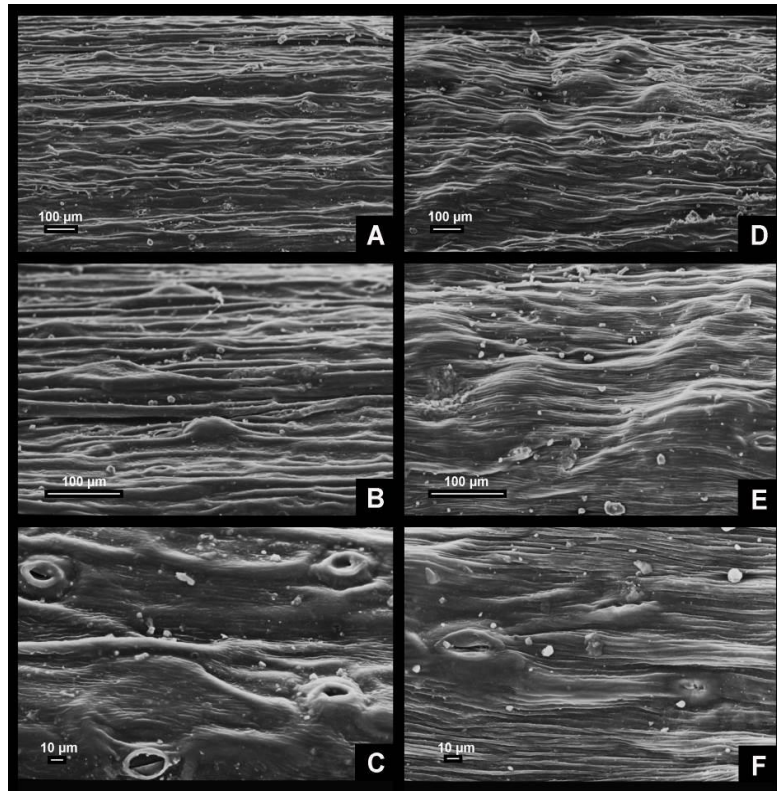


**Fig. 2.** Holotype of *Reseda microcarpa* subsp. *zanjanica* Ranjbar & Asgari (Ranjbar 45832, BASU).

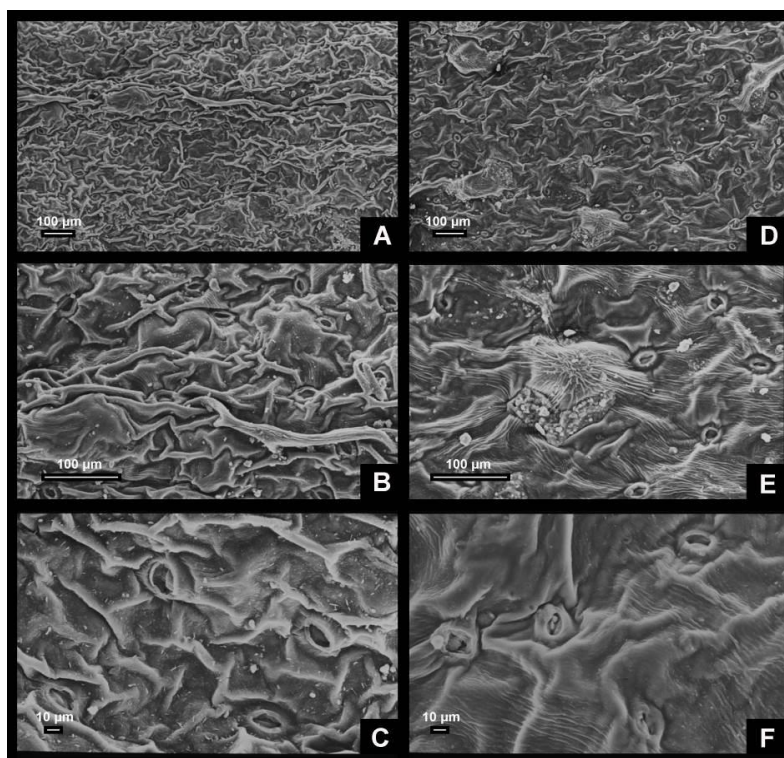




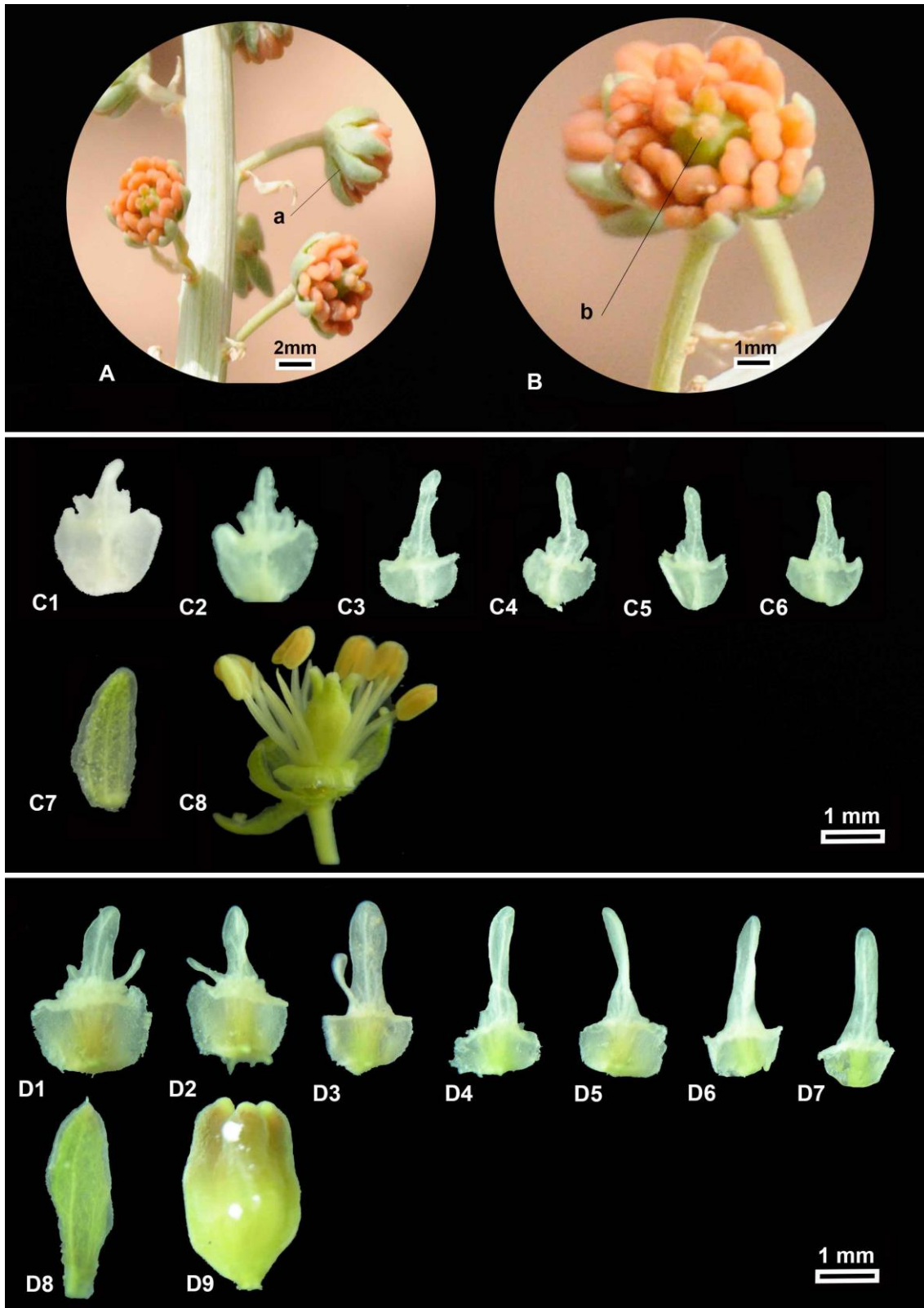
**Fig. 3.** *Reseda microcarpa* subsp. *zanjanica*: A. Inflorescences, B. Flower showing the stamens & ovary, C & D. Adaxial surface of the leaf, E. Abaxial surface of the leaf, F. Habit and habitat.



