Taxonomic Rearrangement of *Arenaria* (*Caryophyllaceae*) in Indian Western Himalaya

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The genus *Arenaria* L. (*Caryophyllaceae*) in the Indian Western Himalaya is studied in detail and rearranged. Three genera, namely *Dolophragma* Fenzl, *Eremogone* Fenzl and *Odontostemma* Benth. ex G. Don, which were previously treated as subgenera under the genus *Arenaria*, are here recognized as distinct genera and corresponding species of *Arenaria* are transferred to them. As concluded in phylogenetic studies, subgenus *Eremogoneastrum* Fenzl is treated as a part of the genus *Eremogone* and new combinations are proposed for eight western Himalayan taxa transferred here under the genus *Eremogone*. Species hitherto treated in *Arenaria* subgenus *Arenaria* are retained as it is, except the sole representative of section *Compressae* McNeill, which is shifted under a newly described monotypic genus *Himgiria*. Similarly, three species hitherto under *Arenaria* subgenus *Solitaria* McNeill now form part of newly described Sino-Himalayan genus *Shivparvatia*. A key to the genera of *Arenaria* and its allies reported from Indian western Himalaya is also provided.

**Key words**: *Arenaria*, *Caryophyllaceae*, *Dolophragma*, *Eremogone*, Himalayas, *Himgiria*, India, new combinations, new genus, *Shivparvatia*.

Recent phylogenetic evidence concludes the genus *Arenaria* is polyphyletic, resulting in a new lineage-based classification of the family *Caryophyllaceae* by Harbaugh et al. (2010) and character evolution of the family as presented by Greenberg and Donoghue (2011), various sub-groups of ‘the Himalayan *Arenaria* Group (sensu McNeill 1962)’ occurring in Indian western Himalayan territory were studied in detail. Field and herbarium (BSD, CAL, DD) studies were followed by literature review (Edgeworth and Hooker 1874, Williams 1895, 1898, Murav’eva 1936, Schischkin 1936, McNeill 1962, Walters 1964, Ikonnikov 1976, Hara and Tebbs 1979, Grierson 1984, Ghazanfar and Nasir 1986, Majumdar 1993, Lu et al. 2001, Wu et al. 2001a, 2001b, Hartman et al. 2005, Rabler and Hartman 2005, Singh and Diwakar 2010, Harbaugh et al. 2010, Greenberg and Donoghue 2011, Dillenberger and Kadereit 2014). Furthermore, each sub-group is restudied by taking into consideration the qualitative importance of currently accepted character set for generic delimitation, particularly for *Arenaria* L. and *Eremogone* Fenzl as accepted in Flora of the North America by Hartman et
al. (2005, http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=111940). Due to lack of field and herbarium studies, species from Indian central (Sikkim) and India’s eastern Himalayan region are not included in the present study. In view of the fact that two new genera are proposed here, a key (Key 1) to genera of the Arenaria Group (sensu McNeill, 1962) reported from the Indian Western Himalayan region is appended. Figure 1 showing images of some representative species is also included for comparison. Wherever essential, particularly for the species under newly described genera, instead of repeated redrawing of the illustrations here, references to published detailed illustrations are provided. Conclusions of the study are presented as follows.

Taxonomic treatment

1. *Arenaria* subgen. *Eremogoneastrum* F. N. Williams


In a phylogenetic study (Harbaugh et al. 2010) the members of *Arenaria* subgenus *Eremogone* (Fenzl) Fenzl along with *Arenaria* subgenus *Eremogoneastrum* F. N. Williams branch out as a separate clade (Harbaugh et al. 2010, fig. 1–2, clade C) from the rest of *Arenaria* (Harbaugh et al. 2010, fig. 1–2, clade B1). This clade is now recognized as a new tribe *Eremogoneae* Rabler & W. L. Wanger (Harbaugh et al. 2010, p. 196) based on the type genus *Eremogone*, whereas the remainders are treated as tribe *Arenariaceae*. This split in *Arenaria* and the recognition of the generic name *Eremogone* is adopted in Flora of North America and all the species formerly under subgenus *Eremogone* along with North American species under subgenus *Eremogoneastrum* have been presently transferred and accepted under the genus *Eremogone* (Hartman et al. 2005, http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=111940). This distinct clade formation of *Eremogoneae* is also supported by another recent phylogenetic analysis of Caryophyllaceae by Greenberg and Donoghue (2011, fig. 1A, 1B). Notably, in a redefined circumscription of *Minuartia*, Dillenberger and Kadereit (2014) not only accepted *Eremogone* as a distinct genus, but to make it monophyletic they suggested its expansion by proposed transfer of the members of *Minuartia* subgen. *Spergella* (Fenzl) McNeill to *Eremogone*. Considering these phylogeny evidences in support of the generic delimitation between *Arenaria* and *Eremogone* and character set used to define tribe *Eremogoneae* (Harbaugh et al. 2010), the placement of the Himalayan species of *Arenaria* subgenus *Eremogoneastrum* characterized by caespitose or pulvinate habit; subulate or linear, spine-tipped, persistent leaves with scarious margins; sub-perigynous flowers and lanceolate-acuminate, broadly scarious-margined, prominently veined sepals is more justified into the genus *Eremogone*.

