

MORPHOLOGICAL AND MICROMORPHOLOGICAL STUDIES OF NONEA (BORAGINACEAE: TRIBE BORAGINEAE) IN IRAN

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Nonea Medik. is one of the major genera of Boraginaceae tribe Boragineae, with approximately 35 species in the world. In this study we focused on reproductive characters, which are not generally affected by environment. Our selected reproductive characters have been the stigma form, position of stigma towards the anthers, form of faucal scales, color, form and symmetry of flowers and characters of mericarps. An identification key using morphological and micromorphological characters has also been proposed. In the present paper above mentioned characters have been described for the first time in *N. turcomanica* M. Pop, *N. lutea* (Desr.) DC. var. *flavescens* Lipsky, *N. persica* Boiss. var. *suchtelenioides* (Riedl) Falatoury & Pakravan, *N. diffusa* Boiss. et Buhse, *N. rosea* (Bieb.) Link and *N. melanocarpa* Boiss. *Nonea suchtelenioides* H. Riedl has been decreased to the variety level of *Nonea persica* as *N. persica* Boiss. var. *suchtelenioides* (Riedl) Falatoury & Pakravan.

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Key words. *Nonea*, Boraginaceae, Taxonomy, micromorphology, stigma, faucal scale, Iran.

بررسی مورفولوژیکی و میکرومورفولوژیکی جنس *Nonea Medicus* (Boraginaceae) در ایران

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جنس *Nonea* Medik. با حدود ۳۵ گونه، یکی از بزرگترین جنسهای خانواده *Boraginaceae* قبیله *Boragineae* در جهان است. در این بازبینی، بیشتر از صفات زایشی، که عموماً کمتر تحت تأثیر محیط قرار می‌گیرند، استفاده شده است. صفات زایشی مورد نظر شکل کلاله، موقعیت کلاله نسبت به بساکها، شکل فلس گلوگاه، رنگ، شکل و تقارن گل و صفات مربوط به مریکارپ نمونه‌ها بوده است. همچنین کلید شناسایی گونه‌ها بر اساس صفات ساختاری و ریز ساختاری پیشنهاد شده است.

در این بررسی برای اولین بار صفات ذکر شده در مورد گونه‌های *N. diffusa* Boiss. et Buhse، *N. lutea* (Desr.) DC. var. *N. diffusa* Boiss. et Buhse، *N. persica* Boiss. var. *suchtelenioides* (Riedl) Falatoury & Pakravan، *N. melanocarpa* Boiss.، *flavescens* Lipsky، *N. turcomanica* M. Pop و *rosea* (Bieb.) Link شرح داده شده است.

Nonea suchtelenioides H. Riedl به سطح واریته ای از *N. persica* کاهش یافته و به صورت *N. persica* Boiss. var. *suchtelenioides* (Riedl) Falatoury & Pakravan معرفی شده است.

INTRODUCTION

Nonea Medik. is one of the major genera of Boraginaceae tribe Boragineae with approximately 35 species distributed from central-western Asia to the

Atlantic area of southern Europe and northern Africa. Its main center of diversity stretches over the Pontic-Caucasian mountain systems and Irano-Turanian-Anatolian highlands, while fewer species occur in

Europe and in the Mediterranean, especially in the semiarid parts of the Maghreb region from Libya to Morocco (Selvi et al. 2006).

The genus *Nonea* Medicus was originally based on the accrescent fruiting calyx and the hairy fornicies inserted at the throat of the corolla; by these characters it has become broadly accepted (Selvi et al. 2006). However, a broad range of inter-specific variation occurs in general habit, life-form, morphology of flowers and fruits, as well as in the structure of pollen grains and stigma (Bigazzi & Selvi 1998, 2000). Such variation is not reflected in the traditional taxonomy of *Nonea*, which still relies on De Candolle's (1846) treatment in three sections based on the form of mericarpids and on the position of the anthers in the corolla tube. De Candolle proposed three sections for *Nonea*; Sect. *Orthocaryum* A. DC. includes the species with erect nutlets, sect. *Cytrocaryum* A. DC. is characterized by curved, reniform nutlets, and sect. *Nonea* (= *Cryptanthera* A. DC.) circumscribes all species with anthers hidden in the corolla tube, which include the great majority.

This infrageneric classification, however, does not reflect the remarkable morphological and chromosomal diversity which is emerging from recent studies. For example, a palynological survey of *Boragineae* has shown that *Nonea* contains the greatest diversity in the tribe, with five pollen types none of which fits into De Candolle's sections (Bigazzi & Selvi 1998). Another survey of stigma forms in the tribe has confirmed *Nonea* as the most variable genus, with six types largely corresponding to the pollen types (Bigazzi & Selvi 2000).

Flora Iranica (Riedl 1967), Flora of Iran (Khatamsaz, 2002) and other Floras attend to the vegetative characters such as form and size of plants, leaf and bracts, whereas based on our study these characters showed a high degree of variation and they are not suitable for the species delimitation. In this study we focused on reproductive characters, which are not generally affected by environment. It's notable that in our field-based revision we observed many variations in vegetative and reproductive characters that haven't been characterized correctly in Flora Iranica & Flora of Iran. Our selected reproductive characters consist of stigma form, position of stigma toward the anthers, form of scales, color, form and symmetry of flowers and characters of nutlets.

This genus is taxonomically critical, mainly due to the difficulty in the identification and observation of the morphological characters with diagnostic value. Vegetative characters which is used to delimitation the species of this genus are not sharp enough, so we have

tried to choose some substituting characters to distinguish between taxa more easily.

Our purpose of this revisionary study of this genus was improving the classification, characterizing the taxa more comprehensively and delimiting the correct name(s) of the taxa named.

