

GAGEA ALEXII (LILIACEAE), A NEW RECORD FROM SUBNIVAL ZONE OF SOUTHERN IRAN WITH KEY AND NOTES ON SECT. INCRUSTATAE

YOUSEF AJANI¹, JALIL NOROOZI² AND IGOR G. LEVICHEV³

¹*Institute of Medicinal Plants (IMP), Iranian Academic Centre for Education, Culture and Research (ACECR), 55 km Tehran-Qazvin freeway, P.O. BOX 31375369, Karaj, Iran
E-mail: ajanisef@yahoo.com*

²*Department of Conservation Biology, Vegetation and Landscape Ecology, Faculty Centre of Biodiversity, University of Vienna, Rennweg 14, A-1030 Wien.
E-mail: noroozi.jalil@gmail.com*

³*Herbarium, Komarov Botanical Institute of the Russian Academy of Sciences, Prof. Popov Str. 2, Saint Petersburg 197376, Russia.
Email: ilevichev@yandex.ru*

Abstract

Gagea alexii Ali & Levichev (*G. sect. Incrustatae* Levichev) is recorded from the subnival zone of the southern mountains of Iran, the Hezar Mts. (Kerman province). Plant associates and some ecological aspects of the habitat of the species are discussed. A distribution map and expanded description of the *G. alexii*, including a cross-section of the peduncle is given. The morphological comparison of this species with its close relatives is also provided. The characters of the *G. sect. Incrustatae* and a key for specific identification are presented. The occurrence of this species in the subnival zone of the Hezar Mts. is a further evidence of the close floristic affinity of the southeastern Zagros with the Hindu Kush and Central Asia especially at high altitudes.

Introduction

Gagea Salisb. (Liliaceae) is a fairly large genus in Iran and its members show much variations in morphology. Several new species and records have been documented by various authors, therefore the number of species belonging to *Gagea* is increased to 35 in Iran (Assadi, 1988; Wendelbo & Rechinger, 1990; Akhiani, 1999; Levichev, 1999a; Zarrei & Zarre, 2005). However, Zarrei *et al.*, (2007), after some modifications, recognized only 26 species. We have strong grounds to believe that, there are many more taxa ($\pm$ up to 40) in Iran, some of which are not yet correctly named. According to Levichev (1999b) and Peterson *et al.*, (2008) the existence of any undescribed species of this genus in the southwest and Mediterranean region is almost certain.

Gagea alexii Ali & Levichev was described from northern Pakistan (Chitral, including boundary area with Afghanistan) and eastern Tajikistan (Ali & Levichev, 2007). This species was recently collected for the first time from the subnival zone of the Hezar-Lalehzar mountains, southern Iran (Kerman province) along with *Senecio subnivalis* Y. Ajani, J. Noroozi & B. Nord (Noroozi *et al.*, 2010).

G. alexii belongs to the *G. sect. Incrustatae* Levichev (Ali & Levichev, 2007). According to Wendelbo & Rechinger (1990), *G. circumplexa* Vved is the only species of this section present in Iran. However, recently Zarrei *et al.*, (2007) mentioned that it should be treated as synonym of *G. setifolia* Baker., but, *G. setifolia* is placed in the sect. *Platyspermum* Boiss. In this article, the separation and correct interpretation of *G. alexii* from widely distributed *G. setifolia* at low altitudes is discussed.

Material and Methods

Population of *G. alexii* has been surveyed in the summer 2009 in Hezar-Lalehzar Mts.: Iran, Kerman province, Rayen, at summit of Hezar mountain, on scree beds, 29°30'41"N, 57°16'23"E, 4455 m, 19 VII 2009, Y. Ajani, J. Noroozi 395. Morphological studies have been conducted on living plants. Vouchers are deposited in ACECR Herbarium- Acronym for the Central Herbarium of Medicinal Plants (Iranian Academic Centre for Education, Culture and Research. This herbarium is not indexed in Index Herbariorum). Morphological characters within the limits of *G. sect. Incrustatae* were repeatedly studied on living specimens in the nature and culture (Levichev, 1999b, 2002).