The fact that the said phylogenetic analysis included two Himalayan members of subgenus *Eremogoneastrum*, viz., *Arenaria bryophylla* and *A. kansuensis*, both falling in the distinct *Eremogone* clade, strongly support the placement of Himalayan members of *Eremogoneastrum* in the genus *Eremogone* instead of *Arenaria*, s.s. Following these results, Dillenberger and Kadereit (2014) transferred Sino-Himalayan *A. kansuensis* under *Eremogone* as *E. kansuensis* (Maxim.) Dillenb. & Kadereit. The transfer and subsequent new combinations are proposed here for the following Indian Himalayan species.

*Eremogone bryophylla* (Fernald) Pusalkar & D. K. Singh, *comb. nov.* [Fig. 1b]


Distribution: India [Jammu & Kashmir to
Sikkim], China, Nepal.

**Eremogone curvifolia** (Majumdar) Pusalkar & D. K. Singh, **comb. nov.**

_Arenaria curvifolia_ Majumdar in Blumea 26: 446, f. 1a–h (1980).

Distribution: India [Uttarakhand (Chamoli: Kuari pass and east of Dakwani)]. Endemic.

**Eremogone edgeworthiana** (Majumdar) Pusalkar & D. K. Singh, **comb. nov.**


Distribution: India [Sikkim], Bhutan, China, Nepal.

**Eremogone ferruginea** (Duthie ex F. N. Williams) Pusalkar & D. K. Singh, **comb. nov.**


Distribution: India [Uttarakhand (Kumaon)]. Endemic.

**Eremogone festucoides** (Benth.) Pusalkar & D. K. Singh, **comb. nov.**

_Arenaria festucoides_ Benth. in Royle, Ill. Bot. Himal. Mts. 1: 81, pl. 21, f. 3 (1834).

Distribution: India [Jammu & Kashmir to Uttarakhand], China, Pakistan.

**Eremogone festucoides** var. _imbricata_ (Edgew. & Hook. f.) Pusalkar & D. K. Singh, **comb. nov.**


Distribution: India [Jammu & Kashmir, Uttarakhand], China.


Distribution: India [Himachal Pradesh, Uttarakhand], Bhutan, China, Nepal.

**Eremogone kumaonensis** (Maxim.) Pusalkar & D. K. Singh, **comb. nov.**

[Fig. 1d] _Arenaria kumaonensis_ Maxim., Fl. Tangut.: 86 (1889).

Distribution: India [Himachal Pradesh, Uttarakhand], China, Nepal.

**Eremogone pulvinata** (Edgew.) Pusalkar & D. K. Singh, **comb. nov.**

_Arenaria pulvinata_ Edgew. in Hook. f., Fl. Brit. India 1: 238 (1874).

_Arenaria polytrichoides_ Edgew. var. _perlevis_ F. N. Williams in J. Linn. Soc. Bot. 33: 405 (1898).


Distribution: India [Sikkim], Bhutan, China, Nepal.

2. **Arenaria** subgen. **Eremogone** (Fenzl) Fenzl

_Arenaria_ subgen. **Eremogone** (Fenzl) Fenzl, Fl. Ross. 1: 360 (1842).

Accepted here as: **Eremogone** Fenzl. in Vers. Darstell. Alsine: 13, pl. [p. 18] (1833).

A single species of this subgenus reported from the Indian Western Himalayan territory is _Arenaria griffithii_, and so far treated under _Arenaria_ section _Sclerophyllae_ (Boiss.) McNeill (McNeill 1962, p. 126). The species shows typical _Eremogone_ characters and since the phylogenetic studies (Harbaugh et al. 2010, Dillenberger and Kadereit 2014) supported the recognition of distinct genus _Eremogone_ as explained above, its correct placement under the genus _Eremogone_ is as follows.


_Arenaria griffithii_ Boiss., Diagn. Fl. Orient.
Distribution: India [Jammu & Kashmir: Karakoram and Ladakh], Afghanistan, China, Kazakhstan and Pakistan.

3. *Arenaria* subgen. **Dolophragma** (Fenzl) McNeill


Accepted here as: *Dolophragma* Fenzl in Ann. Wiener Mus. Naturgesch. 1: 63 (1836).