MATERIALS AND METHODS

This survey is mostly based on material that we have collected from wild populations with our friends help. (table 1) A few herbarium specimens were examined to complete a comprehensive coverage of the taxonomic range of *Nonea* in Iran. Specimens have been studied without fixation or preparation except boiling when it was necessary. For light microscopy, stigmas were observed by an Olympus BX51 light microscope with a video camera Olympus DP12 model. Samples were scanned with a Dino-Lite digital microscope AM413T model. To describe characters, terminology was followed Selvi & al. (2001, 2002 & 2006), Flora of Turkey and Flora of the USSR.

RESULTS

Flower

In this study, symmetry and color of throat and limb of flowers are used for the determination (table 2). The yellow color of throat in *N. cspica*, *N. persica* and *N. persica* var. *suchtelenioides* are distinctly different from the limb. The flower in *N. diffusa*, *N. pulla*, *N. rosea*, *N. persica* and *N. persica* var. *suchtelenioides* is curved (table 2).

Nutlet

The straight nutlets belong to 3 taxa, *N. lutea* (figure 1c, 2c), *N. lutea* var. *flavescens* (figure 1b, 2b) & *N. rosea*. *N. anchusoides* (figure 1h, 2e) & *N. turcomanica* (figure 1d, 2d) have semi- curved nutlets. *N. diffusa* (figure 1g, 2h) has the largest nutlets and *N. turcomanica* & *N. stenosen* (figure 1i, 2i) have the smallest nutlets. Nutlets' characters can only be used for identification when they are ripe. Most nutlets more or less are hairy. Basal rings in *N. pulla* (figure 1k, 2l), *N. stenosen*, *N. diffusa*, *N. persica* (figure 1i, 2j) and *N. persica* var. *suchtelenioides* (figure 1j, 2k) are distinctly dentate. Basal rings in *N. melanocarpa* (figure 1f, 2g) and *N. stenosen* are not thick. *N. stenosen* nutlets are finely whitish tuberculate (table 3).

Stigma, papillae and faucal scale

In the specimens three types of stigma were observed. First, *Pulmunaria-Anchusa* (Bigazzi & Selvi 2000). The papillae show the typical lageniform structure,

Table 1. List of the investigated *Nonea* taxa including origin of voucher specimens.

Taxa	Locality	Collector & Herb. No.
<i>N. anchusoides</i> Boiss. & Buhse	Azerbaijan, Sahand mount. 2500-3000 m	Mozaffarian 69857-TARI, dupl. in TUH.
<i>N. caspica</i> (Willd.) Don.	Esfahan, 30 km after Ardestan to Kashan, 113 m, E 52 10, N 33 33	Pakravan 2900-Alzahra University herbarium (Aluh.)
	Tehran, to Saveh, 10 km before Nasimshahr, 1200m	Falatory 2901-Aluh.
	Markazi, Zarandieh, Mamonieh, 1300m	Falatory 2902-Aluh.
	Tehran, Mahdasht to Eshtehard, 26 km to Eshtehard, 1090 m	Falatory 2920-Aluh.
	Tehran, Karadj to Ghazvin, 109 km after Tehran, 1220 m	Falatory 2921-Aluh.
<i>N. diffusa</i> Boiss. et Buhse	Markazi, Tehran to Saveh, 80 km to Saveh, 1040 m	Falatory 2903-Aluh.
	Tehran, 15 km after Ziaran to Taleghan, 2100 m	Falatory 2904-Aluh.
	Tehran, Lavasanat, Saheli Ave., 1700m	Falatory 2925-Aluh.
<i>N. lutea</i> (Desr.) DC. var. <i>flavescens</i> (C. A. Mey.) Lipsky	Gilan, Bandar Anzali, - 28 m Mazandaran, Ramsar	Mohamadjany 2905-Aluh. Gholizadeh 2906-Aluh.
<i>N. lutea</i> (Desr.) DC. var. <i>lutea</i>	Gilan, Rasht to Asalem, Laksar, -28 m	Falatory 2907-Aluh.
	Mazandaran, Minodasht, 5 km after Jangal-deh	Nattaj 2908-Aluh.
	Mazandaran, Chaloos, Shariatabad	Nattaj 2927-Aluh.
	Gorgan, Jangal-é Ghorogh	Nattaj 2928-Aluh.
<i>N. macrantha</i> (Ridley) Baytop	Azerbaijan, Moghan, kuhe Sahand,	Sharif, 6503-IRAN or 2623
<i>N. melanocarpa</i> Boiss.	Tehran, Saveh highway, to Firouzabraham, 1090 m	Falatory 2909-Aluh.
	Tehran, Lavasan, Naran, 1260 m	Falatory 2910-Aluh.
	Tehran, Lavasan, Saheli Ave., 1700 m	Falatory 2922-Aluh.
	Tehran, Kan, Park-é Kohsar, 2116 m, E 50° 57' 03" N 35° 56' 09"	Keshavarzi 2926-Aluh.
<i>N. persica</i> Boiss.	Tehran, Lar (preserve), 2440 m	Falatory 2911-Aluh.
	Esfahan, Kashan, Ghamsar	Pakravan 2912-Aluh.
	Markazi, Arak, Meighan, 1711m, E 49 44 90 N 34 7 9	Malek Mohammadi 2913-Aluh.
<i>N. persica</i> Boiss. var. <i>suchtelenioides</i> (Riedl) Falatory & Pakravan	Tehran, Lavasanat, Naran, 1700 m	Falatory 2914-Aluh.
	Kerman, mt. Hazaran	Famouri 5339-IRAN
	Tehran, Ziaran to Taleghan, 15 km after Ziaran, 2100 m	Falatory 2923-Aluh.
<i>N. pulla</i> (L.) DC.	Azerbaijan, Meshkinshahr to Ahar, 30 km to Ahar, 1200 m	Pakravan 2915-Aluh.
	Hamedan, Ganjname	Rastipisheh 2916-Aluh.
<i>N. rosea</i> (Bieb.) Link	Azarbaiejan, Arasbaran, Kaleibar to Makeidi, 1200 m	Pakravan 2917-Aluh.
<i>N. stenosen</i> Boiss. & Balansa	Turkey, Seyithar, Vazilikaya	Pakravan 2918-Aluh.
<i>N. turcomanica</i> M. Pop.	Tehran, Mahdasht to Karadj, 1195m	Falatory 2919-Aluh.
	Tehran, Khalij-e Fars highway	Falatory 2924-Aluh.
	Gorgan, Gonbad-e Kavus, Khashkalan	Sharif 5269-Iran

Table 2. Characters of flowers in *Nonea* species.