Result and Discussion

For the "Flora Iranica", the account of the genus *Gagea* was primarily prepared by P. Wendelbo (1927-1981), however, after the death of Wendelbo, it was finalized by Karl Heinz Rechinger (Wendelbo & Rechinger, 1990). Analysis of the texts and images clearly showed incorrect nomenclature of some taxa (expert's opinion I.G. Levichev); particularly concerning *G. setifolia*. In Kew (K), one of the syntypes bear the label: "Pakistan, Kurram valley, Ally Khel, [17 IV 1879] J.E.T. Aitchison n104", the label, is also signed by P. Wendelbo (04.1958), which he designates as lectotype of *G. setifolia*. However, this choice of the lectotype had never been published and consequently it was only indicated recently (Ali & Levichev, 2007: 54).

The specimen of lectotype *G. setifolia* (Aitchison n104, K) and the image published on Tab. 10 under name *G. setifolia* (Wendelbo & Rechinger, 1990), is of two different species from two different subdivisions of the genus, i.e.: for *G. sect. Platyspermum* and for *G. sect. Incrustatae* respectively. Features of the last taxon (mixed with attributes of *G. aitchisoniana* A.Terracc.) under name *G. setifolia*, appear in text on page 28 Flora Iranica: "... planta in sicco atroviridis.. ", "... folium basale... glabrum... ", "... tepala 3-4.5 mm lata... ". Such characteristics don't correspond with the specimen of *G. setifolia* in the specified lectotype. The plants of the lectotypus (Aitchison n104) are in a stage of flowering, but already have a yellow shade, all leaves and peduncle are incrustated along the longitudinal edges by a hard superficial collenchymas, narrow tepals of the perianthium are long pointed. Rigidity and a characteristic ribbing of all parts of a plant, sharp perianthium tepals, as well as fast loss of a green shade are all characteristic features of *G. sect. Platyspermum*.

Associations of *G. aitchisoniana* (and indirectly *G. alexii*) with *G. setifolia* begin with a combination of *G. setifolia* var. *aitchisoniana* (A.Terracc.) Pascher. Subsequently, *G. setifolia* has been considered having a restricted distribution to alpine mountains of the Pamir (Ikonnikov, 1963; Vvedensky, 1963: 222). Later on inaccurate information has increased because of its inclusion in *G. iliensis* M.Pop. (Vvedensky, 1971: 33). The diagram of this last species (Goloskokov, 1958, Tab. 11, fig. 9) does not correspond at all with the specimen "Aitchison n104". All of the above-stated facts compelled us to describe the high-altitude plants from Pamir and Pakistan under the name *G. alexii*.

The distribution of the species of *G. sect. Incrustatae* are disjunctive among the plains and mountains of the Irano-Turanian region, from Lake Balkhash up to Persian Gulf, and from Anatolia up to the Western Himalayas.

In view of the morphological features, *G. sect. Incrustatae* have a special position in the genus. In some representatives of this section, separate features of other genera of lily are present. For example in the genus *Tulipa*, there are a sharp crest in the bottom of a bulb, vertical stolons which are deepening, a grey, easily erased wax covering of an

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epidermis etc. are percent From this section 9 taxa are known, one of which (from range, Pamir-Alaj) to be studied in detail and for this reason it has not been included in the key (given below).

All representatives of the genus including this section the ontogeny consists of annually replaced shoots. Each shoot develops in two years and forms cyclic annual roots (Levichev, 1999a, 2001a; 2001b). In the first cycle from the bottom scale, roots and one bud are formed from which the shoot in the second cycle develops. Roots of the first cycle usually have species-specific value. Quite often, these roots are ageotropically focused, strongly incrassate and also are very rigid. It is highlighted by scalarified roots especially in *G. circumplexa*. After dying off scalarified roots remain intact for several years. Besides mechanical protection of a bulb, empty, thick-walled cells of these roots (Levichev, 1999a, fig. 5), keep an additional stock of moisture. In other species, roots of the first cycle, are also focused geotropically and neither they differ in thickness nor from the roots of second cycle.

Features of the basal leaf and peduncle, also possess an interesting specificity. An illustration of the cross-section forms in the genus *Gagea* has been used for the first time for a basal leaf in *G. lutea* (L.) Ker Gawl. (Oeder, 1768, Tab. 378) and for a peduncle in *G. spathacea* (Hayne) Salisb. (Müller, 1775, Tab. 612), and also, as an evident distinctive indication that there are other species of *Gagea* in Sicily (Lojacono, 1909, Tab. 7, 8, 10). The form and anatomical characters of the leaf and peduncle are recognized as important and reliable taxonomic criteria for the differentiation of sections of the genus (Davlianidze, 1976: 23-24; Levichev, 1982a: 18). For this reason, images showing the features of epidermis, collenchyma, bundles, fistulas etc. may indicate a new species (Levichev, 1981, 1982b, 2001, etc.; Krasovskaya & Levichev, 1986; Peruzzi *et al.*, 2007; Ali and Levichev, 2007; Hamzaoglu *et al.*, 2008; 2010, etc.). With similar analytical species diagram (Levichev, 2002: 232) it is preferable to refer as well publications of surveys (Levichev, 1997; Peruzzi *et al.*, 2008, etc.). The form of a peduncle is especially specific. As it is established, that the second basal leaf (as well all others leaves in an inflorescence) accretes with a peduncle from the basis up to an inflorescence and functions as the lower floral leaf (Levichev, 2001a: 8, 32, Tab. 8, fig. 8, 16-20; 2001b). Accretion forms a dissymmetric and the specific configuration of the transverse section of the peduncle.