Two species reported from the Indian Himalayan region (Majumdar 1993); *Arenaria polytrichoides* Edgew. [in Hook. f., Fl. Brit. India 1: 237 (1874)] and *A. densissima* Wall. ex Edgew. & Hook. f. [in Hook. f., Fl. Brit. India 1: 239 (1874)] belong to *Arenaria* subgen. *Dolophragma* (Fenzl) McNeill (McNeill 1962). There is some disagreement about the species rank of *A. densissima*, for which varietal status under *A. polytrichoides* is suggested by some authors (Hara and Tebbs 1979, Singh and Diwakar 2010). Of these, only one, *A. polytrichoides*, is reported from Indian western Himalaya. This subgenus differs from *Arenaria*, s.s. in pulvinate or densely caespitose habit; imbricate-tetrastichous (in *A. polytrichoides*), persistent leaves showing hardened leaf margins and leaf apex, and inconspicuously veined sepals. In habit, it shows similarity with currently delimited tribe *Eremogoneae* and hence until further conclusive phylogeny evidence is found, its placement in the parental genus *Dolophragma* rather than *Arenaria*, s.s. (where it is a clear misfit) seems more justified and hence accepted as follows.

**Dolophragma polytrichoides** (Edgew.) Pusalkar & D. K. Singh, **comb. nov.**


Distribution: India [Himalaya: Sikkim, Himachal], Bhutan, China and Nepal.

4. *Arenaria* subgen. **Odontostemma** (Benth. ex G. Don) F. N. Williams


Accepted here as: *Odontostemma* Benth. ex G. Don, Gen. Hist. 1: 449 (1831).

A natural group of about 30 species (McNeill 1962, p. 129) characterized by 2-carpels [styles two], capsule opening by four valves or teeth, truncate calyx with obscurely veined, broadly membranous-margined sepals, saccate at base; seeds without cell-like markings, non-setaceous leaves and petals retuse, emarginate or fimbriate at apex. Phylogenetic study supported the recognition of *Odontostemma* as a distinct genus (Harbaugh et al. 2010: 195). Only the type species is reported from the Indian western Himalayan region:

**Odontostemma glandulosum** Benth. ex G.
Don, Gen. Syst. 1: 449 (1831).


Distribution: India [Uttarakhand, Sikkim], Bhutan, China, Nepal.

5. *Arenaria* subgen. Solitaria McNeill


A small, yet a very distinctive group, correctly assembled by McNeill (1962) under *Arenaria* subgenus Solitaria McNeill (1962). This group is characterized by dwarf, laxly caespitose high-altitude herbs; basal part of stem with scale-like laminless leaves; upper stem leaves non-persistent, flat and broad, laxly arranged (never linear-setaceous or grass-like), relatively longer (more than 5 mm long), neither forming rosette, nor imbricate-tetrastichous; leaf margin thickened or not, neither scarious nor hardened; leaf apex thickened, subspinos-pointed; flower solitary, large showy; calyx thickened at apex, narrowly scarious-margined; petals large, obovate, double the sepal with broad lamina and conspicuously narrowed base; stigma shorter than style and few-seeded capsule shorter than calyx. Within *Arenaria*, this group does not show close relationship with other subgenera. McNeill (1962, p. 97) clearly mentioned that though, through *A. glanduligera*, subgenus Solitaria is probably related to subgenus Odontostemma, but without any connecting species between them. The transfer as suggested by Ikkonikov (1976) to *Dichodon* Bartl. ex Rchb., which is usually not accepted as a distinct genus but as *Cerastium* subgenus Dichodon (Bartl. ex Rchb.) Fenzl (Murav’eva 1936) is not acceptable as Dichodon was described primarily separating 3-stylate *Cerastium* species and clearly differs from *Arenaria* sect. Solitaria by taller habit; distantly placed leaves, much shorter than internodes; 2-lobed petals; long exserted conical or oblong-cylindrical and many-seeded capsules. The comparison of the combined diagnostic character set revealed that the group under consideration [subgenus Solitaria] differs from the rest of the *Arenaria* group (including all subgenera), and other *Caryophyllaceae* genera in many important morpho-taxonomical characters as explained below. In our opinion, this group deserves to be recognized at genus rank and hence the same has been described here as a new genus. Though, McNeill (1962) correctly defined this group under subgenus Solitaria McNeill, this name can not be retained at generic rank as it represents a technical Latin term describing morphology (Solitaria – Latin adjective) and as per *International Code of Nomenclature for Algae, Fungi, and Plants* (Melbourne Code), vide Art. 20.2: ‘The name of a genus may not coincide with a Latin technical term in use in morphology at the time of publication unless it was published before 1 January 1912 and was accompanied by a species name published in accordance with the binary system of Linnaeus’ (McNeill et al. 2012). F. N. William’s (1895) sectional epithet ‘Sikkimenses’ is not acceptable for retention as clearly indicated by McNeill (1962: 128) that it was (misplaced in the type subgenus Euarenaria) based primarily on solitary flower character and hence included many alpine species with differential lineage affinities. This group of three alpine Himalayan species is here proposed to form a new genus, ‘Shivparvati’.

*Shivparvati* Pusalkar & D. K. Singh, gen. nov. [Caryophyllaceae]

Type: Shivparvatia glanduligera (Edgew.) Pusalkar & D. K. Singh [≡ Arenaria glanduligera Edgew.]