Characters taxa	Color of limb	Color of throat	Shape of flower	Symmetry of flowers
<i>N. anchusoides</i>	bluish-violet to dull pink	same to limb	infundibular	actinomorphic
<i>N. caspica</i>	orange-red	yellow	narrowly infundibular	± zygomorphic
<i>N. diffusa</i>	blue-violet, blue-white, white-pink, dark red	yellow or different from limb	curved, infundibular	± zygomorphic
<i>N. lutea</i> var. <i>flavescens</i>	yellow	pale yellow	infundibular	actinomorphic
<i>N. lutea</i> var. <i>lutea</i>	yellow	pale yellow	infundibular	actinomorphic
<i>N. macrantha</i>	dark purple	pale purple	infundibular	actinomorphic
<i>N. melanocarpa</i>	purple-violet	±same to limb	narrowly infundibular	± zygomorphic
<i>N. persica</i>	purple-brown	yellow	distinctly curved and irregularly infundibular	asymmetrical and inclined
<i>N. persica</i> var. <i>suchtelenioides</i>	purple-brown	yellow	distinctly curved and irregularly infundibular	asymmetrical and inclined
<i>N. pulla</i>	purple-brown	±same to limb	distinctly curved and irregularly infundibular	asymmetrical and inclined
<i>N. rosea</i>	purple-pink	yellow	infundibular	actinomorphic
<i>N. stenosolen</i>	purplish- red	±same to limb	narrowly infundibular	actinomorphic
<i>N. turcomanica</i>	pale yellow- white	yellow	narrowly infundibular	actinomorphic

characterized by an apical plate like cap. The length of these lobes is different and in *N. lutea* are longer than the others. *Pulmunaria-Anchusa* type occurs in *N. caspica*, *N. diffusa*, *N. melanocarpa*, *N. lutea*, *N. lutea* var. *flavescens*, *N. turcomanica* and *N. rosea*. Second, *Nonea pulla* type (Bigazzi & Selvi 2000). The papillae which maintain the typical lageniform structure, are large in size and densely packed, and show an average number of cap lobes (fig. 3). This group consists of a small number of *Nonea* taxa, but is somewhat heterogeneous and can be subdivided into three subtypes (Bigazzi & Selvi 2000). The first consists only of *N. anchusoides*, an Irano-Turanian species characterized by a subcylindrical stigma with lateral papillae (Bigazzi & Selvi 2000). The second consists of *N. macrantha* & *N. stenosolen* and is characterized by a deep narrow cleft reaching the style. The third consists of *N. pulla*, *N. persica* and *N. persica* var. *suchtelenioides*, which are characterized by a large stigma and lobes that are widely separated and more or less strongly spreading. In *N. caspica* and *N. turcomanica* distinctly there are two types of papillae, *Pulmunaria-Anchusa* type in general and *Nonea vesicaria* type in apical notching. In *Nonea vesicaria* type (fig. 3b) (Bigazzi & Selvi 2000).

In five taxa, *N. lutea*, *N. lutea* var. *flavescens*, *N. turcomanica*, *N. rosea* and *N. macrantha*, anthers are overlapping the scales and in *N. persica* styles not reaching the anthers.

In *N. persica* and *N. persica* var. *suchtelenioides* (fig. 4d and fig. 5b) faucal scales consist of short stiff hairs. Faucal scales of *N. rosea* are hairy and papillose (fig. 4c & fig. 5d). Faucal scales in *N. anchusoides*, *N. pulla* (fig. 5a), *N. macrantha* (fig. 4b & fig. 5a) & *N. stenosolen* (fig. 5a) are densely long hairy (table 4).

DISCUSSION

Reproductive characters seemed very useful in the delimitation of the species of *Nonea* and therefore, a key to the species mainly based on reproductive characters was prepared.

Flower

Color of limb and throat of flowers are distinguishable characters among some taxa. *N. caspica* has orange-red limb and yellow throat, this character distinguish it from *N. melanocarpa* with purple flower and from *N. diffusa* with white-pink or blue-violet flower, but these characters are only usable in fresh materials as they are changed in drying.

Stigma, papillae and faucal scale

Form of stigma and faucal scales are useful characters especially in distinguishing *N. persica* and *N. pulla* as they are very similar in habit, but faucal scale in *N. persica* consists of short stiff hairs and in *N. pulla* consists of long hairs. It is noticeable that according to our study *N. pulla* is restricted to west of Iran. *N. pulla*

Table 3. Characters of nutlets in *Nonea* species.

Characters Taxa	Nutlet's shape	Basal ring	Indumentum
<i>N. anchlussoides</i>	semi-curved, with lateral beak	thick, with short teeth	puberulent
<i>N. caspica</i>	horizontal, transversally ovoid, with lateral beak	± thick, with 10-20 small teeth	glabrous or puberulent at base
<i>N. lutea</i> var. <i>flavescens</i>	straight, oblong, densely rugose, with short obtuse apex	thick	slightly or markedly downy
<i>N. lutea</i> var. <i>lutea</i>	straight, oblong-cylindrical, longitudinally rugose, with short obtuse apex	thick	puberulent
<i>N. macrantha</i>	horizontal, subreniform,	scarcely thickened, with short teeth	glabrous
<i>N. melanocarpa</i>	horizontal, transversally oblong, with lateral beak	not thickened, with up to 20 small wrinkles	downy with hairs longer on ring
<i>N. persica</i>	horizontal, transversally ovoid, with lateral beak, rugose, ± cristate	± thick, dentate	puberulent
<i>N. persica</i> var. <i>suchtelenioides</i>	horizontal, transversally ovoid, with lateral beak, very rugose	± thick, dentate	puberulent
<i>N. pulla</i>	subglobular, with lateral beak, netted-rugose	± thick, dentate	downy
<i>N. rosea</i>	straight, oblong, obtuse	thick	± downy
<i>N. stenosen</i>	transversally ovoid, with small lateral beak, reticulate-rugose, finely whitish tuberculate	with 11- 14 teeth	puberulent
<i>N. turcomanica</i>	markedly curved, almost horizontal, with apex pressed to the side, semi-ovate	thick	± downy

Table 4. Characters of flowers in *Nonea* species.