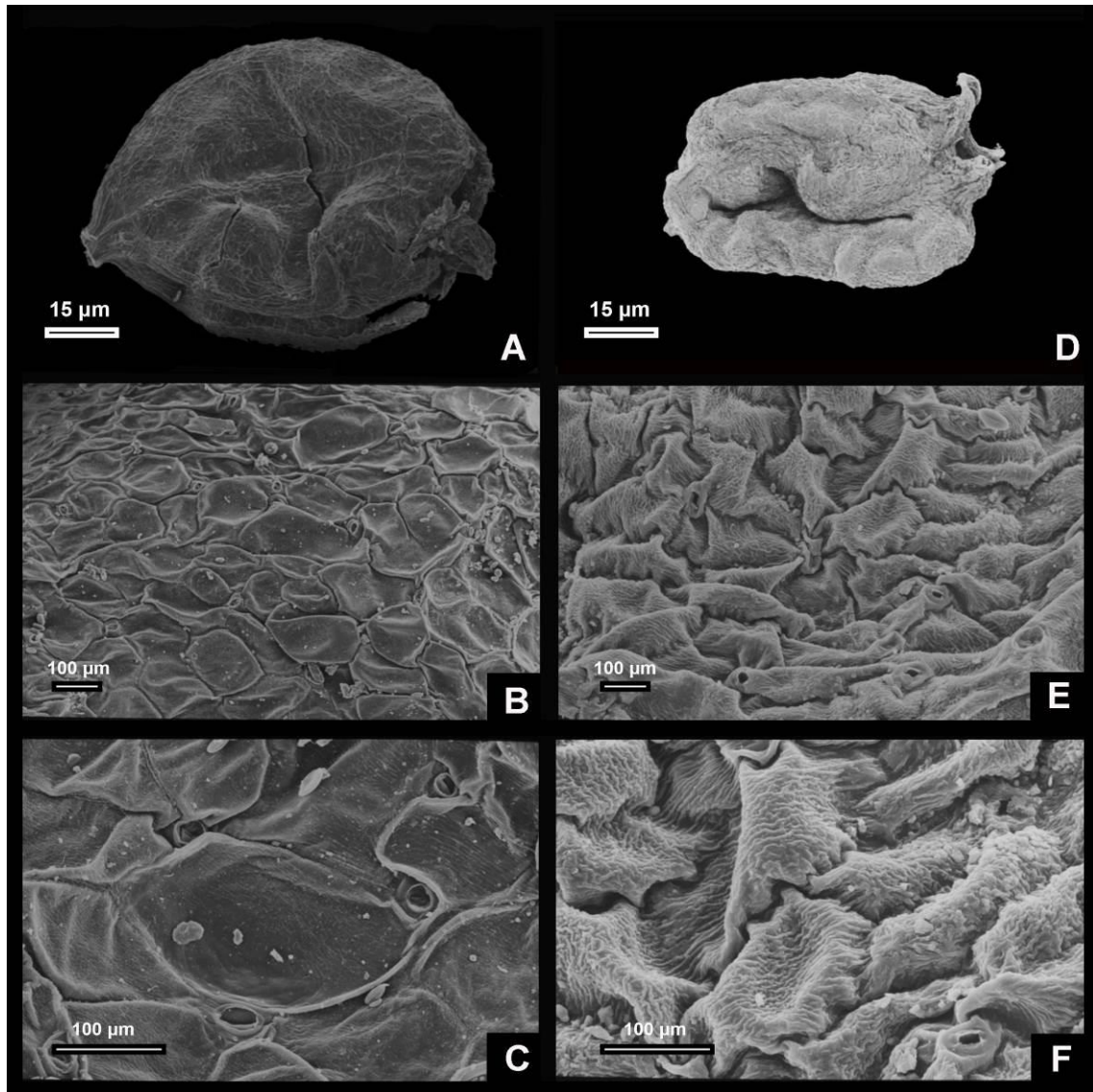
**Fig. 4.** Scanning electron micrographs of stem surface: A-C. *Reseda microcarpa* subsp. *microcarpa*, D-F. *R. microcarpa* subsp. *zanjanica*.