Shivparvatia Pusalkar & D. K. Singh is allied to Arenaria L. s.s. [in which it is traditionally placed], but differs in dwarf, caespitose habit with clustered flowering stems, persistent basal sheathing scale-like laminaless leaves, upper stem leaf apex thickened, pointed or sub-spinous; leaf margin thickened or not (not hardened); sepal base narrowed, apex usually thickened, veins inconspicuous; flower solitary, large showy, sub-perigynous; petals obovate with conspicuously narrowed base; stigma much smaller than style (excluding stigma) [not long linear stigma covering large part of style and hence longer than style] and capsule short stipitate. Shivparvatia differs from Dichodon Bartl. in laxly, but closely arranged leaves, overlapping or not and always longer than internodes (leaves neither distantly placed nor shorter than internodes); flowers conspicuously sub-perigynous; calyx base narrowed; petal apex not lobed, stigma much shorter than style and globose-ovoid, few-seeded (less than 10) capsule shorter than and covered by calyx (capsule oblong-cylindrical or conical, long-exserted, many-seeded, often ± curved in Dichodon). It is distinguished from Eremogone Fenzl (sensu Hartman et al. 2005) and Dolophragma Fenzl., which are allied groups in the subgeneric key of Arenaria by McNeill (1962), in laxly caespitose habit (neither pulvinate nor densely caespitose); stems few to many from base, usually much branched, sparsely to densely clustered; stems/branches erect or ascending, caespitose with basal part showing sheathing scale-like laminaless leaves, glabrous, ciliate- or glandular-pubescent throughout or in the form of lines; basal stems often yellow, glabrous, glossy and younger parts pubescent (S. glanduligera). Leaves laxly arranged, overlapping or slightly separate on current year’s branches, always longer than internodes, sessile or subsessile, flattened, succulent, sub-succulent or non-succulent, ovate, sub-orbicular, broadly elliptic, oblong-elliptic or spatulate (S. stracheyi), 2–8 × 1–4 mm, base broadly connate forming cupular cavities at node, margins entire, thickened or not, apex acute or acuminate, cuspidate, conspicuously thickened, pointed or sub-spinous, sometimes blackish, surfaces glabrous, ciliate, white, yellowish to brownish hairy or glandular-pubescent, vein inconspicuous or midvein conspicuous, lateral submarginal veins conspicuous in dried leaves. Flowers white, lilac, pink, pinkish white, purple-tinged pink or lilac-tinged white, often darker at petal base, solitary, terminal, 7–15 mm across, weakly perigynous to sub-perigynous, sessile or pedicellate; bracts paired, opposite, foliaceous; pedicel 0–4 cm long, erect or nutant, green, purple or reddish-brown, glabrous, densely white-villous or densely glandular-ciliate; disc conspicuous, prominently so in fruiting. Sepals 5, usually green, flushed or tinged with purple,
sometimes purplish, linear, oblong or ovate to lanceolate, spreading or apically excurved, 3–4 × 0.5–1.5 mm, base narrowed, apex obtuse or acute, usually thickened, rarely not thickened, margins narrowly membranous, white or coloured, glabrous, ciliate or glandular-ciliate with non-impressed, inconspicuous veins. Petals 5, alternisepalous, attached to hypanthium, white, lilac, pink, pinkish white, lilac-tinged white or purple-tinged pink, often with dark pink, purple or lilac base (S. glanduligera), usually obovate, sometimes broadly oblong-ovate with conspicuous narrowed base, 4–10 × 2–7 mm, 1.5–2 times as long as sepals, apex obtuse or rounded, sometimes acute. Stamens 10 (5+5), unequal to subequal (antipetalous stamens longer than antiseropal), arising from receptacle, 3–8 mm long; filaments white, pink or purple, subulate; anthers greenish, yellow, pink, purple, bluish-violet to violet-black; antiseropal stamens with prominent or small, degenerate gland at base on exterior side. Ovary oblong-ovoid to obovoid, greenish, 1–2 mm long; styles 3; stigma often clavate, smaller than style (excluding stigma). Capsules ovoid, shorter than calyx, opening by 6 teeth or valve, shortly stipitate; placenta small, with irregular and unequal branches; seeds few, up to 10, sub-reniform-ovate, flattened, often with one sub-concentric furrow, greyish to brownish or reddish brown, often irregularly compressed, wingless, surface reticulate or spongy, lustrous or not.

Etymology: The genus is named after the god Shiv and the goddess Parvati of the Himalaya as per Hindu Mythology. Notably, two of the species now included under this genus, S. glanduligera [= Arenaria glanduligera] and S. stracheyi [= Arenaria stracheyi] were collected by Gen. R. Strachey and J. E. Winterbottom during 1846–1849 [the first collection from the interiors of the Himalaya] at Barji Kang pass and Rakas tal [Rakshas tal], respectively (Edgeworth and Hooker 1874). Barji Kang pass is located in Kumaon, India [on holy Kailash-Mansarovar pilgrimage route], whereas Rakshas tal is located in Tibet near the base of sacred Mt. Kailash, the home of the lord Shiv and goddess Parvati.