Characters Taxa	Stigma form	Papillae form	Faucal scales indumentum	Position of stigma
<i>N. anchlussoides</i>	<i>Nonea pulla</i> type-1	<i>Pulmunaria-Anchusa</i> type	densely long-hairy	style reaching the anthers
<i>N. caspica</i>	<i>Pulmunaria-Anchusa</i> type	<i>Pulmunaria-Anchusa</i> type & <i>Nonea vesicaria</i> type	hairy	style reaching the anthers
<i>N. lutea</i> (var. <i>flavescens</i>)	<i>Pulmunaria-Anchusa</i> type	<i>Pulmunaria-Anchusa</i> type	hairy	style reaching the anthers or slightly pass them
<i>N. lutea</i> var. <i>lutea</i>	<i>Pulmunaria-Anchusa</i> type	<i>Pulmunaria-Anchusa</i> type	hairy	style reaching the anthers or slightly pass them
<i>N. macrantha</i>	<i>Nonea pulla</i> type-2	<i>Pulmunaria-Anchusa</i> type	densely long hairy	style slightly exerted from the throat
<i>N. melanocarpa</i>	<i>Pulmunaria-Anchusa</i> type	<i>Pulmunaria-Anchusa</i> type	hairy	style reaching the anthers
<i>N. persica</i>	<i>Nonea pulla</i> type-3	<i>Pulmunaria-Anchusa</i> type	short, stiff hairs	style not reaching the anthers
<i>N. persica</i> var. <i>suchtelenioides</i>	<i>Nonea pulla</i> type-3	<i>Pulmunaria-Anchusa</i> type	short, stiff hairs	style not reaching the anthers
<i>N. pulla</i>	<i>Nonea pulla</i> type-3	<i>Pulmunaria-Anchusa</i> type	densely long hairy	style reaching the anthers
<i>N. rosea</i>	<i>Pulmunaria-Anchusa</i> type	<i>Pulmunaria-Anchusa</i> type	long- hairy & papillose	style slightly exerted from the throat
<i>N. stenosen</i>	<i>Nonea pulla</i> type-2	<i>Pulmunaria-Anchusa</i> type	densely long-hairy	style reaching the anthers
<i>N. turcomanica</i>	<i>Pulmunaria-Anchusa</i> type	<i>Pulmunaria-Anchusa</i> type & <i>Nonea vesicaria</i> type	hairy	style reaching the anthers or slightly pass them