In addition to what has already been published (Levichev, 1990; Peterson *et al.*, 2008) herewith a detailed description of sect. *Incrustatae* is presented.

Plants are smooth, elastic, soft, dark and blue-green, often with wax for a short time (bloom). The vegetative reproduction is known only in *G. balchaschensis* M.Pop. Deepening of a bulb during seed reproduction occurs by means of geotropic stolon which at a young age annually lowers a replacement bulb to a greater depth (*G. incrustata* Vved., *G. iliensis*). Basal leaf always one, unifacial type, on cross-section roundish, often fistulose, with a ring arrangement of vascular bundles, *G. incrustata* and *G. iliensis* have it in 1/4 - 1/2 accretes with a peduncle, in other species it is free. Second basal leaf always accretes with a peduncle, resulting in a partially or completely enveloped peduncle in a circle, and is separated by means of the lower floral leaf. Peduncle smooth, in cross-section roundish or unsymmetrically roundish with a ring arrangement of vascular bundles. Inflorescence 1-3 (-4) flowered, umbrella-shaped, leaves and pedicles are collected in a verticil. Sometimes for old and large specimens, the lower floral leaf is located below a common verticil, the smallest leaves may be present on pedicles. Pedicles often shorter than a perianth and straight. Capsule spherical; seeds thin-flat, with a small arillus on the chalazal end, easily dispersed by the wind.

Key for the Identification of species belonging *G. sect. Incrustatae*

- 1 + Tunics of the bulb continue to a well pronounced long neck.....2
 - Tunics of the bulb without or with a very short neck.....5
- 2 + Neck coriaceous, parchment-like, in the form of the whole or disrruptate tube; a basal leaf in cross-section roundish, with lateral flattening along the top.....3
 - Neck fiber-like, splitting in the filament; plants very small, 1-2 flowered; a vegetative bulbil semi teardrop-like with its own short sclerified roots; the internal tepal widely rounded..... *G. balchaschensis* M.Pop. 1936, in sched.
- 3 + Tunics of bulb not hidden under roots; pedicles shorter than a perianth; the base of the bulb with downwards focused crest..4
 - Tunics of bulb hidden under a dense braiding from the thick, ageotropically focused sclerified roots; basal leaf with a small central fistula and the poorly-concave ventral surface; tepals elliptic; pedicles 1.5-2 times longer than tepals.....
*G. circumplexa* Vved. 1952, Not. Syst. (Tashkent), 13: 28.
- 4 + Tunics of bulb thickly coriaceous, covered by the comb-type ledges; the first basal leaf without a fistula, accretes with a peduncle up to level of soil.....
*G. incrustata* Vved. 1941, Fl. Uzbekist. 1: 542, 416.
 - Tunics of bulb smooth, thickly coriaceous, splits longitudinally; tepals widely elliptic; first basal leaf with a small fistula in the center, on 1/4 accretes with the peduncle.*G. iliensis* M.Pop. 1936, Bull. Kazakh. Gosud. Univ. 1: 93, fig.
- 5 + Flowers narrowly bell-shaped; tepals narrowly-lanceolate; 4-5 leaves at the base of the inflorescence.....6
 - Flowers widely bell-shaped on short pedicles; tepals widely elliptic, rounded at top (in the end of flowering their tips are convolute and seem acute, 2-3 leaves at the base of the inflorescence. The bulb with very plentiful thin roots and is often greatly disproportionate. *G. aitchisoniana* A.Terracc., 1904, Boll. Soc. Ort. Palermo, II, fasc. 4: 5. (*G. setifolia* var. *aitchisoniana* (A.Terracc.) Pascher, 1905. Repert. Sp. Nov. Regni Veg., 1: 193.....*G. setifolia* sensu Wendelbo et Rech.f. 1990, p. p.)
- 6 + Basal leaf long, in 1.5-2 times exceeding the inflorescence; alpine plants.....7
 - Basal leaf does not exceed inflorescence; pedicles are in different length, the longest are 2-3 times longer than a perianth, tepals linearly extended; plants of lower altitude.....*G. luteoides* Stapf, 1885, Denkschr. Acad. Wien, 50, 2: 80.
- 7 + Tepals elongated-lanceolate, pointed at top; pedicles of different lengths, shorter or are equal to tepals; lower leaf present at the base of inflorescence is lanceolate and proportional to an inflorescence.....*G. alexii* Ali et Levichev, 2007. Fl. Pakist. 215: 57, fig. 17, C-H (*G. setifolia* sensu Wendelbo et Rech.f. 1990, p. p.)
 - Tepals (especially internal) rounded at top; pedicles in 1.5-2 times longer than perianth; the lower leaf of the inflorescence narrow, exceeding the inflorescence*G. kopetdagensis* Vved. 1932, in Fl. Turkmen. 1, 2: 260.