A Sino-Himalayan genus comprising three* species found in alpine meadows, scree, sandy river bank, along streams and rivulets, rocky-grassy glacial morainic deposits, bank of alpine lakes and gravelly grasslands in greater and trans Himalaya and Tibetan plateau region 3000–5500 m in India [Jammu & Kashmir to Sikkim], Bhutan, China and Nepal.

[*From their description in Flora of China (Lu et al. 2001), it seems that three additional Chinese species [Arenaria forrestii Diels, A. ramellata F. N. Williams, A. rhodantha Pax & Hoffm.] also belong here, but since type specimens of these species are not seen by the authors, these species are not transferred here].

**Key to the species**

1a. Glabrous herb; leaves spatulate, linear-oblong or elliptic-spathulate ........ 3. S. stracheyi
1b. Ciliate or glandular-pubescent herbs; leaves oblong, ovate, broad elliptic ..................... 2

2a. Herbs with ciliate pubescence; disc gland small; petals entirely pure white; sepal margin thickened ........................................ 1. S. ciliolata
2b. Herbs with glandular pubescence; disc gland prominent; petal pink, lilac, pinkish white, lilac-tinged white or purplish (not pure white); often with dark coloured petal base; sepal margin scarious, not thickened ........... 2. S. glanduligera

1. **Shivparvatia ciliolata** (Edgew.) Pusalkar & D. K. Singh, **comb. nov.**


**Key to the varieties**

1a. Pedicel and flower erect ........... var. *ciliolata*
1b. Pedicel recurved, flower nutant ............

...................................................... var. *pendula*
1.1. *Shivparvatia ciliolata* var. *ciliolata*
Distribution: India [Greater Himalaya: Uttarakhand, Sikkim], Bhutan, China (Xizang), Nepal.

1.2. *Shivparvatia ciliolata* var. *pendula* (Duthie ex F. N. Williams) Pusalkar & D. K. Singh, **comb. nov.**
Description: F. N. Williams (1898).
Distribution: India [Greater Himalaya: Uttarakhand], Nepal.

2. *Shivparvatia glanduligera* (Edgew.) Pusalkar & D. K. Singh, **comb. nov.** [Fig. 1e–f]
**Lectotype** (here designated): **INDIA**. Sikkim. J. D. Hooker 11 (K000742193; K000742194, K000742195, GH00353887–isoelectotypes).
Distribution: India [Greater Himalaya: Uttarakhand, Sikkim], Bhutan, China (Xizang), Nepal.

3. *Shivparvatia stracheyi* (Edgew.) Pusalkar & D. K. Singh, **comb. nov.**
Distribution: India [Trans and Greater Himalaya: Jammu & Kashmir (Ladakh), Uttarakhand], China (W. Xizang), ?Nepal.
Note: Study of specimens indicated that the species has spathulate, linear-oblong or narrowly elliptic-spathulate leaves and lanceolate, oblong, linear-oblong or oblong-lanceolate sepals as correctly mentioned by Edgeworth (1874). The illustration of the species in Flora of China (Wu & al., Fl. China Illustr. 6: 41, f. 1–5, 2001) correctly depicts leaves and sepal of *S. stracheyi*, but on the other hand the description (Wu & al. in Wu & al., Fl. China 6: 53, 2001), referring to orbicular leaves and orbicular sepals needs further study and verification.

6. *Arenaria* subgen. *Arenaria*
*Arenaria* L., Sp. Pl. 1: 423 (1753) [subgen. *Arenaria* (s.s.)]

Accepted here as: *Arenaria* L., Sp. Pl. 1: 423 (1753).
Three Indian Western Himalayan species belonging to this section are accepted here in the
genus Arenaria as follows:

Distribution: India [Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh], Bhutan, Nepal, China, Pakistan.

Arenaria neelgherrensis Wight & Arn., Prodr. Fl. Ind. Orient. 1: 43 (1834). [Fig. 1a]
Distribution: India [Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Punjab, Maharashtra, Tamil Nadu], China, Nepal, Pakistan.


