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Diversity of Caryophyllaceae Juss. in Uttarakhand (India)

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Abstract

In this paper, we reviewed the records of Caryophyllaceae family of flowering plants reported from Uttarakhand state of India. Family Caryophyllaceae Juss. in Uttarakhand is represented by 24 genera 75 species, 2 subspecies and 6 varieties. Based on the herbarium history, literature survey and additional observations by the authors, 11 taxa were excluded from the flora of Caryophyllaceae of Uttarakhand. *Cherleria sedoides* was reported for the first time from India and Uttarakhand. Hitherto, the misidentification of the *Cherleria sedoides* and *Cherleria biflora* in the Himalayas, and identification ambiguity between *Cerastium glomeratum* and *C. fontanum* subsp. *vulgare* were resolved. We found that *Stellaria depressa* is a new record to the flora of Uttarakhand. New combinations of *Stellaria patens* subsp. *patens*, *Stellaria patens* subsp. *semivestita* and *Sabulina kashmirica* var. *foliosa* have been proposed. Based on the taxonomic history, and observations of the live and herbarium specimens, the synonymy of *Sagina purii* for *S. apetala* was concluded. This study summarises and presents the updated flora of Caryophyllaceae family in Uttarakhand based on these new findings.

Keywords: Alpine meadows, *Arenaria*, *Cherleria*, new combination, new record, *Silene, Stellaria*

Introduction

Caryophyllaceae Juss. is a major family of Angiosperms and ranked as the 24th largest family with 93 genera and 2395 species (Thorne & Reveal 2007). Though, the number of species and genera of the family varies from different sources as Catalogue of Life (2024) reported 104 genera with 3397 species and Stevens (2024) reported 101 genera with 2625 species. The family Caryophyllaceae also known as the pink family or carnation family, occurs almost worldwide particularly in the Northern Hemisphere except for most of the wet tropics and is mainly centered in the Mediterranean area of the Old World. Members of the family Caryophyllaceae are distinctive in having nodes often swollen, with simple opposite leaves, an inflorescence of solitary flowers or dichasial cymes, and biseriate, actinomorphic, usually pentamerous flowers with distinct, clawed petals, stamen ten or lesser, obdiplostemonous, a superior ovary with distally free-central or basal placentation, and a capsular fruit opening by teeth or valve (Bittrich 1993 a; b).

With the advancement of molecular and phylogenetic techniques, a few of the very diversified genera of the family such as *Arenaria* L., *Minuartia* L., *Gypsophila* L. *Pseudostellaria* Pax, *Silene* L. and *Stellaria* L. have been re-circumscribed (Dillenberger & Kadereit 2014; Pusalkar & Singh 2015; Sadeghian *et al.* 2015; Zhang *et al.* 2017; Madhani *et al.* 2018, Sharples & Tripp 2019; Jafari *et al.* 2020). On the basis of these studies, some new genera such as *Minuartiella* Dillenb. & Kadereit, *Mcneillia* Dillenb. & Kadereit, *Himgiria* Pusalkar & D. K. Singh, *Shivparvatia* Pusalkar & D. K. Singh, *Balkana* Madhani & Zarre, *Hartmaniella* M. L. Zhang & Rabeler, *Nubelaria* M. T. Sharples & E. Tripp, *Graecobolanthus* Madhani & Rabeler, *Rabelera* (L.) M. T. Sharples & E. Tripp, *Petroana* Madhani & Zarre and *Engellaria* Iamonico have been described (Dillenberger & Kadereit 2014; Pusalkar & Singh 2015; Zhang *et al.* 2017; Madhani *et al.* 2018; Sharples & Tripp 2019, Iamonico 2021 a) and some genera such as *Cherleria* L., *Eremogone* Fenzl, *Dolophragma* Fenzl, *Facchinia* Rchb., *Odontostemma* Benth. ex G. Don, *Bolanthus* (Ser.) Rchb., Deut. Bot. Herb.-Buch, *Cyathophylla* Bocquet & Strid, *Heterochroa* Bunge, *Habrosia* Fenzl. *Sabulina* Rchb , *Schizotechium* Fenzl and *Dichodon* (Bartl. ex Rchb.) Boiss have been reinstated (Dillenberger & Kadereit 2014; Hernández-Ledesma *et al.* 2015; Pusalkar & Singh 2015; Sadeghian *et al.* 2015; Pusalkar & Srivastava 2016; Madhani *et al.* 2018; Iamonico 2021 b). Lidén (2018) and

Lidén & Oxelman (2023) correctly identified many erroneous identifications of *Silene* species in the Himalayan region.

The Himalayan mountainous area can be broadly divided into two biogeographic zones: the Trans-Himalayas and the Himalayas (Rodgers & Panwar 1988). The Himalayan region also harbours an enormous diversity of the family. There are nearly 29 genera and 150 species of the family are present in the Himalayan areas. Out of 150 species, 37 species (24.5%) are endemic to the Himalaya and 59 species (39.3%) are endemic to the Himalaya and adjacent Tibet (Xizang) (Chandra 2016). This study systematically evaluated the documented records of the Caryophyllaceae family of angiosperms within the state of Uttarakhand. Uttarakhand, by large, lies in the Himalayan region with the northernmost parts falling in the Trans-Himalayas (Rodgers & Panwar 1988). By conducting a meticulous review of published records augmenting with the authors' own observations, we aimed to provide a comprehensive overview of the species richness and distribution of the Caryphyllaceae plant family in this ecologically significant region.