The original description of the *G. alexii* in Flora of Pakistan is deficient in the features of fruits (Ali & Levichev, 2007). In this paper, additional characters are given, including the dimension, texture and shape of peduncle, seed, and fruitcase, which are described and illustrated (Figs. 1 & 2).

Gagea alexii Ali et Levichev

Holotype: Chitral, N Pakistan., J.D.A . Stainton 2847(BM)

Plants single, (8-)10-15 cm, smooth, blue-green. Bulb 8-10 (-13) mm in diameter, oviform, covered by greyish-brown, thin-coriaceous, continued in a fiber-like neck (0.5-1 cm long) tunics, without thickened *sclerified* roots. Generative specimens without bulbils. Peduncle 3-11 cm long, in cross-section pressed-roundish, about 2-3 mm in diameter (Fig. 2A & B). Basal leaf single, up to 13 (-17 cm), curved, linear (circular in fresh, pressed in dried), almost twice exceeding the inflorescence, 1-2 mm broad, in cross-section roundish, with little concave ventral surface (Fig. 1A). Leaves on peduncle 2-3(-5), in whorl; lower are equal or are longer inflorescence, narrowly-lanceolate, 2-3 (-4) mm broad, gradually pointed, in cross-section keel-shaped, upper diminishing (Fig. 1A & B). Inflorescence 1-3 (-5)-flowered; umbrella-shaped, pedicles equal or unequal, extended, 0.5-20 mm long. Tepals narrowly-lanceolate, 8-15 mm long, elongating at anthesis, 0.9-1.7 (-3) mm broad, inside pale yellow, outside green, internal palea-bordered, little shorter and already than external, at apical parts pointed at hooded tip. Anthers brownish (yellow), linear (3 mm long), dehiscence oblong (about 1.7 mm long). Ovary narrowly-oval. Capsule in fruiting spherical, 9-10 mm, glabrous, green or greenish magenta. Seeds thin-flat, triangular, 3×2.5 mm, yellow, glossy, rugo-faveolate (Fig. 1C).

General distribution: E Tajikistan, N Pakistan and S Iran. Presence in E Afghanistan is probable (Fig. 3A).

In drawing 2A the cross-section of a peduncle at 4 cm above a bulb is represented. Epidermis I- layered, covered by cuticle. Followed by 3-4 layered hypodermis. Vascular bundles 13, on the periphery forming an incorrect ring, phloem usually roundish, conic xylem, both are surrounded by sclerenchyma. Central parts including only spongy with sclerenchyma. Cross-section of a peduncle 2-3 mm above a bulb. Epidermis 2 layered, covered by cuticle. Vascular bundles completely 11, a ventral surface (concerning a dorsal rib accreting with a peduncle of the second basal leaf) a little concave (Fig.2B).

The close relatives of *G. alexii* are *G. aitchisoniana*, *G. luteoides* and *G. circumplexa*. All these species are placed in *G. sect. Incrustatae*. Two later species are distributed in Iran (Assadi, 1988; Wendelbo & Rechinger, 1990). Although, *G. luteoides* has been recorded from northwest Iran, Arasbaran protected area, but it has been reduced to the synonymy of *G. liotardii* (Sternb.) Schult. et Schult. f. (Assadi 1988; Zarrei *et al.*, 2007)². These problems demand special and separate studies. In this paper, we have accepted *G. luteoides* and *G. circumplexa* as distinct species for flora of Iran.