Arenaria compressa McNeill [≡ Arenaria trichotoma auct. non Boiss. (1856): Royle ex Edgew. & Hook. f. (1874)], a sole representative of section Compressae McNeill (1962) is a very curious and extremely distinctive species as pointed out by McNeill (1962). With stout, subcaespitose habit; strict, rigid stems; narrow, apically sub-spinous leaves; coriaceous, scarious-margined calyx and compressed seeds, it appears more close to Éremogone members than Arenaria, s.s. However, it differs from Éremogone in dichotomously or trichotomously branched stem; similarly branched, strict, laxly many-flowered inflorescence; non-persistent, distantly arranged, flattened, lanceolate or linear-lanceolate leaves (not linear-setaceous or grass-like); leaves neither in persistent rosette nor imbricate-tetristichous; leaf margin neither hardened nor scarious; fruiting receptacle very slightly hardened (not prominently woody); stamens 10, only five oppositi-sepalous with long filaments bearing fertile anthers, the other five (oppositi-petalous) with short filaments bearing sterile, underdeveloped anthers and seeds with incumbent cotyledons becoming longitudinally folded away from the radicle. It is distinguished from Arenaria L., s.s. in stout, subcaespitose, tall habit; strict, erect, rigid, fragile stems with prominent turgid nodes; trichotomously branched, strict, erect inflorescence; narrow, apically sub-spinous, distantly arranged leaves; very slightly hardened fruiting receptacle; coriaceous, scarious-margined, often abruptly cuspidate-pointed sepals, and strongly compressed, winged seeds showing broad cotyledons becoming longitudinally folded away from the radicle. The presence of five undeveloped, sterile anthers here is a constant diagnostic character. In addition to its stout, rigid, di- or trichotomously branched habit forming strict yet fragile (easily broken at nodes) skeleton; trichotomously branched, strict inflorescence, and strongly compressed, winged seeds, it also shows broad incumbent cotyledons becoming longitudinally folded away from the radicle, which is unique in the group (McNeill 1962, p. 93). The species does not fit in any of the subgroups or allies of Arenaria, which are here treated as distinct genera, nor any other genera of Caryophyllaceae and hence is treated here under distinct genus.

The sectional epithet ‘Compressae’ used by McNeill represents a technical Latin term describing morphology (Compressus – Latin participle, meaning flattened) and according to International Code of Nomenclature for Algae, Fungi, and Plants (Melbourne Code), Art. 20.2 [stated above in detail under Shivparvatia] it can not be retained at generic rank. Hence a new name ‘Himgiria’ is chosen at generic rank. Additionally the epithet is not suitable for a
generic name because ‘Compressae’ is a plural of an adjective (Art. 20.1).

**Himgiria** Pusalkar & D. K. Singh, **gen. nov.**

[Caryophyllaceae]


*Himgiria* Pusalkar & D. K. Singh is allied to *Eremogone* Fenzl, but differs in dichotomously or trichotomously branched stem; similarly branched, strict, laxly many-flowered inflorescence; non-persistent, distantly arranged, flattened, lanceolate or linear-lanceolate leaves (not linear-setaceous or grass-like); basal leaves neither in persistent rosette nor imbricate-tetrastichous, rather basal and lower stem leaves early disappearing; leaf margin neither hardened nor scarious; fruiting receptacle very slightly hardened (not prominently woody); stamens 10, five oppositi-sepalous with long filaments bearing fertile anthers, five (oppositi-petalous) with short filaments bearing sterile, underdeveloped anthers and seeds with incumbent cotyledons becoming longitudinally folded away from the radicle. It differs from *Arenaria* L. in stout, caespitose, tall habit; strict, erect, rigid, fragile stems with prominent turgid nodes; trichotomously branched, strict, erect inflorescence; narrow, apically sub-spinous, distantly arranged leaves; very slightly hardened fruiting receptacle; coriaceous, scarious-margined, often abruptly cuspidate-pointed sepals, and strongly compressed, winged seeds showing broad cotyledons becoming longitudinally folded away from the radicle.

Perennial herbs, 30–60 cm high; roots and rootstock robust, woody; stems few to many from base, stout, rigid, erect, subcaespitose, dichotomously or trichotomously branched, sometimes simply branched in upper part; branches long, strict, fragile, terete or angled, rarely furrowed, glabrescent, finely pubescent or glandular villous. Leaves opposite, sessile, estipulate, non-persistent, often basal and lower stem leaves early disappearing, distantly arranged; upper cauline often with vegetative shoots, so appearing spuriously whorled at some nodes or sometimes with well-developed axillary branches, linear, broadly linear or linear-lanceolate, 1–4 cm × 1–5 mm, thick, opaque, midvein conspicuous, base broad, clasping or not, margin entire, recurved or flat, neither hardened non-scarious, apex acute or sub-acute, subspinous or pointed, surfaces glabrous, finely pubescent or glandular villous. Panicle trichotomously branched of laxly many-flowered, cymes; branches long, strict, prominently so in infructescence; lower bracts foliaceous, smaller; upper bract and bracteoles very small, ovate-lanceolate, membranous or with broad membranous margins; peduncle stout, up to 10 cm long, glabrous or sparsely pubescent below; pedicel slender, 0.5–4.5 cm long, glabrous. Flowers white, erect, 4–6.5 mm across. Fruiting receptacle slightly thickened. Perianth and stamens hypogynous or weakly perigynous. Sepals 5, ovate, ovate-lanceolate, oblong, oblong-lanceolate or oblong-ovate, coriaceous, 3–5 × 1.5–3 mm, glabrous, midvein raised, lateral veins obscure in flower, sub-conspicuous or conspicuous in fruiting, base broadened, margin broad membranous or scarious, apex acute to obtuse or abruptly acuminate with cuspidate-pointed tip. Petals 5, white, ovate, oblong-ovate, narrowly lanceolate, linear-lanceolate to elliptic-ovobovate, equaling or slightly exceeding sepal, acute or obtuse. Stamens 10, only five oppositi-sepalous with long filaments (2.8–4 mm) and fertile anthers, the other five (oppositi-petalous) with short (1–1.5 mm) filaments and sterile underdeveloped anthers. Glands very small. Ovary obovoid, 4–5 mm long; styles 3, linear, longer than ovary, often coiled. Capsule ovoid, opening by 6 valves; seeds up to 5, ovate-sub-orbicular, discoid, 2–3 × 1.6–2.5 mm, reddish brown or
buff, strongly compressed, with flat wings; cotyledons lanceolate, incumbent, longitudinally folded away from radicle.