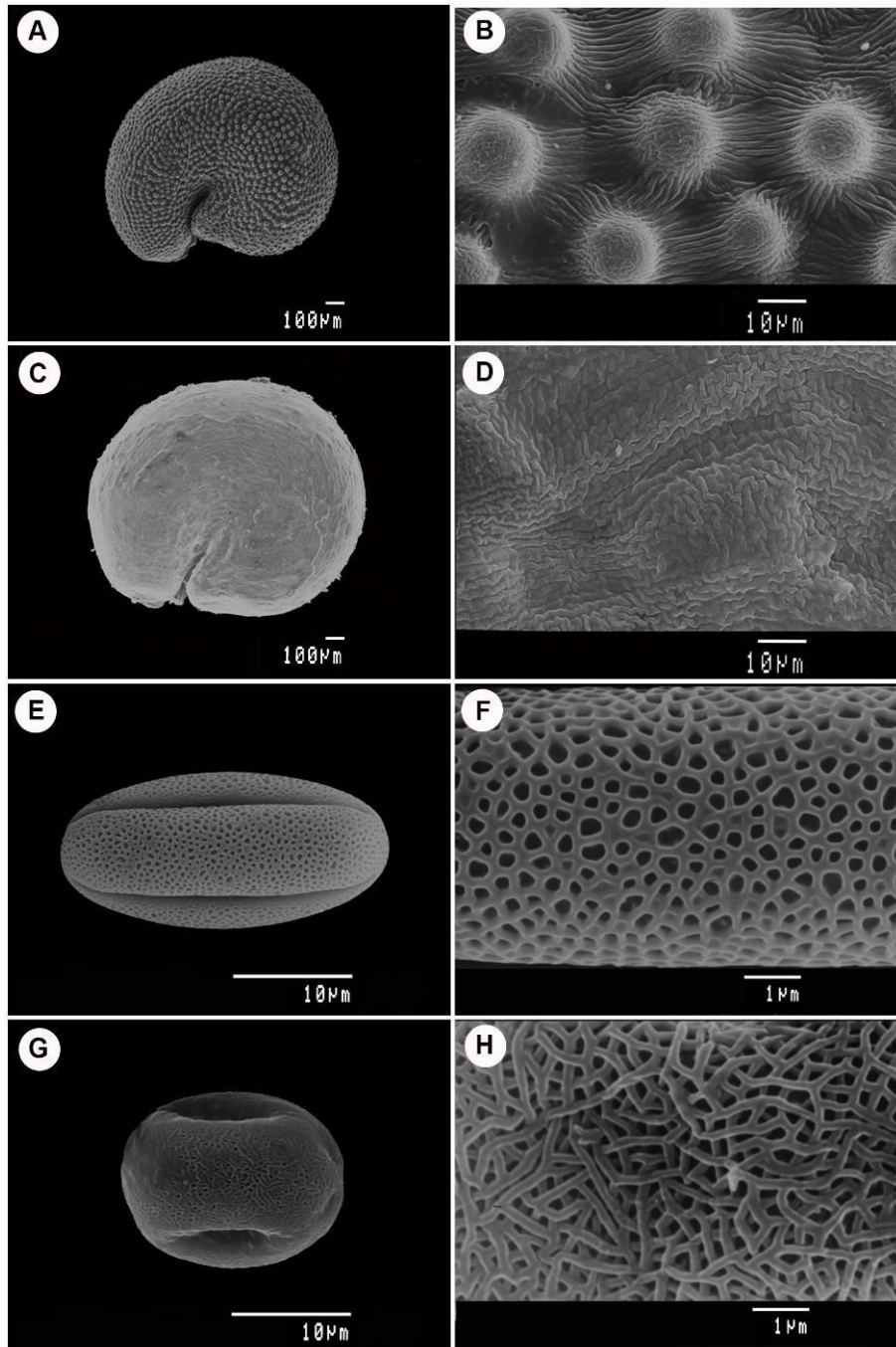
**Fig. 5.** Scanning electron micrographs of leaf surface: A-C. *Reseda microcarpa* subsp. *microcarpa*, D-F. *R. microcarpa* subsp. *zanjanica*.