G. alexii differs from *G. aitchisoniana* in having narrow and pointed tepals. In this species the breadth of tepals is 0.9-1.7 mm and apical parts are pointed, but in *G. aitchisoniana* they are broader and seem to be pointed. *G. alexii* differs from *G. circumplexa* by the absence of thick sclerified roots. This species differs from *G. luteoides* by the short pedicels and a long basal leaf, which are 0.5-2 mm, 10-15 cm in *G. alexii* and 15-30 mm, 6-12 cm in *G. luteoides*, respectively.



Fig.1. *Gagea alexia*: at 4455 m a.s.l. on 20 July 2009. B. Umbel-like inflorescence with capsule and upper leaves. C. Seeds.

According to the approach of Braun-Blanquet (1964), a phytosociological relevé site (100 m²) was sampled in the habitat of *G. alexii* and some ecological characteristics of the habitat were also recorded (Table 1)

Hezar-Lalehzar Mts. are isolated mountains in southern Iran, Kerman province. These mountains are botanically less known with a high rate of endemic species, especially in high altitudes (Noroozi *et al.*, 2010). Recently, some local endemic species like *Senecio eligulatus* B. Nord., Moussavi & Djavadi, *Ferula hezarlalehzarica* Ajani & S. subnivalis Y. Ajani, J. Noroozi & B. Nord., are described from high altitudes of these mountains (Nordenstam *et al.*, 2002; Ajani & Ajani, 2008; Noroozi *et al.*, 2010).