Etymology: The genus is named after its habitat in the Himalaya. In India, this mightiest ‘Lord of Mountains’ is also called in Sanskrit ‘Himgiri’ [‘him’ means snow and ‘giri’ means mountain].

A monotypic genus distributed in Afghanistan, Tibetan plateau region of China (Xizang) and trans Himalayan cold desert region of India (Himachal Pradesh: Lahaul-Spiti (Spiti division – Samdo-Kaurikh, Spiti valley, Gue valley, Gechang) and Kinnaur (Umi-Chini)). The solitary representative, *H. compressa*, is found in mountain gravels, on open dry slopes, in scree and rocky or boulder-strewn areas between 2400–4500 m.


**Type:** INDIA. Kunawar (Kinnaur, Himachal Pradesh), V. Jacquemont 1470 (GH00353892–holotype).


Habitats and distribution: As under the genus.

**Key to the genera of the Arenaria group**

[sensu McNeill 1962]

1a. Styles 2; capsules opening by 4 valves or teeth ............................................. **Odontostemma**

1b. Styles 3; capsule opening by 3 or 6 valves or teeth ............................................. **Sabolina**

2a. Capsule opening by 3 valves ...... **Sabulina***

2b. Capsule opening by 6 valves or teeth ......  3

3a. Pulvinate or densely caespitose herbs; leaves persistent, linear-subulate or grass-like; if caespitose, in dense rosette or if broadly ovate, then smaller than 5 mm and imbricate-tetristichous; leaf margin scarious or thickened; sepal apex not thickened ................................. 4

3b. Laxly caespitose or simple, non-caespitose herbs; leaves not persistent, flat, broad and flaccid, laxly or distantly arranged, relatively long (more than 5 mm long), never linear-setaceous or grass-like, neither forming rosette, nor imbricate-tetristichous; leaf margin not scarious, if thickened then sepal apex hardened ............ 5

4a. Fruiting receptacle hardened; sepal prominently veined ......................... **Eremogone**

4b. Fruiting receptacle not hardened; sepal obscurely veined ................. **Dolophragma**

5a. Erect, stout herbs, 30–60 cm high, with strict, fragile stem; nodes prominently turgid; leaves linear or linear-lanceolate; inflorescence erect, strict, trichotomously branched; seeds suborbicular-ovate, discoid, strongly compressed, winged; cotyledons longitudinally grooved or folded away from radicle .................................... **Himgiria**

5b. Erect, ascending or decumbent, flexible herbs, if erect, less than 20 cm high; neither stout nor with strict branches; leaves lanceolate, orbicular, ovate, broadly elliptic, obovate, spathulate or oblong-elliptic; nodes not prominently turgid; flower solitary or inflorescence diffusely and irregularly branched; seeds and cotyledons not as above .............................. 6

6a. Lower part of the stem with scaly, laminaless leaves; leaf base broadly connate, forming cupular cavities at node; leaf apex hardened, pointed or sub-spinous; leaf margin thickened or not; flower solitary, large, showy; sepal apex thickened; sepal obscurely veined; petal obovate, large and broad, twice the calyx, with conspicuously narrowed base; stigma shorter than style; seeds up to 10 ............... **Shivparvatia**

6b. Lower part of the stem with simple
leaves or remnant petiole bases, without scaly, laminaless leaves; leaf base narrowly connate, not forming cupular cavities at node; leaf apex neither hardened, nor pointed to sub-spinous; leaf margin not thickened; flower many, small, not showy, in cyme; sepal apex not thickened; sepal prominently veined; petal oblong-ovate or narrowly obovate, shorter than to slightly longer...
than calyx, base short, cuneate; stigma longer than style; seeds more than 20 ............ Arenaria

*Note: Two Western Himalayan species accepted by Dillenberger and Kadereit (2014) under the genus Sabulina Rchb., viz. S. foliosa (Royle ex Edgew & Hook. f.) Dillenb. & Kadereit and S. kashmirica (Edgew. & Hook. f.) Dillenb. & Kadereit, have long been treated under Minuartia in the Himalayan Floras as M. foliosa (Royle ex Edgew & Hook. f.) Majumdar and M. kashmirica (Edgew. & Hook. f.) Mattf., respectively. However, both these species were originally described under Arenaria, as A. foliosa Royle ex Edgew. & Hook. f. and A. kashmirica Edgew. & Hook. f. and hence the genus Sabulina is included here in the key for comparison of characters.