Material and Methods

The study was carried out in the Himalayan state of Uttarakhand, India. It comprises of diverse topographies and habitats from plains and *Terai* regions in the south and east to dense forests and snow-covered peaks of the Himalayas in the north and west, facilitating plants of the family Caryophyllaceae flourish well in the state. For the present study, a detailed literature survey was carried out of various floras and checklists, *viz.*, Edgeworth & Hooker (1874), Williams (1898), Smith & Cave (1911), Shishkin (1936), Walters (1964), Majumdar & Giri (1983) Chowdhery & Wadhwa (1984), Grierson (1984), Ghazanfar & Nasir (1986), Majumdar (1993), Hajra *et al.* (1996), Srivastava (1998), Press *et al.* (2000), Majumdar (2002), Uniyal *et al.* (2007), Gogoi *et al.*, (2021). Regional floras such as Babu (1977), Duthie (1906), Gaur (1999), Gupta (1968), Naithani (1984), Pusalkar & Singh (2012), Pusalkar & Srivastava (2018), Raizada & Saxena (1978), Rana *et al.* (2003) were consulted. Various research papers, *viz.*, McNeill (1962), Pusalkar & Singh (2015), Pusalkar & Srivastava (2016), Lidén (2018) and Lidén & Oxelman (2023) *etc.* were also consulted. The threatened status of the species was assessed after Nayar & Shastry (1987-90) and Rao *et al.* (2003). A total of 73 research articles/reviews/books were consulted for the present work.

For the correct identity of the species protologues of the species were observed, and POWO (2024) was followed for accepted names. Herbarium specimens of Western Himalayan species housed in the herbaria of Botanical survey of India, Northern Circle, Dehradun (BSD), Hemwati Nandan Bahuguna Garhwal University, Srinagar, Garhwal (GUH), Forest Research Institute, Dehradun (DD), Wildlife Institute of India (WII), Kumaon University Nainital, Central National Herbarium (CAL) and Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India (GBPUH) were consulted. However, for type specimens and original collections of the species virtual herbarium as Kew Herbarium (http://apps.kew.org/herbcat/gotoHomePage.do) and Tropicos herbarium (https://www.tropicos.org/) were consulted.

Results and Discussion

Our review concluded that family Caryophyllaceae in the Uttarakhand is represented by 24 genera 75 species, 2 subspecies and 6 varieties. *Silene* L. is the largest genus of the family represented by 21 species followed by *Stellaria* L. (12 species) and *Eremogone* Fenzl (06 species). A list of genera and their respective species is provided in table 1. A detailed account of species along with their distribution, occurrence and other information is provided in appendix 1. Based on the herbarium history, literature survey and additional observations by the authors, 11 taxa have been excluded from the flora of Caryophyllaceae of Uttarakhand (appendix 2). Major findings of the present research are being presented here in details.

3.1. New Record to the Flora of India

During the study of the Caryophyllaceae of Uttarakhand, various new records have been reported by authors for the Indian and the Western Himalayan flora (Chandra & Rawat 2016; Chandra & Rawat 2017; Chandra & Rawat 2018; Chandra *et al.* 2020; Chandra & Rawat 2021). In the present study, we report *Cherleria sedoides* L. as a new record to the flora of India and Uttarakhand.

3.1.1. Collection of the *Cherleria sedoides* L. from Uttarakhand;

During a visit to the alpine Himalaya of Uttarakhand, the author (DSR) collected specimens of *Cherleria sedoides* L. from the Vasukital area of district Rudraprayag and both the authors collected specimens from the Ralam area of district Pithoragarh. The identity of the specimens was confirmed after Ghazanfar & Nasir (1986), Majumdar (1993), Halliday (1993) Dequan & McNeill (2001) Rabeler & Hartman (2005), Moore & Dillenberger (2017). The specimens were also matched photographically with the image of *Cherleria sedoides* L. provided by Moore & Dillenberger (2017).

Description of the species: *Cherleria sedoides* L., Sp. Pl. 1: 425. 1753; *Minuartia sedoides* (L.) Hiern, *Jour. Bot. (London)* 37: 321. 1899.