**Fig. 6.** Flower of *Reseda microcarpa* subsp. *zanjanica*: A. Sepal, B. 3-toothed ovary, C. Petals of *R. microcarpa* subsp. *microcarpa*, (C1-C2) superior petals, (C3-C4) lateral petals, (C5-C6) anterior petals, (C7) sepal, (C8) flower & ovary. D. *R. microcarpa* subsp. *zanjanica*, (D1-D2-D3) superior petals, (D4-D5) lateral petals, (D6-D7) anterior petals, (D8) sepal, (D9) ovary.



**Fig. 7.** Scanning electron micrographs of fruit: A-C. *Reseda microcarpa* subsp. *microcarpa*, D-F. *R. microcarpa* subsp. *zanjanica*.



**Fig. 8.** Scanning electron micrographs of seeds and pollen grains: A, B. Seed coat ornamentation of *Reseda microcarpa* subsp. *microcarpa*, C, D. Seed coat ornamentation of *R. microcarpa* subsp. *zanjanica*, E. Equatorial view of prolate pollen grain in *R. microcarpa* subsp. *microcarpa*, F. Reticulate-fossulate exine of *R. microcarpa* subsp. *microcarpa*, G. Equatorial view of prolate-spheroidal pollen grain in *R. microcarpa* subsp. *zanjanica*, H. Reticulate-striate exine ornamentation of *R. microcarpa* subsp. *zanjanica*.

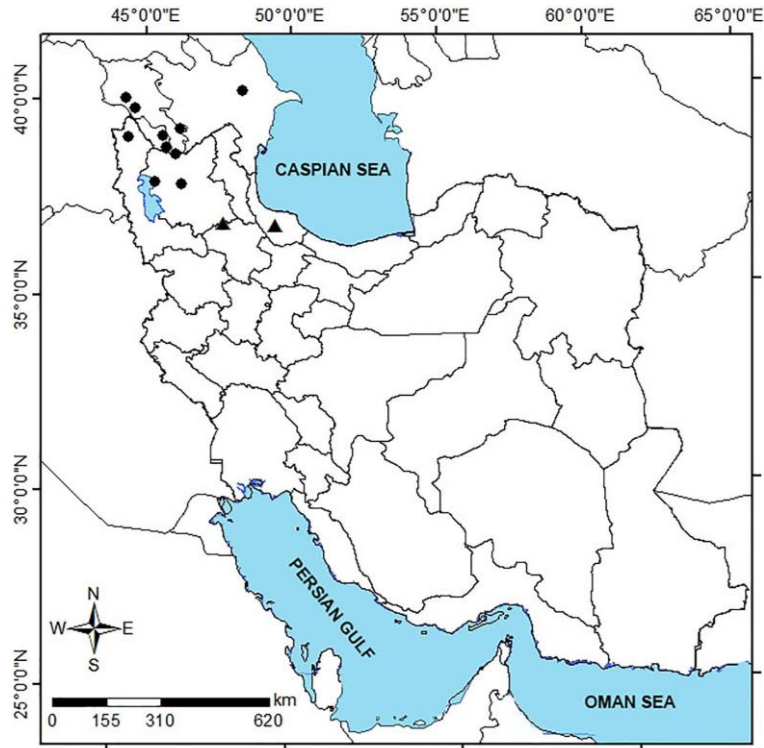


Fig. 9. Distribution map of *Reseda microcarpa* subsp. *microcarpa* (●), *R. microcarpa* subsp. *zanjanica* (▲).