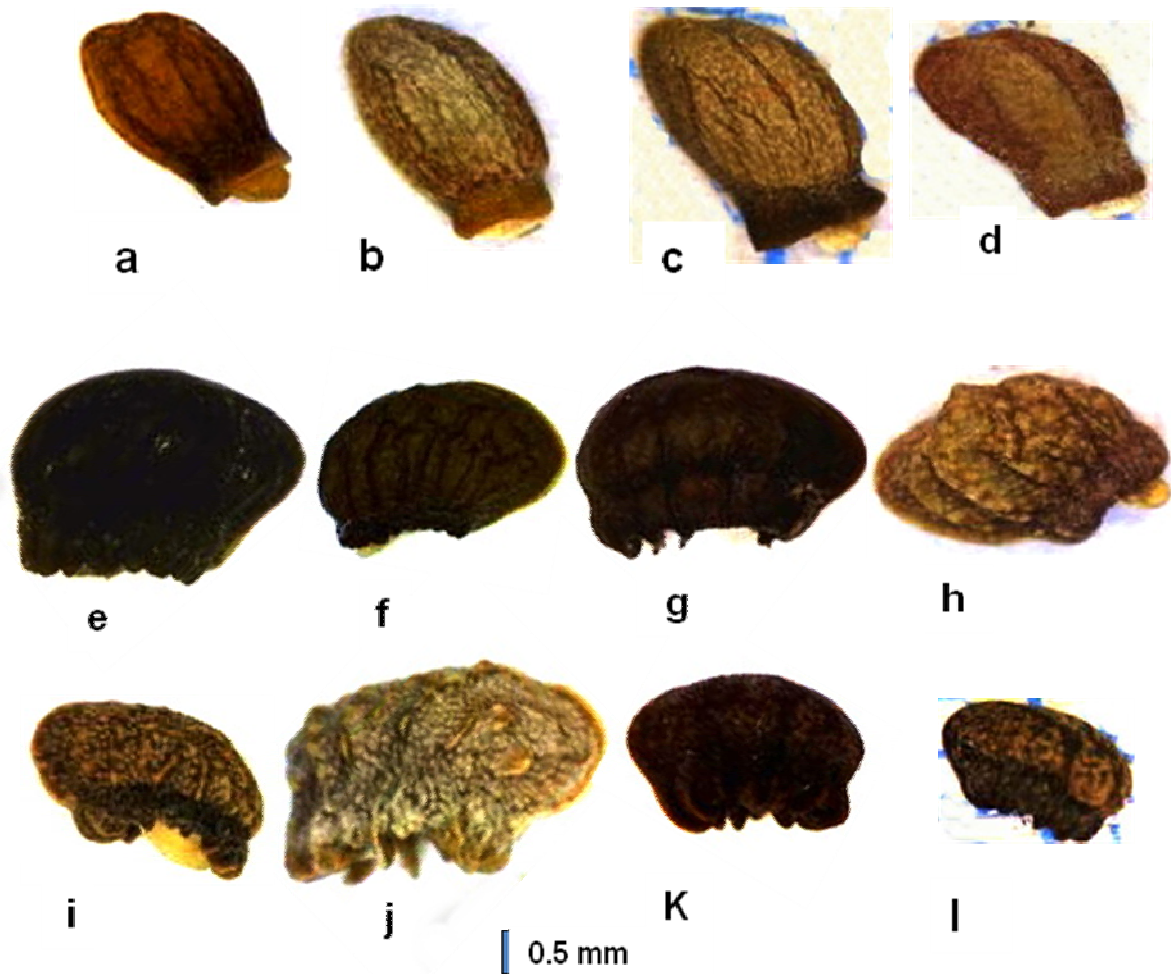


Fig. 1. Nutlet. (a) *Nonea lutea*. (b) *N. lutea* var. *flavescens*. (c) *N. rosea*. (d) *N. turcomanica*. (e) *N. caspica*. (f) *N. melanocarpa*. (g) *N. diffusa*. (h) *N. anchusoides*. (i) *N. persica*. (j) *N. persica* var. *suchtelenioides*. (k) *N. pulla*. (l) *N. stenosolen*.

and *N. macrantha* have the same faucal scales but different subtypes of stigma.

Papillae are generally the same in these taxa but different in *N. caspica* which has two types of papillae followed by the other variation in characters such as having narrower leaves and taller stem.

Nutlet

Straight, curved or semi-curved nutlets may be used to distinguish some taxa. Semi curved nutlets occur only in two taxa, *N. turcomanica* and *N. anchusoides*. *N. turcomanica* is annual with yellow to white flowers and *N. anchusoides* is perennial with bluish violet flowers. Size and number of teeth in basal ring of nutlets are other characters to separate taxa. They are finely dentate in *N. diffusa*, wrinkled in *N. melanocarpa*, and with 10-20 small teeth in *N. caspica*. Most nutlets are

more or less hairy, therefore the absence or presence of hairs on nutlets is not useful as it has been used in some Floras. Nutlet characters can be used for identification only when they are ripe, also, not sufficient alone, but they should be used with other characters.

New combination

Nonea persica* Boiss. var. *suchtelenioides* (Riedl) Falatoury & Pakravan, **comb. nov.*

Syn.: *N. suchtelenioides* H. Riedl in *Wendelbo, Acta Univ. Bergensis Ser. Math. Nat.* 1962, 1: 37.

Typus: [Iran] Bakhtiari: Kuh Rang, *Wendelbo* 942, (BG.).

Specimen seen: Kerman: Kuh-e Hazaran, *Famouri* 5339-E.