Herbs, perennial, caespitose, forming loose yellowish-green cushion up to 10 cm across. Taproot deep, woody stock giving rise to many prostrate stems. Vegetative branches on stem longer, 3–5 cm, spreading; flowering branches in the axil of leaves with broad sheathing base, erect, very short up to 1cm long. Leaves on vegetative shoots distant in proximal part, fascicled at distal end, opposite, connate at the base, basal tube pilose and up to 1mm long, lamina sessile, linear, entire, acute or rounded at apex, 5–7 × 0.75–1 mm, margin minutely pilose with few celled uniseriate trichomes in lower half, papillose in upper half, one nerve at base, obscurely 3 nerved in upper half; leaves on flowering shoot imbricate, concealing stem, linear–subulate, entire, acute or obtuse, central nerve conspicuous other obscure, 4–5 × 0.75–1 mm, upper lamina thickened, finely pubescent on the dorsal surface and leaf margin with uniseriate trichomes. Cymes terminal, 1- few-flowered. Bracts paired, lanceolate, pilose- like leaves, 3-nerved in the upper half. Flowers pedicellate, solitary or paired, axillary or terminal; pedicels finely pubescent with eglandular hairs, 2–3 mm, elongating in fruits. Flowers all bisexual, 2–3 mm across, greenish. Sepals 5, subequal, ovate-–lanceolate, obtuse or acute, 2.5–3.5 × 1–1.5 mm, scarious margined, 3 nerved, green, ligneous in fruit, finely pubescent on the abaxial side and lower half of margins, completely spreading at seed dispersal stage. Petals absent, when rarely present only 1 or 2 in a flower (seen in only 2 flowers of 55 examined), lanceolate, smaller to sepals, 1 nerved, 2 × 0.5mm, obtuse. Stamens 10 in two whorls, equal, all fertile, shorter than sepal, 2–3 mm long, antisepalous stamens with broader filament and a minute bilobed gland at base. Ovary ovoid, 1.5 mm; style 3, up to 1 mm long. Capsule ovate-elliptic, 2.5–3.5 mm long, glabrous, enclosed by persistent hardened calyx, equal to sepals, opening by 3 valves separate to base. Seed 7–12 per capsule, comma-shaped, light to dark brown, 0.5–0.75 mm, compressed, angular, smooth on sides, wrinkled on dorsal side, exstrophiolate, with U shaped outer darker area and hyaline center, embryo curved (Figure 1).

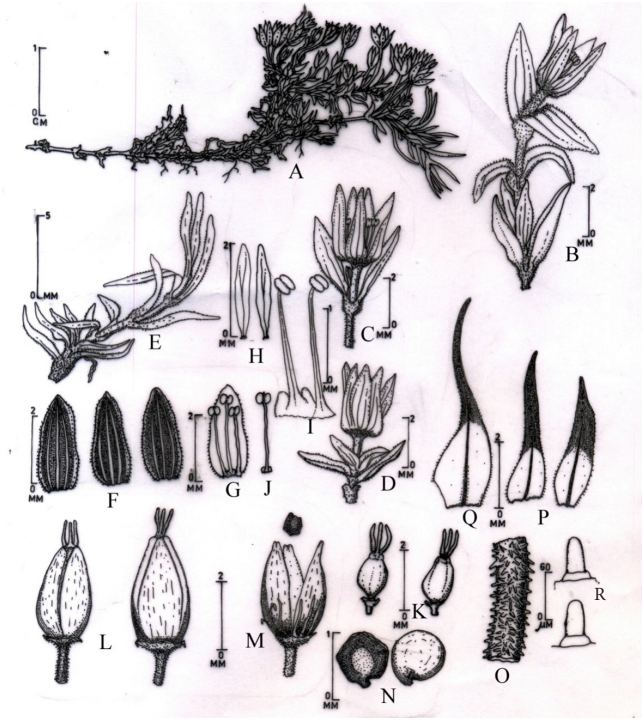

Figure 1. *Cherleria sedoides* L. A- Plant habit, B- Flowering shoot, C, D- Flower, E- Vegetative shoot, F- Sepal abaxial surface, G- Sepal with stamen, H- Petal, I- Stamen with prominent gland at base, J- Single stamen, K- Gynoecioum, L- Mature gynoecium, M- Fruit, N-Seed, O- Trichomes arrangement on stem, P- Upper leaf, Q- Lower leaf of flowering shoot, R- Eglandular trichomes.

Flowering: July–August

Fruiting: August–October

Distribution: The native range of the species is the European Mountains (POWO, 2024). Species present in moist alpine slopes, near the boulders, above 4000 m elevation in the Himalayas along with the moss species. Due to small size and cohabitating with the moss species this species was ignored by the botanical explorers.

Specimen Examined: India, Uttarakhand, Garhwal: Rudraprayag District, Kedarnath area, Vasukital area, 30º43'48.4"N 79º01'0.3"E, 4400m, 24.8.2005, *D.S. Rawat 609* B (GBPUH!). Kumaon: Pithoragarh District, Ralam valley, near Barjikang Pass, 30.310355, 80.272524, 4300m, 05.08. 2017, *D.S. Rawat & Satish Chandra 1205* (GBPUH!)

Note: The species was erroneously reported new to Indian flora by Majumdar & Giri (1983) as *Minuartia sedoides* (L.) Hiern (erstwhile name of *Cherleria sedoides* L.) on the basis of the specimens housed in CAL herbarium (specimens details provided below). During the present study, the authors studied the specimens cited by Majumdar & Giri (1983) for their finding. It was observed that those specimens actually belong to *Cherleria biflora* (L.) A.J.Moore & Dillenb. (*Minuartia biflora* (L.) Schinz & Thell.) and were erroneously identified as *Minuartia sedoides* due to the reasons mentioned further.