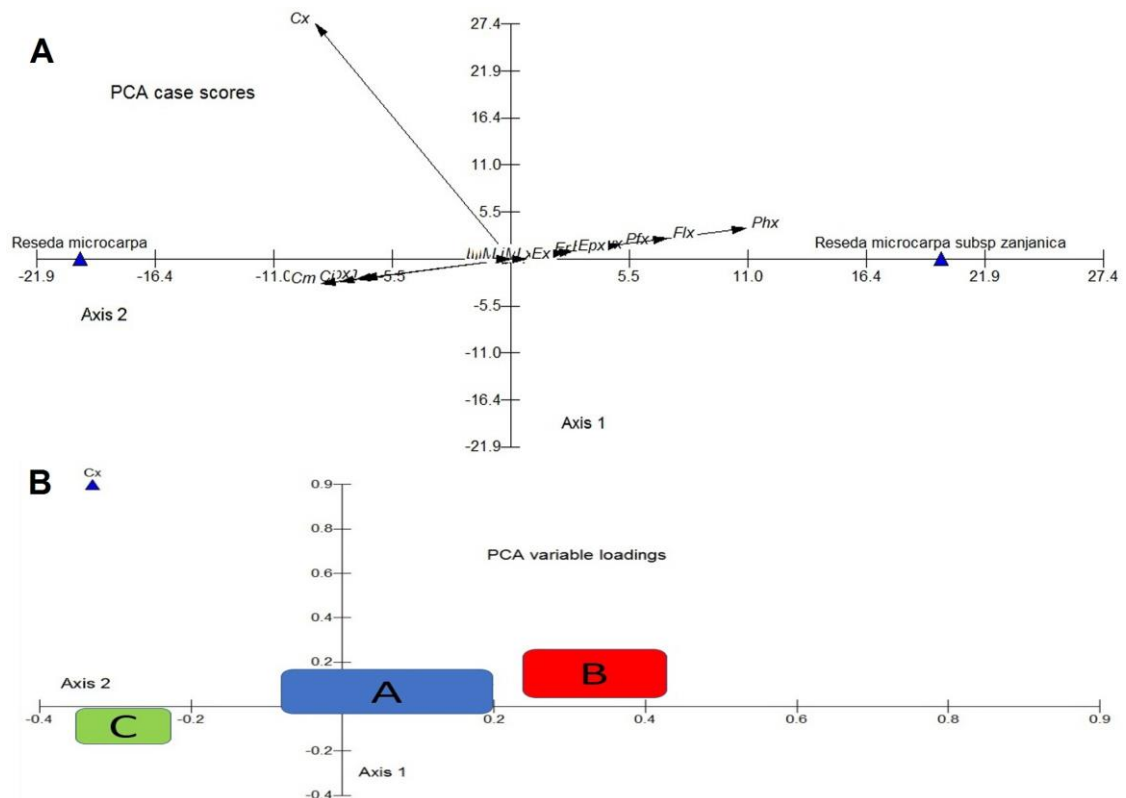


Fig. 10. The PCA scatterplot obtained from overlapping of the studied taxa (case scores) (A) and the quantitative and qualitative morphological characteristics (variable loadings) (B). Case scores (taxa): *Reseda microcarpa* subsp. *microcarpa* and *R. microcarpa* subsp. *zanjanica*. Variable loading (all quantitative and qualitative morphological characteristics): Characteristic group B included: minimum and maximum of plant height, and inflorescence length; Characteristic group C included: minimum and average of polar and colpus of pollen grain, and maximum of polar of pollen grains; Characteristic Cx (maximum of colpus) and characteristic group A included the other quantitative and qualitative morphological characteristics.

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