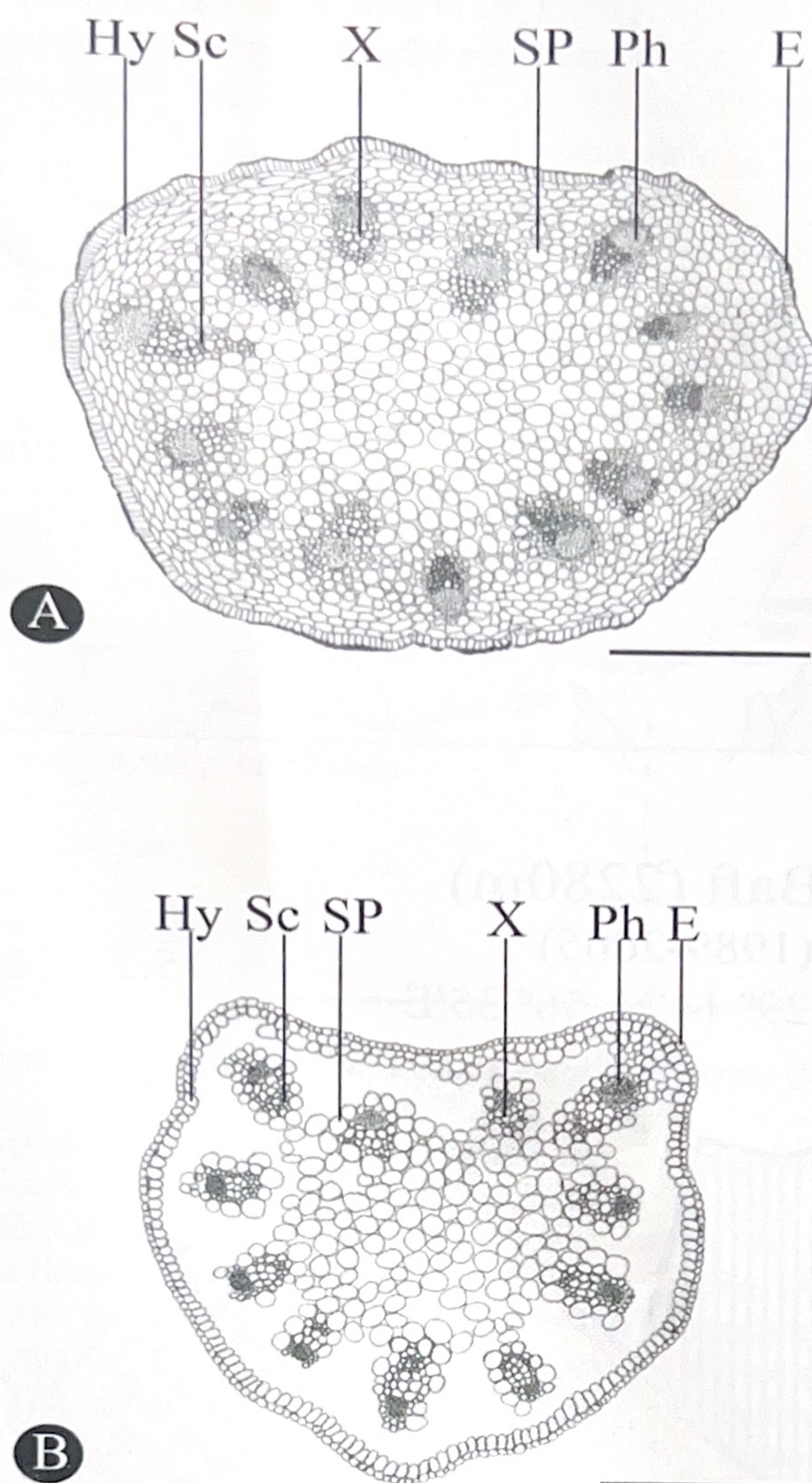


Fig. 2. *Gagea alexii*: Diagrammatic transvers sections of peduncle. A. 4 cm above bulb; B. 2-3 mm above bulb; Sc - sclerenchyma; SP - spongy parenchyma; X - xylem; Ph - phloem; BS - vascular sheath, E - epidermis; Hy - hypodermis. (Scale bars - 1 mm).

Assadi 1988; Zarrei *et al.*, 2007, accepted the *G. fistulosa* (Ramond ex DC. in Lam. et DC.) Ker Gawl. which according to Articles 34.1a, c and 52.1 ICBN is incorrect in relation to name *G. liotardii* (Sternb.) Schult. et Schult. f. See Levichev, 2006: 942.