Majumdar & Giri (1983) reported flowers of the *Minuartia sedoides* as unisexual. During our observation of the specimens, we found all the specimens having bisexual flowers. Due to small petals of the species, Majumdar & Giri (1983) might have omitted their presence. They considered capsule valves as petals. Consequently, capsule valves were termed as petals in male flowers and reported no gynoecium. They further

Table 1. List of genera of Caryophyllaceae and their respective species in Uttarakhand

S. no	Genus	Species
1	*Acanthophyllum* C.A.Mey.	01
2	*Arenaria* L. s.s.	03
3	*Cerastium* L.	03
4	*Cherleria* L.	01
5	*Dianthus* L.	03
6	*Dichodon* (Bartl. ex Rchb.) Rchb.	01
7	*Dryamria* Willd. ex Schult.	02
8	*Eremogone* Fenzl	06
9	*Gypsophila* L.	01
10	*Herniaria* L.	02
11	*Lepyrodiclis* Fenzl	01
12	*Odontostemma* Benth. ex G.Don	03
13	*Polycarpaea* Lam.	01
14	*Polycarpon* Loefl.	01
15	*Pseudostellaria* Pax	01
16	*Sabulina* Rchb.	01 (2 varieties)
17	*Sagina* L.	02
18	*Schizotechium* (Fenzl) Rchb.	03
19	*Shivparvatia* Pusalkar & D.K. Singh	03 (02 varieties)
20	*Silene* L.	21
21	*Spergula* L.	01
22	*Spergularia* (Pers.) J. Presl & C. Presl	01
23	*Stellaria* L.	12 (2 subspecies, 2 varieties)
24	*Thylacospermum* Fenzl.	01

described abortive ovaries in male flowers; because, to that time gynoecium became a capsule. Similarly in female flowers Majumdar & Giri (1983) reported no petals because what they thought of as petals were here considered as ovary and capsule. Bisexual flowers and the abortive nature of the ovary in *M. sedoides* were not reported in any of the flora (Shishkin 1936; McNeill 1962; McNeill 1984; Dequan & McNeill 2001). Halliday (1993) mentioned the abortive stamen and ovary of *M. sedoides* but the rest of the morphological characters described by him to *M. sedoides* did not match with the description by Majumdar & Giri (1983) and the specimens cited by them. The absence of petal is one of the key characteristics of *M. sedoides* (Halliday 1993). Based on the absence of petals (at least in the female flowers of specimens), Majumdar & Giri (1983) erroneously considered these specimens as *M. sedoides*. Majumdar & Giri (1983) further separated both *M. sedoides* and *M. biflora* on the basis of seed ornamentation pattern but that character is not promising and prominent (Halliday 1993). The rest of the morphological characters described by Majumdar & Giri (1983) to differentiate *M. sedoides* and *M. biflora* are not sufficient to distinguish both species (Halliday 1993).

During our observation of the specimens, we found that all flowers are bisexual and petals are present in all. The description of the specimens matches with the description of *M. biflora* (Ghazanfar & Nasir 1986; Majumdar 1993; Hal

liday 1993; Dequan & McNeill 2001) and qualified them to be part of *M. biflora* populations. Hence, it can be concluded that *M. sedoides* reported earlier by Majumdar & Giri (1983) was, in fact, erroneous identification of *M. biflora* specimens.

Specimen observed
INDIA, Kashmir, Frozen lake, 3500 m, 12.09.1961, *Wadhwa and Vohra 62* (CAL!); Khilan 13.07.1899, *Inayat* s.n. (CAL!); Deosai plains, shores of shersar lake, 13000-14000 ft, 15.09.1893, J.F. *Duthie* 14052 (CAL!); Baltistan, Chataninala, west of Dras, 29.08.1893, J.F. Duthie 13888 (CAL!) (Figure 2).

Key to identify species from allied species in the Himalayas:
Cherleria biflora (L.) A.J. Moore & Dillenb. is an allied species of *C. sedoides* in the Western Himalayas. Both species can be distinguished on the basis of the following characters:

1a. Flower usually more than 1 to 3, in cymes; petals present, equaling or exceeding sepals.....*Cherleria biflora*

1b. Flowers solitary; petals absent or if present shorter than sepals.....*Cherleria sedoides*

3.2. New Record to the Flora of Uttarakhand:
Stellaria depressa Em. Schmid was previously described from the Ladakh region (India) and subsequently reported from Tibet (China). The current specimens of the species were collected from the Chhojan area, Byans valley of Pithoragarh district Uttarakhand by G.S. Rawat, G. Singh and B.S. Kalakoti. These specimens are housed in the herbaria of the Wildlife Institute of India, Dehradun, and Kumaun University, Nainital, respectively. After matching the characters of the specimens with the description of *Stellaria depressa* (Shilong & Rabeler 2001, Doležal *et al.* 2018, Schweingruber *et al.* 2020) its identity was confirmed. An image of the type specimen of the species, provided by Wang *et al.* (2020), was also consulted for further identification.

Description of the species: *Stellaria depressa* Em. Schmid in Repert. Spec. Nov. Regni Veg. 31(816–825): 41. 1932; C. Shilong & R. K. Rabeler, in Wu *et al.*, Fl. China 6: 22. 2001.

Herb, perennial. Stem diffused, loosely tufted, erect–decumbent, 8–15 cm long, glabrous. Leaves elliptic-oblong, 3–7×2–4 mm, glabrous, mid vein prominent. Flower 2–7 in dichasial cyme. Bracts 2, ovate-lanceolate, 3–4 mm long, fully scarious, glabrous, apex acuminate. Pedicel 2–4 mm long, glabrous. Sepals 5, ovate-–lanceolate, 3.5–4.5×1–1.5 mm, veins 3, margin scarious, apex acute–obtuse. Petals 5, white, 2–2.5 mm long, shorter than sepals, bipartite up to base, lobes lanceolate, apex obtuse. Stamens 10, antisepalous with a prominent gland at the base, 0.75–1.5 mm long, antipetalous stamens without gland at the base, 0.5 mm long. Ovary ovoid, 1–1.5×1 mm, style 3, 1 mm long. Capsule ovoid–orbicular.