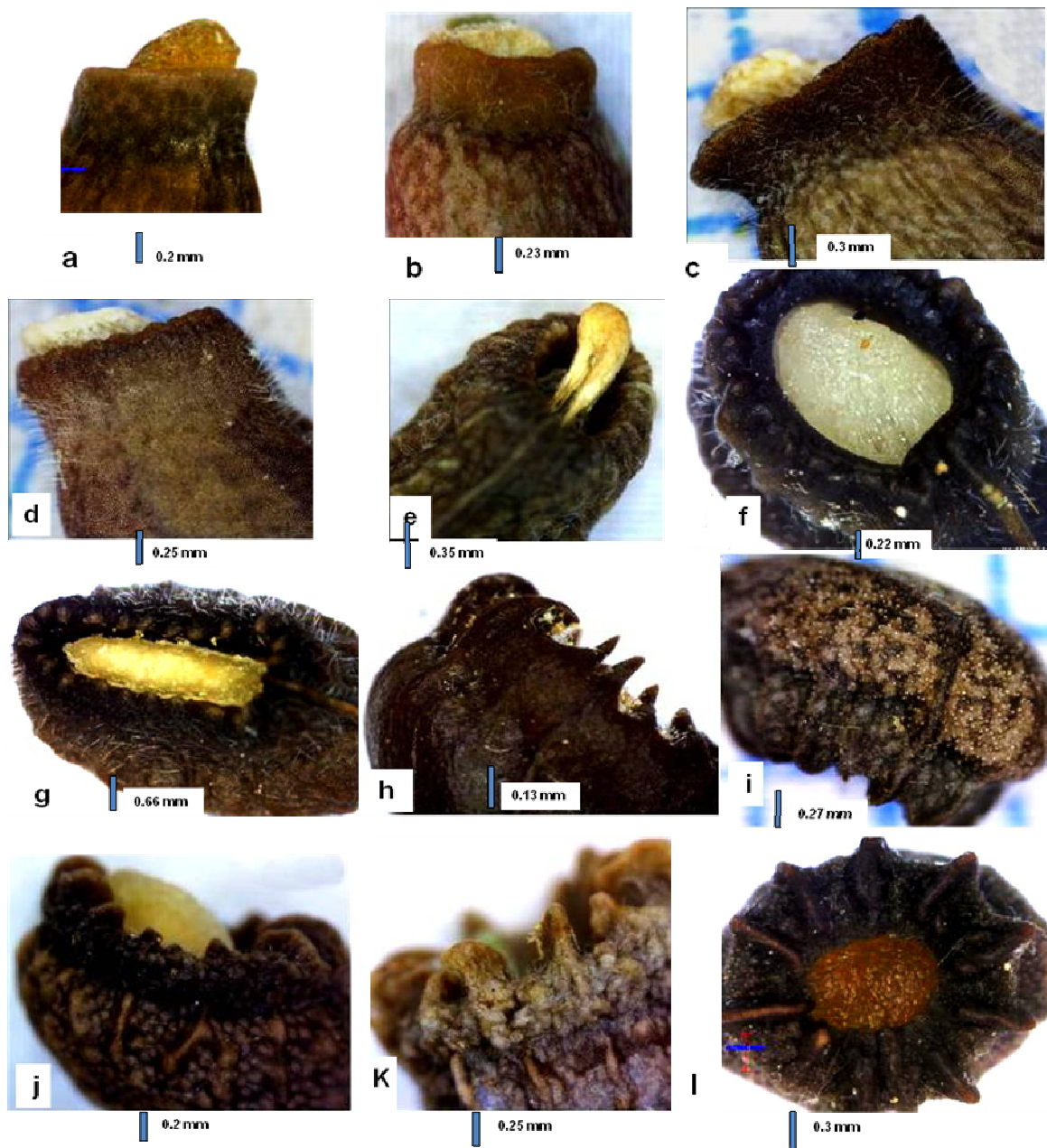


Fig. 2. Nutlet. (a) *N. lutea*. (b) *N. lutea* var. *flavescens*. (c) *N. rosea*. (d) *N. turcomanica*. (e) *N. anchusoides*. (f) *N. caspica*. (g) *N. melanocarpa*. (h) *N. diffusa*. (i) *N. stenosolen*. (j) *N. persica*. (k) *N. persica* var. *suchtelenioides*. (l) *N. pulla*.

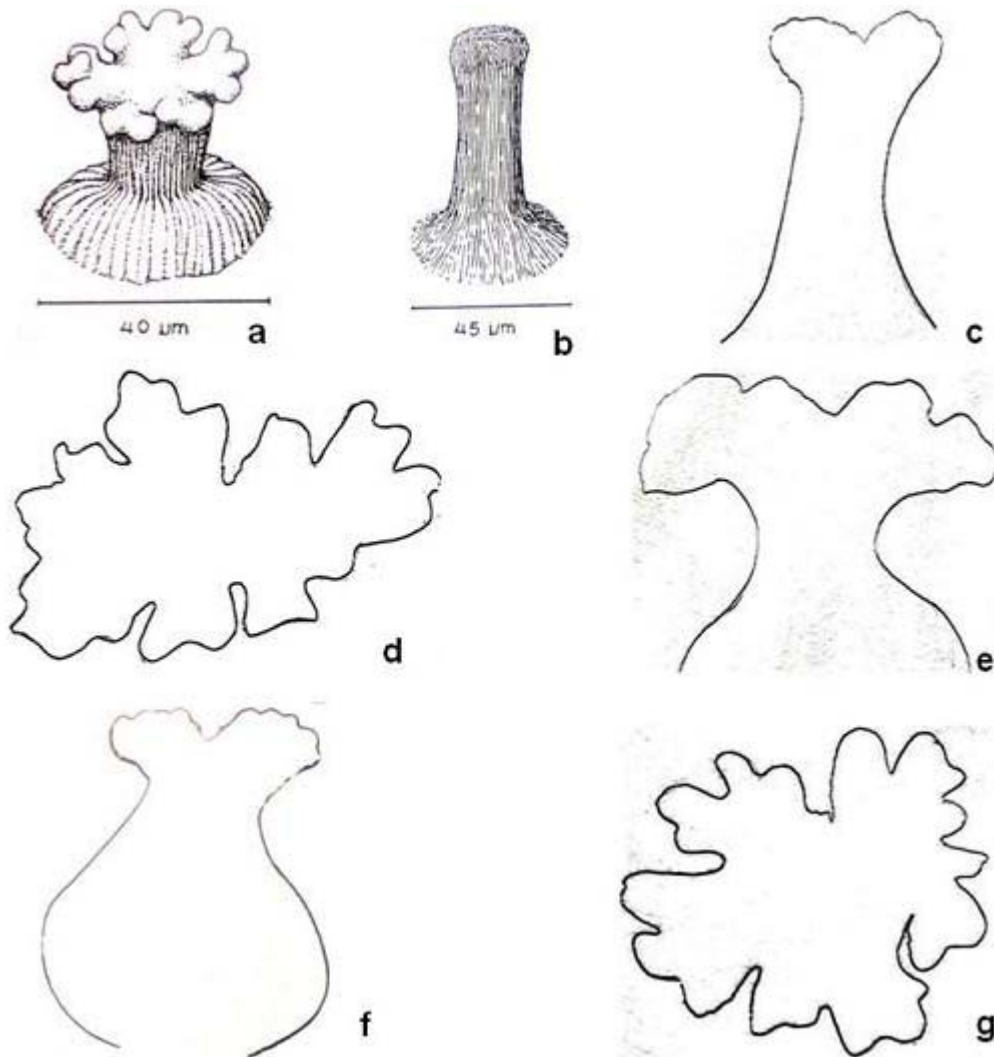


Fig. 3. Papillae. (a) *Pulmunaria-Anchusa* type. (b) *Nonea vesicaria* type (Bigazzi & Selvi 2000). (c) *N. lutea*. (d & e) *N. melanocarpa*. (f & g) *N. diffusa*. d & g) form of caps.