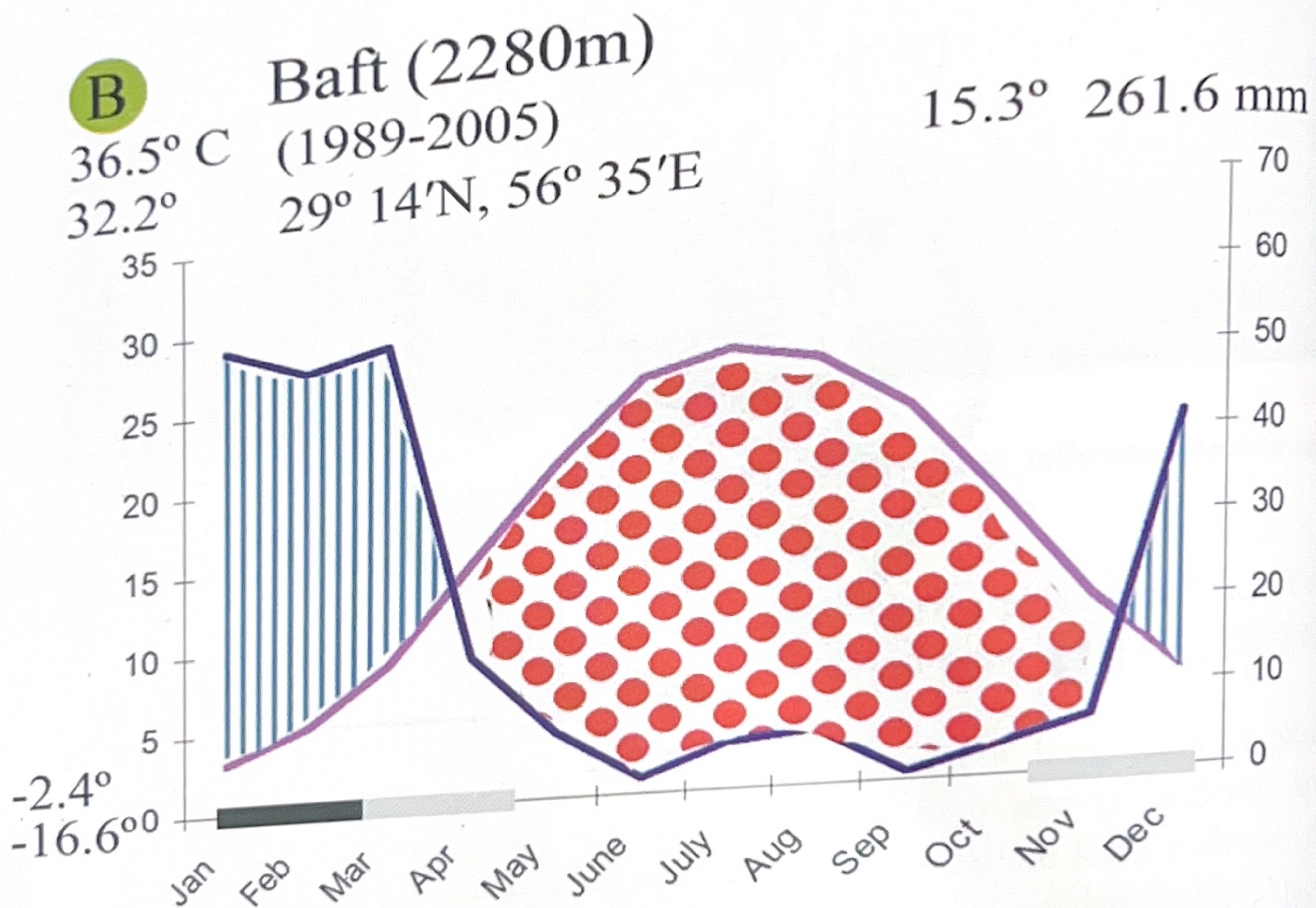
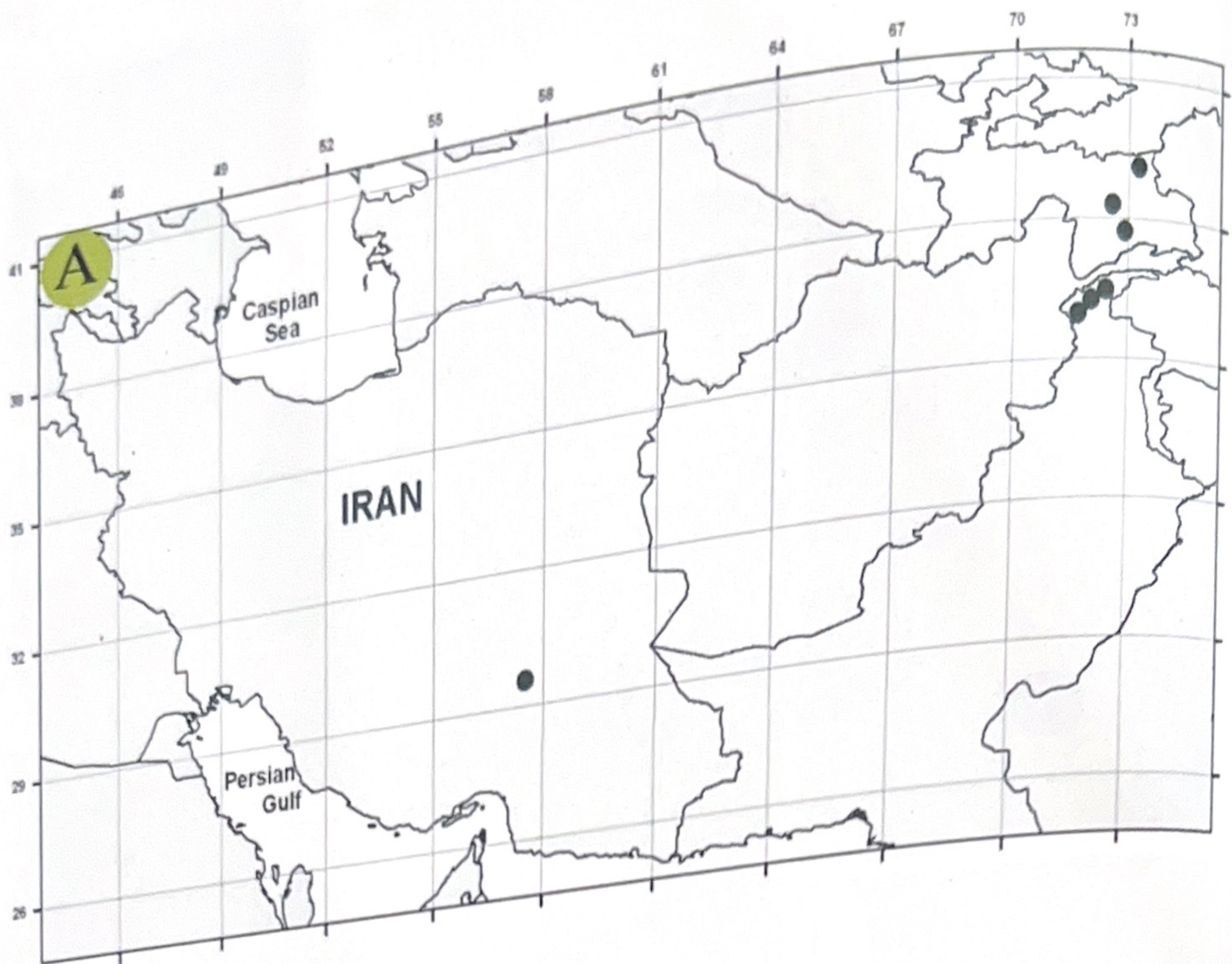