Flowering: July–August

Fruiting: August–September

Distribution: This species was earlier recorded from Tibet (China) and Ladakh regions. In the flora of India, Majumdar (1993) excluded this species because he did not see specimens. In the present work, we include this species on the basis of specimens housed in the herbarium of the Wildlife Institute of India, Dehradun, and Kumaun University, Nainital, collected by G.S. Rawat, G. Singh and B.S. Kalakoti, respectively, from Chhojan area of Byans valley, Pithoragarh district. This was a new record for the flora of Uttarakhand.

Specimens examined: Kumaon: Pithoragarh district, Byans valley, Chhojan, 4800 m, 18 July 2004, *G.S. Rawat & G.S. 14547* (WII!); 18 July 1983, *B.S. Kalakoti 1788* (Kumaon University Herbarium).

Key to identify species:
Species of the *Stellaria* as *S. decumbens* Edgew., *S. congestiflora* H. Hara, and *S. umbellata* Turcz. are allied species of the *S. depressa* in the higher alpine zones of the Himalayas. Here keys are provided to differentiate them, considering *S. media* (L.) Vill. as a common representative of the *Stellaria* genus.

1a. Inflorescence terminal umbellate or sub umbellate cyme..... .....*S. umbellata*

1b. Inflorescence axillary or terminal dichasial cyme……2

2a. Plant cushion forming or tufted……3

2b. Plant diffused, prostrate, ascending or erect……*S. media*

3a. Leaf apex obtuse; bract not foliaceous, fully scarious…… .....*S. depressa*

3b. Leaf apex acuminate, slightly pungent; bract foliaceous……4

4a. Inflorescence dense cyme, forming corymb….*S. congestiflora*

4b. Flower solitary or 2–6 per cyme……*S. decumbens*

3.3. Taxonomic revisions/corrections including new combinations and synonymy

3.3.1. New Combination in *Stellaria patens*
The whole distribution range of the *Stellaria patens* D. Don and *S. semivestita* Edgew. were sampled in Uttarakhand and specimens were collected. After examining the protologue and type specimens of both species, it is proposed that *S. semivestita* should be treated as a subspecies of *S. patens*. Solitary flowering in the *S. semivestita* was the prominent character for distinguishing both species (Edgeworth & Hooker 1874). During the present study, it was found that S. *patens* has both solitary flowering at lower elevations and lax many-flowered cyme at higher elevations. Thus, the separation of both species on this ground is not justifiable.

After a critical examination of a large number of specimens from its entire distributional range (1500-4000 m elevation) *Stellaria semivestita* Edgew. is now being merged with *S. patens* D. Don and is proposed as a subspecies.

Stellaria patens D. Don subsp. *semivestita* (Edgew.) S. Chandra & D.S. Rawat *comb et stat. nov.*
≡*Stellaria semivestita* Edgew. in Hook. f., Fl. Brit. India 1: 230. 1874.

Type: (Syntype) INDIA, Uttrakhand: Kumaon, Lohaghat, 1500 m, May 1845, *T. Thomson s.n. K000723661* (K Image !).

Stellaria semivestita is morphologically very similar to *S. patens* D. Don and these two species were separated on the basis of inflorescence. *Stellaria patens* is mentioned as having axillary or terminal dichasial cyme and *S. semivestita* as having a solitary flower in protologue (Edgewoth & Hooker 1874). But after examining both species in nature we found that *S. patens* may have solitary or 2–3 flowers in cyme when present at lower elevations. Both share some characteristics as stem quadrangular, 10 –50 cm, decumbent, branched, yellow-green, and eglandular hairy in villous vestiture. Leaves linear-lanceolate, hairy at both surface and margin, mid vein conspicuous, apex acute. The flower is axillary or terminal, solitary in both when *S. patens* is present at lower elevations and inflorescence bracts are shorter than sepals, and scarious. Similarly, the sepal is glaborus, mid vein prominent and the other