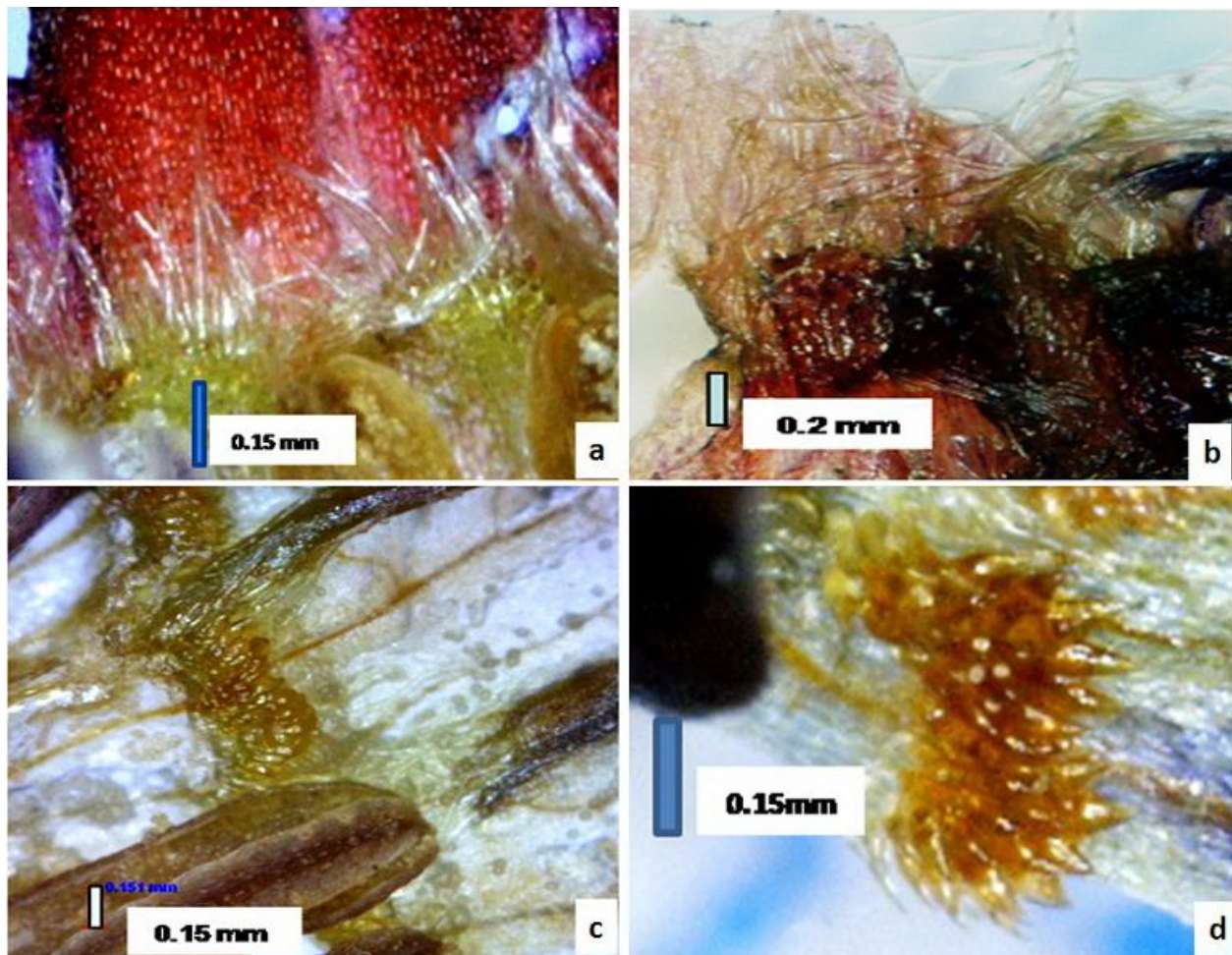


Fig. 4. Faucal scales. (a) *Nonea melanocarpa*. (b) *N. macrantha*. (c) *N. rosea*. (d) *N. persica*.

In this study it has been considered that differences of *N. suchtelenioides* Riedl and *N. persica* Boiss is not enough to separate them as two distinct species. The foregoing characters to separate *N. suchtelenioides* from *N. persica* in Flora Iranica (Riedl l. c.) are not useful. The two taxa differ in shape and density of fruting calyx and habit of stem. Fruiting calyx is larger and more sparse and stems are ascending-prostrate in *N. persica* var. *suchtelenioides*, whereas in *N. persica* var. *persica* fruting calyx is smaller and less sparse and the stems are erect or erect-ascending.

Changing ranks comparing to recent Floras

Nonea lutea (Desr.) DC. var. *flavescens* (C. A. Mey.) Lipsky. Fl. Kavk. (1899) 395.
Syn. *N. flavescens* (C. A. Mey.) Fisch. & C. A. Mey., Ind. Sem. Hort. Petrop. 17 (1835).

Typus: [Caucasia] in campis praesertim argilloso-salsis prope Sallian et lenkoran, 29 IV 1830, C. A. Meyer.

N. lutea and *N. flavescens* formerly known as distinct species (Khatamsaz 2002; Riedl 1967) do not have enough different characters to be distinguish as two distinct species. *N. flavescens* said to differ from *N. lutea* only in rarely branching stems and spatulate leaves. As these characters are not constant and there are minor differences on reproductive characters, they are treated as varieties of the same species here (see tables).

Nonea macrantha (H. Riedl) A. Baytop, Notes Roy. Bot. Gard. Edinburgh 35 (3): 299 (1977).

Syn.: *Nonea pulla* (L.) DC. subsp. *macrantha* H. Riedl, Öst. Bot. Zeitschr. 110: 531 (1963).

Typus: [Iraq] "*Nonnea armena* Boiss. et Huet // Kurdistan (Assyria orient), in montis Helgurd (ditionis Riwanduz), regione superior, 3000 m, 26 VI 1893", *J. bornmüller* 1629.