Fig. 3. A. Distribution map of *Gagea alexii*; B. The climate diagram of Baft meteorological station for 1989-2005: 29° 14'N, 56° 35'E, 2280 m Mean annual precipitation 261.6 mm, Mean annual temperature = 15.3°C, Absolute maximum temperature = 36.5°C, Mean daily maximum of the hottest month = 32.2°C, Monthly means of precipitation = dark blue line, Monthly means of temperature = pink line, Humid period = blue shading, Arid period = red circles, Mean daily minimum temperature of the coldest month = -2.4°C, Absolute minimum temperature = -16.6°C, Months with a mean daily minimum temperature below 0°C = black line, Months with an absolute minimum below 0°C = grey line.

Table 1. Species composition of the *Artemisia persica* community (habitat of *Gagea alexii*) based on one phytosociological relevé from subnival zone of Hezar mountains, northern slope of the highest peak. The symbols show cover-abundance of each species according to the method of Braun-Blanquet (1964), where 1 = <5% [or over 50 small plants or 1-5 large plants], += <1% [1-5 small plants].

Relevé	1
Coordinates:	29°30'41"N 57°16'23"E
Sample area (m ²)	100
Inclination (°)	20
Altitude (m)	4455
Aspect	NE
Vascular plants (%)	5
Scree (%)	92
Solid rock (%)	2
Bare ground (%)	1
Litter (%)	-
Species	
<i>Artemisia persica</i>	+
<i>Asperula glomerata</i> subsp. <i>condensata</i>	+
<i>Nepeta lasiocephala</i>	1
<i>Astragalus melanodon</i>	1
<i>Potentilla nuda</i>	1
<i>Scrophularia subaphylla</i>	+
<i>Gagea alexia</i>	+

Associate species: *Artemisia persica* Boiss., *Asperula glomerata* (M. B.) Griseb.

Subsp. *condensata*, *Nepeta lasiocephala* Benth., *Astragalus melanodon* Boiss., *Potentilla nuda* Boiss. and *Scrophularia subaphylla* Boiss. The main percentage of ground is covered with scree (ca. 92%) and vegetation cover is low (ca. 5%). The dominant species of this zone in Hezar-Lalehzar mountains is *Artemisia persica* (Fig. 1A; Table 1).

The floristic relationship and close affinity of the southeastern Zagros with Hindu Kush and Central Asia especially in high altitudes was discussed previously (Hedge & Wendelbo, 1978; Noroozi *et al.*, 2008 & 2010). Disjunct distribution of *G. alexii* in upper limit of vascular plants in Hezar mountains (above 4455m) is another evidence of this type of distribution pattern (Fig. 3). The occurrence of *G. alexii* in Hezar mountains above 4455m is the highest known record of this genus. Since the habitat of this species is too narrow and is limited to upper zone of this mountain and also because it is endangered by several factors due to the occurrence of many local endemics (Noroozi *et al.*, 2010), therefore serious efforts for conservation and protection of these endangered by several factors mountains are strongly suggested.

Conclusions

Both the descriptions and the images of *G. setifolia* in Flora Iranica are incorrect. The description is attributed to *G. aitchisoniana* (et p.p. *G. alexii*), image - *G. alexii*. The

type of specimen (Aitchison n104, Lectotype, K) determined by Per Wendelbo as *G. setifolia* belongs to *G. sect. Platyspermum*. Our field expeditions to the Hezar mountain S revealed the occurrence of *G. alexii* (*G. sect. Incrustatae*) at the higher altitudes of Iran. This record is the highest altitude known today for this genus. The presence of this species in the subnival zones of the Hezar Mts. is further valid evidence of the close floristic affinities of Hezar-Lalehzar Mts, isolated mountains in southeastern Zagros, with the Hindu Kush and Central Asia especially in high altitudes. The habitat of *G. alexii* is so narrow, and endangered by several factors, that the serious conservation efforts of this area is strongly suggested.

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