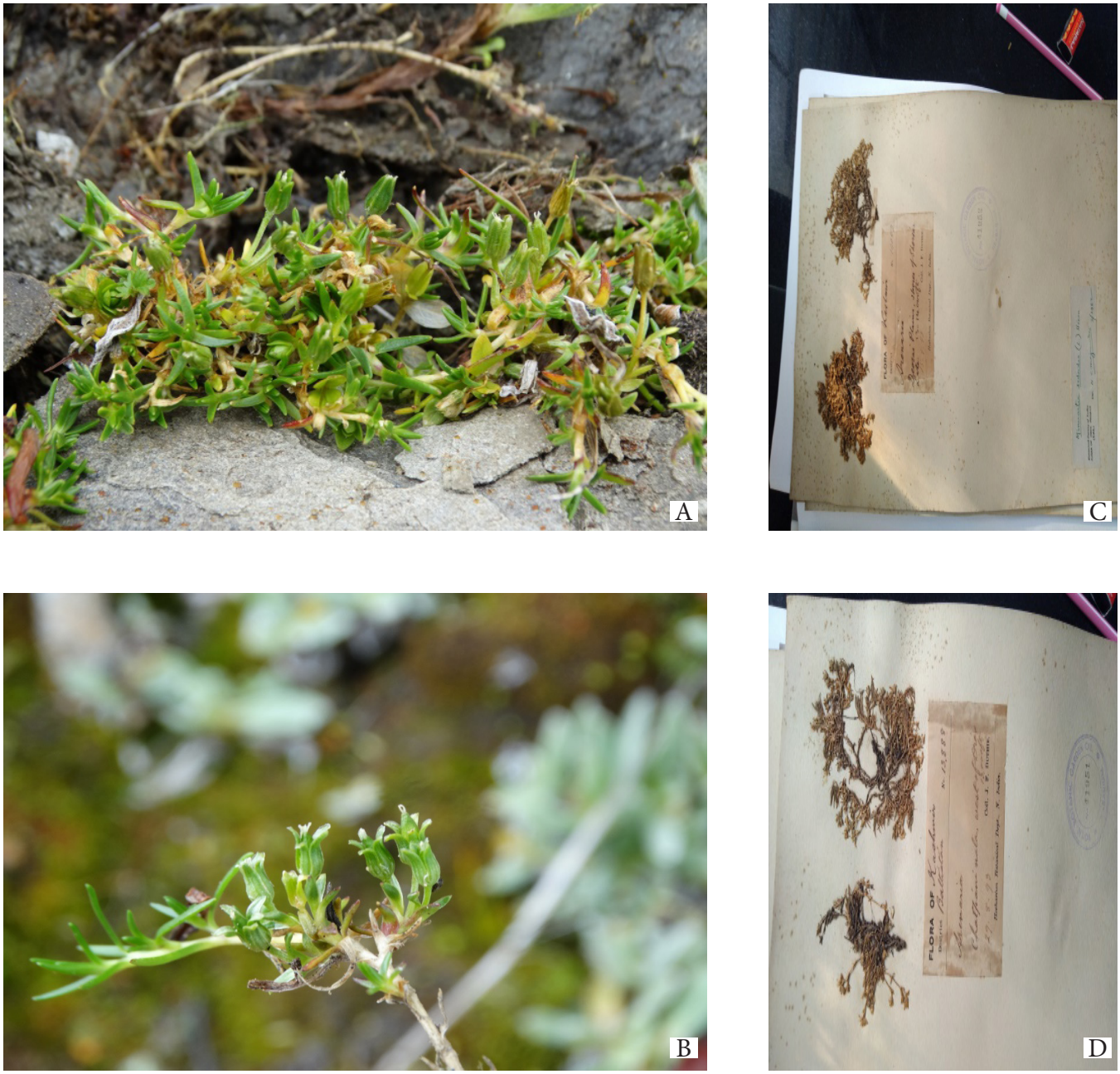

Figure 2. *Cherleria sedoides* L. A. habit, B. flowering shoot; *Cherleria biflora* (L.) A.J. Moore & Dillenb. C, D. herbarium specimen housed in CAL.

two veins are obscure in both species.

Keys to subspecies:
1a. Stem hairy with antrorse uniseriate eglandular hairs; hairs persistent; inflorescence usually dichasial cyme, rarely solitary axillary, inflorescence bract fully glabrous..... .....*Stellaria patens* subsp. *patens*

1b. Stem hairy with appressed uniseriate eglandular hairs; hairs deciduous; flowers solitary axillary; inflorescence bract hairy at margins..... *Stellaria patens* subsp. *semivestita*

3.3.2. New Combination of *Sabulina kashmirica*
Sabulina kashmirica (Edgew. & Hook. f.) Dillenb. & Kadereit var. *foliosa* S. Chandra & D.S. Rawat. comb. nov.
≡ Minuartia *kashmirica* var. *foliosa* (Royle ex Edgew. & Hook.f.) Pusalkar, Fl. Uttarakhand 1: 671 2018.
≡ *Minuartia foliosa* (Royle ex Edgew. & Hook.f.) Majumdar in J. Indian Bot. Soc. 44: 142 1965.
≡ *Arenaria foliosa* Royle ex Edgew. & Hook.f. in Hook.f. Fl. Brit. India 1: 236 1874.

Type: (Syntype) INDIA, North West Himalaya: 1832, *Royle, J.F. s.n. acc. no. K000742096* (K Image!)

The conventional genus *Minuartia* L. *s.l.* has been split into various new genera on the basis of phylogenetic relationship (Dillenberger & Kadereit 2014). The species *Minuartia kashmirica* (Edgew.) Mattf. is now transferred to the genus *Sabulina* as *Sabulina kashmirica* (Edgew.) Dillenb. & Kadereit. Consequently, the variety of the *Minuartia kashmirica* must be transferred to the *Sabulina kashmirica*. Thus, the new combination of the variety is proposed here.