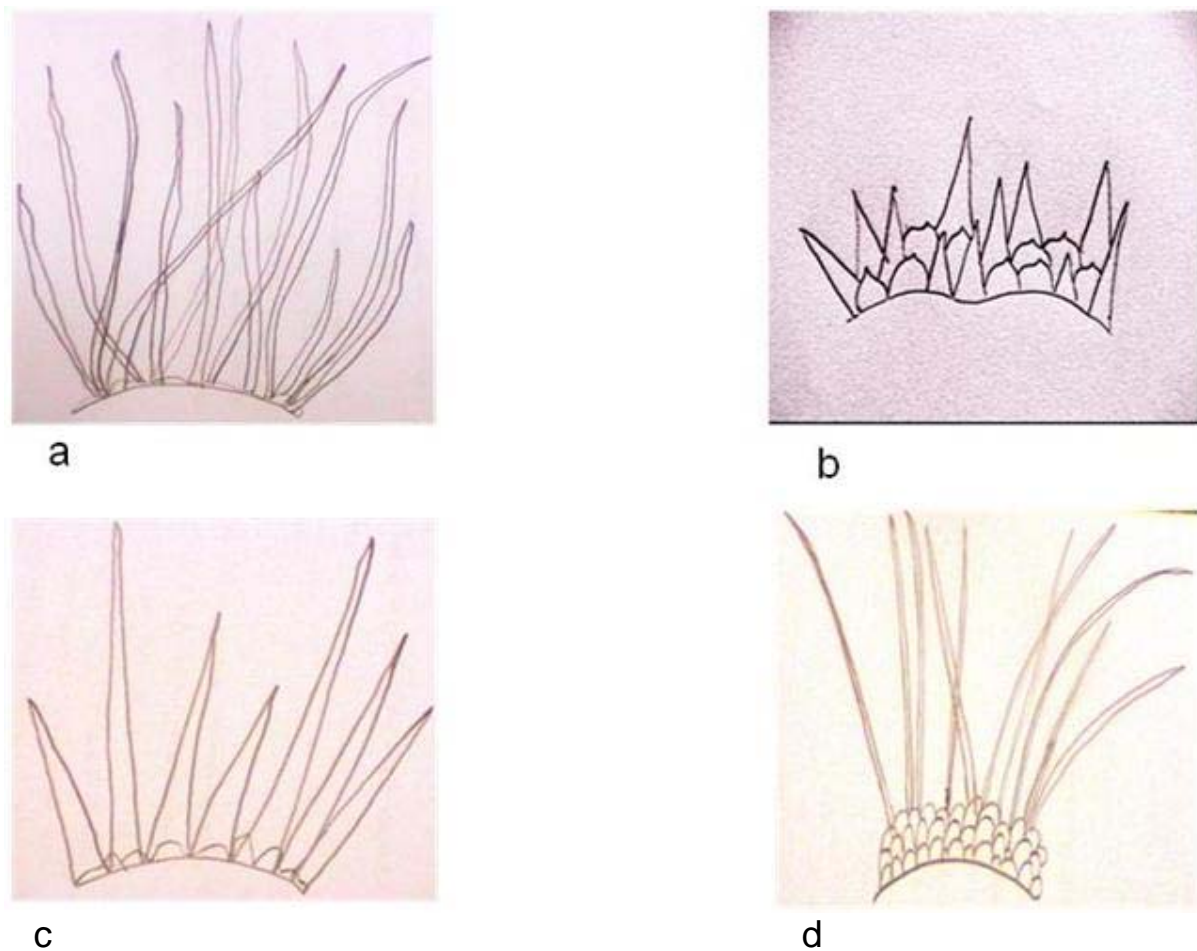


Fig. 5. Hairs of faucal scales. (a) long hairy in *N. anchusoides*, *N. macrantha*, *N. pulla* and *N. stenosolen*; (b) short, stiff hairs in *N. persica* and *N. persica* var. *suchtelenioides*; (c) hairy in other taxa; (d) Long-hairy & papillose in *N. rosea*.

N. macrantha was formerly treated as a synonym of *N. pulla* (Khatamsaz 2002) or as a subspecies of *N. pulla* (Riedl 1967) but our results showed that they bear enough differences on reproductive characters to distinguish them as distinct species (see tables).

Nonea diffusa Boiss. & Buhse, Mem. Soc. Nat. Mosc. 1860: 152 (1860).

Various herbarium specimens have been determined as *N. caspica* either in herbaria or in the literature which show a very wide range of characters in size and shape of stems, leaves, flowers and nutlets. The examination of many herbarium specimens as well as fresh materials in the field showed that they belong to two species, *N. caspica* with narrow root, orange-red flower, yellow throat of corolla and 10-20 small toothed nutlets, and those with fleshy root, big white-pink or blue-violet flower and finely dentate nutlets may be referable to *N.*

diffusa. In fact *N. caspica* is highly variable, already divided by Riedl (1967) to three subspecies. Obviously, further studies based on field observations of the distribution of whole complex, studies of type specimens and other data are needed to clarify taxonomic status of *N. caspica* complex.

Simplified key to *Nonea* species

- | | |
|---|--|
| 1. Nutlets erect | 2 |
| 1. Nutlets curved or semi-curved | 4 |
| 2. Flower yellow or white | 3 |
| 2. Flower red or violet | <i>N. rosea</i> var. <i>lutea</i> |
| 3. Plant small; leaf distinctly spatulate | <i>N. lutea</i> var. <i>flavescens</i> |
| 3. Plant large; leaf not spatulate | <i>N. lutea</i> |
| 4. Nutlets semi-curved | 5 |
| 4. Nutlets curved | 6 |

5. Annual; flowers yellow or white; scales hairy
N. turcomanica
5. Perennial; flowers bluish-violet
N. anchusoides
6. Annual 7
6. Perennial 9
7. Leaves oblong-lanceolate; flower purple, throat not yellowish; one type of papillae; nutlets with many wrinkles
N. melanocarpa
7. Leaves lanceolate-linear; flower orange-red, pink-white, blue-violet, throat yellowish or different from the limb; ± 2 types of papillae; nutlets dentate 8
8. Plant densely branched; flower orange-red (in dried specimen purple); nutlets medium size
N. caspica
8. Plant poorly branched; flower not orange-red; flowers and nutlets distinctly large; nutlets largely dentate
N. diffusa
9. Scales with stiff hairs 10
9. Scales densely long-hairy 11
10. Stem erect to erect- ascending; Inflorescence dense; fruting calyx not expanding
N. persica var. *persica*
10. Stem ascending-prostrate; inflorescence not very dense; fruting calyx expanding
N. persica var. *suchtelenioides*
11. Bracts very small and narrow
N. stenosolen
11. Bracts larger than calyx 12
12. Branched from base and above the middle; cauline leaves loose
N. pulla
12. Branched above the middle; cauline leaves dense
N. macrantha

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