Conclusions

The large and complex Caryophyllaceae genus Arenaria has been always considered as an assemblage of distinct groups, with differential affinities. In view of recent phylogeny evidences (Harbaugh et al. 2010, Greenberg and Donoghue 2011) supporting the genus to be polyphyletic, the present morpho-taxonomic reassessment was undertaken. Based on clade formation and branching pattern in phylogenetic tree and in particular, the delimitation of Eremogone and Arenaria followed by subsequent recognition of distinct tribe Eremogoneae, qualitative character selection and diagnostic character set is reframed and reapplied to other sub-groups of Arenaria (sensu McNeill, 1962) in Indian western Himalaya. The study results in the following conclusions:

1) As concluded in phylogenetic study (Harbaugh et al. 2010, Greenberg and Donoghue 2011), genus Eremogone Fenzl (including Arenaria subgen. Eremogoneastrum Fenzl) is accepted as a genus distinct from Arenaria. After detailed morpho-taxonomic study and confirmation of diagnostic characters as per currently accepted delimitation (Hartman et al. 2005), eight Indian Himalaya taxa (seven species and one variety) were transferred to Eremogone and subsequent new combinations are proposed.

2) Study revealed that members of Arenaria subgen. Dolophragma with pulvinate or densely caespitose habit; imbricate-tetrasichous, persistent leaves are morphologically similar to currently delimited Eremogone, with similar habitats and undoubtedly out of place in the tribe Arenarieae. However, Dolophragma members differ in hardened leaf margins, not hardened (non-incrassate) fruiting receptacle/calyx base and obtuse sepal with non-impressed (obscure) veins. These less significant diagnostic characters suggested its possible merger with Eremogone, but without phylogeny evidence to conclude the same. So, its placement in the parental genus Dolophragma Fenzl seems more proper than in Arenaria, s.s. (tribe Arenarieae, where it is clear misfit) and hence a single species (Arenaria polytrichoides Edgew.) of this group reported from western Himalaya is here treated under Dolophragma.

3) In line with phylogeny conclusion by Harbaugh et al. (2010) with agreement of morpho-taxonomical characterization Odontostemma Benth. ex G. Don is recognized as a distinct genus. No transfer is proposed as only the type species occurs in the Indian western Himalaya.

4) Arenaria subgen. Solitaria McNeill, characterized by dwarf, laxly caespitose habit; basal part of stem with scale-like lamina-less leaves; upper stem leaves non-persistent, flat and broad, laxly arranged (never linear-setaceous or grass-like), relatively longer (more than 5 mm long), neither forming rosette, nor imbricate-tetrasichous; leaf margin thickened or not, neither scarious nor hardened; leaf apex thickened, sub-spinous-pointed; flower solitary, large showy; calyx thickened at apex and narrowly scarious-margined; petals large, obovate, double the sepal with broad lamina and conspicuously narrowed base; stigma shorter than style and few-seeded capsule shorter than
calyx was found to be a distinctly evolved group of high altitude species without clear affinities. This group of three species is now concluded to have a significant diagnostic character set worth generic rank and hence is recognized here as a new genus *Shivparvata* Pusalkar & D. K. Singh.

5) Three Indian Western Himalayan species belonging to *Arenaria* sect. *Arenaria*, with typical *Arenaria* characters are accepted here in the genus *Arenaria*, without any change.

6) A solitary representative of *Arenaria* sect. *Compressae* McNeill [= *Arenaria compressa* McNeill (≡ *Arenaria trichotoma* auct. non Boiss. (1856): Royle ex Edgew. & Hook. f. (1874)] was found to be a very curious and extremely distinctive species, differing in many significant key characters from the allied groups. Based on a set of qualitative diagnostic characters, present study concluded its distinct placement at generic rank, and hence a new monotypic genus *Himgiria* Pusalkar & D. K. Singh is recognized here to include the same species.

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References


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P. K. Pusalkaraa, D. K. Singhb: インド西ヒマラヤ産ノミノツヅリ属（ナデシコ科）の分類

最近の分子系統学的研究の成果を踏まえ、形態的形質にもとづいて、インド・西ヒマラヤ産のノミノツヅリ属植物（ナデシコ科）の学名を整理した。Dolophragma Fenzl, Eremogone Fenzl, Odontostemma Benth. ex G. Don は従来ノミノツヅリ属 Arenaria の下で亜属として扱われていたが本稿では独立した属として認めた。これに伴い、それぞれの学名をここで認めた新属の下で組み替えた。また、ノミノツヅリ属 Solitaria 亜属と


Compressae 篇に関してはそれぞれ独立した属と認め、命名規約にしたがって新属 Shivparvata Pusalkar & D. K. Singh と Himgiria Pusalkar & D. K. Singh とし、同様に新属の下での学名の組み替えを行った。

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