3.3.3. Synonym of *Sagina purii* for *Sagina apetala*
The species *Sagina purii* R.D. Gaur was described by Gaur (1992) after distinguishing it from *Sagina saginoides* (L.) H. Karst. All the characteristics of this species match well with the

description of *S. apetala* of the Western Himalayas except the presence of petals and the warty surface of seeds. Though, *S. apetala* do possess petals (Cullen 1984), these are absent in the Western Himalayan populations. In the protologue of *S. purii* ovary shape and capsule shapes are not described and petals are considered as broader than sepals. After examining type collection of *S. purii* (12807) housed in GUH herbarium, we found that petals are altogether absent and seeds are not warty as described in the protologue but wrinkled. Structures which are described as petals in the protologue are capsule valves, which are alternisepalous in position and erroneously considered as petals by Gaur (1992). Capsule open by 4 valves in *S. apetala* and each valve is equal to or slightly broader than sepals. In the publication by Gaur (1992), herbarium sheet number 12807 GUH was mentioned as holotype but his sheet contains two plants pasted over it thus making it syntype. After a critical examination of the material of *S. purii* and various collections of *S. apetala* from the Western Himalayas, we conclude that *S. purii* does not qualify as a separate species, but it should be merged with *S. apetala*.

3.3.4. Case of *Cerastium glomeratum* in the Himalayas

In Himalaya, *Cerastium fontanum* Baumg. is sometimes erroneously identified as *C. glomeratum* Thuill. Both these species are distinguished by their inflorescence. *Cerastium fontanum* contains lax cyme inflorescence while *C. glomeratum* contains dense cyme; flowers clustered together forming glomerule (Baumgarten 1816; Dequan & Morton 2001; Morton 2005; Thuiller 1799; Wyse Jackson 1995; 2000). Both of the species are native to Europe and introduced in other parts of the globe. In Uttarakhand, both species are reported (Uniyal *et al.* 2007; Pusalkar & Singh 2012). In the Flora of British India, Edgeworth & Hooker (1874) described both species under C. vulgatum L. as two varieties- *C. vulgatum* var. *glomerata* (Thuill) Edgew. & Hook. f. and *C. vulgatum* var. *trivialis* Edgew. & Hook. f. Edgeworth & Hooker (1874) distinguished both these varieties on the basis of fruiting pedicel. *Cerastium vulgatum* var. *glomerata* was mentioned as having fruiting pedicel shorter than sepals while *C. vulgatum* var. *trivialis* was mentioned having fruiting pedicel longer than sepals.

During the present study, we found that pedicel length varies with age of the plant in *Cerastium*. Young plants contain short pedicels and peduncles, hence inflorescence appears as glomerule of *C. glomeratum*. Pedicel and peduncle length increases as plant ages and inflorescence appears as lax cyme of *C. fontanum.* In the same population inflorescence may look like glomerule in the early season; while lax cyme in the late season. In the present study, we observed plants from different localities of Uttarakhand in different seasons and found the same pattern in pedicel and peduncle length and consequent inflorescence pattern. Specimens of both species, collected from Uttarakhand and housed in DD, BSD, GUH, Kumaon University herbarium and WII Dehradun, also show the same pattern in pedicel and peduncle length.

After studying the protologue of *C. glomeratum* (Thuiller 1799) it is clear that flowers in this species are strictly clustered together and form glomerule. But in the plants present in Uttarakhand this phase is not permanent rather it is transitory and ultimately forming lax cyme, hence cannot be considered as *C. glomeratum*. In lax cyme, the peduncle ultimately branches into three pedicels which is a characteristic feature of *C. fontanum* (Baumgarten 1816). *Cerastium fontanum* is also divided further into many subspecies and varieties. The most common - *C. fontanum* subsp. *vulgare* Greuter & Burdet can be distinguished from *C. fontanum* subsp. *fontanum* by the presence of both glandular and eglandular hairs; petals equaling sepals and capsules 9–13 mm long. While, *C. fontanum* subsp. *fontanum* is characterised by the presence of only eglandular hairs; petals 1.3-1.5 times as long as sepals and capsules 11–17 mm long (Morton 2005; Wyse Jackson 1995; 2000). The plants present in Uttarakhand possess both glandular hairs and eglandular hairs; petals as long as or slightly exceeding sepals and fruit length reaches up to 10 mm, hence belong to *C. fontanum* subsp. *vulgare* not the *C. glomeratum*.

3.4. Key to genera of Caryophyllaceae of Uttarakhand

1a. Leaves stipulate; sepals often with a dorsal subapical appendage; styles often fused at the base or for most of their length.....2.

1b. Leaves exstipulate; sepals without a dorsal subapical appendage; styles free or very rarely fused..... 7

2a. Stipule inconspicuous; sepal apex obtuse; fruit utricle..... .....*Herniaria*

2b. Stipule conspicuous; sepal apex acute or hooded; fruit capsule.....3

3a. Style free throughout.....4

3b. Style united at base or throughout.....5

4a. Leaves usually pseudoverticillate; stipule not connate; style 5(3).....*Spergula*

4b. Leaves decussate; stipules connate; style 3..... .....*Spergularia*

5a. Sepals herbaceous; petals usually bipartite near to base, auriculate.....*Drymaria*

5b. Sepals sacrious; petals usually entire to slightly emarginate, auricle absent.....6

6a. Leaves obovate–spathulate; sepal hooded; styles 3 distinct.....*Polycarpon*

6b. Leaves linear–oblong; sepal not hooded; styles united..... .....*Polycarpaea*

7a. Sepals free or only basally connate; petals not or only inconspicuously clawed; base of episepalous stamens often with a nectar gland.....8

7b. Sepals connate, often for most of their length; petals mostly clawed; base of episepalous stamens without nectar glan ds.....23

8a. Root flashy, tuberous; flowers dimorphic .....*Pseudostellaria*

8b. Root not tuberous; flowers monomorphic.....9

9a. Petal bipartite.....10

9b. Petal not bipartite.....11

10a. Petals usually bipartite to base; capsule ovoid–globose, capsule open up to base or near to mid.....12

10b. Petal bipartite to 1/3; capsule cylindrical, capsule open only at apex.....13

11a. Capsule open by valves as many as styles.....14

11b. Capsule open by valves twice as many as styles.....15

12a. Stem sub-scandent or stout; inflorescence many-flowered

 https://doi.org/10.63033/JWLS.SOAX9088

panicle of compound cyme; capsule with 1(–2) fertile enlarged seed .....*Schizotechium*

12b. Stem decumbent or tufted; inflorescence many-flowered dichasial cyme; capsule with many seeds.....*Stellaria*

13a. Styles 3; capsule open by 6 valves..... *Dichodon*

13b. Styles 5; capsule open by 10 valves..... *Cerastium*

14a. Petal apex lacerate; styles 2; capsule open by 2 valves..... .....*Lepyrodiclis*

14b. Petal apex obtuse or rounded; styles 3–5; capsule open by 3–5 valves.....16

15a. Stem densely tufted, cushion forming; leaves 3–5 veined.....*Cherleria*

15b. Stem erect or loosely tufted, not cushion forming; leaves strictly 3 veined.....*Sabulina*

16a. Leaves linear; styles usually 4 or 5; capsule open by 4 or 5 valves.....*Sagina*

16b. Leaves ovate–lanceolate; style 3; capsule open by 3 valves.....17

17a. Inflorescence umbellate cyme.....*Holosteum*

17b. Inflorescence various but not umbellate cyme.....18

18a. Plants cushion forming; leaves congested, linear–subulate, apex apiculate or spinose.....19

18b. Plants not cushion forming; leaves not congested, variously shaped, apex not apiculate or spinos.....20

19a. Stamen longer than sepals; style 2 (3); capsule open by 4(6) valves.....*Thylacospermum*

19b. Stamen shorter than sepals; style 3; capsule open by 6 valves.....*Eramogone*

20a. Leaves distinctly petiolate, more than 3 cm long; styles 2; capsule open by 4 valves.....*Brachystemma*

20b. Leaves sessile or subsessile; less than 3 cm long; styles 2–3; capsule open by 4–6 valves.....21

21a. Leaves and sepals saccate at base; styles 2–3..... .....*Odontostemma*

21b. Leaves and sepal not saccate; styles 3.....22

22a. Leaf base broadly forming cupular cavity at node; flower solitary; petal twice as long as sepals.....*Shivparvatia*

22b.Leaf base narrowly connate not forming cupular cavity at node; flowers numerous in cyme; petals shorter than or slightly exceeding sepals.....*Arenaria*

23a. Style 3 or 5, never 2.....*Silene*

23b. Style 2, rarely 3.....24

24a. Calyx tubular, veins more than 20..... *Dianthus*

24b. Calyx campanulate to cylindrical, veins 5.....25

25a. Leaves oblong–lanceolate; calyx conspicuously 5 wing ed.....*Gypsophila*

25b. Leaves ovate–spathulate; calyx campanulate, not winged... .....*Acanthophyllum*

Conclusion

The state Uttarakhand has varied topography including the Trans-Himalayan cold dessert, snow line, alpine meadows, temperate dense forests and open plains that allow for a high diversity of the Caryophyllaceae in the state. Our review concluded that family Caryophyllaceae in the Uttarakhand is represented by 24 genera 75 species, 2 subspecies and 6 varieties. Herbarium history, literature survey and observations by the authors revealed that 11 taxa of the family erstwhile reported from the Uttarakhand should be excluded from the flora of Uttarakhand. The taxonomic ambiguity of the *Cherleria sedoides* and *Cherleria biflora* in the Himalayas was resolved. The study reported *Cherleria sedoides* first time from India (Uttarakhand) and *Stellaria depressa* was recorded as new to the flora of Uttarakhand. In the present study, a new combination of *Stellaria patens* subsp. *patens, Stellaria patens* subsp. *semivestita* and *Sabulina kashmirica* (Edgew. & Hook. f.) Dillenb. & Kadereit var. *foliosa* are proposed. Synonymy of *Sagina purii* for *S. apetala* was concluded based on the taxonomic history and observation of the live and herbarium specimens. On the basis of morphological features, differences and occurrence of the *Cerastium glomeratum* and *C. fontanum* subsp. *vulgare* in Uttarakhand was also resolved.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY

No data was used in this research.

ORIGINALITY STATEMENT

iThenticate software shows a high overlap (>40%) with the first author's PhD thesis; however, the overlapping document is only archived on internet and not published as a peer reviewed article.

AUTHORS' CONTRIBUTION

The first author (SC) conducted field and lab studies and wrote the manuscript. The second author (DSR) further improved the manuscript and added line diagram of *Cherleria sedoides*.

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