

***SAXIFRAGA MINUTISSIMA*, A NEW SPECIES FROM THE GARHWAL HIMALAYA, INDIA, AND ITS IMPLICATIONS FOR THE TAXONOMY OF THE GENUS *SAXIFRAGA* (SAXIFRAGACEAE)**

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Saxifraga minutissima D.S.Rawat, a new and extremely small species of *Saxifraga* (Saxifragaceae), is described from the Garhwal Himalaya, India. It differs from all other species of *Saxifraga*, except *Saxifraga bicuspidata*, in having five stamens and lacking petals. It can be distinguished from *Saxifraga bicuspidata* in having leaves and sepals entire. The finely striate pollen exine pattern of *Saxifraga minutissima* indicates that the species belongs to *Saxifraga* section *Ciliatae*. Its prostrate, axillary leafy shoots and lack of crisped, rufous hairs strongly suggests a place in *Saxifraga* subsection *Serpyllifoliae*, where one of its closest relatives may be *Saxifraga stella-aurea*.

Keywords. Pollen, *Saxifraga minutissima*, *Saxifraga* section *Ciliatae* subsection *Serpyllifoliae*, Saxifragaceae, *Saxifragella*, seeds.

INTRODUCTION

Routine floristic surveys have been conducted by one of the authors (D.S.R.) in alpine zones of the Garhwal Himalaya over the last two decades. During these surveys, a remarkable new species belonging to *Saxifraga* section *Ciliatae* Haw. was discovered, and is described and illustrated here with notes on its habitat and discussion of its taxonomic relationships. The species is discussed in the context of the classification by Gornall (1987).

SPECIES DESCRIPTION

***Saxifraga minutissima* D.S.Rawat, sp. nov. Figs 1, 2.**

A congeneribus omnibus differt, praeter *Saxifraga bicuspidata* Hook.f., floribus apetalis et staminibus 5(–6). A *Saxifraga bicuspidata* foliis et sepalis integris differt. Species habitu cum *Saxifraga stella-aurea* Hook.f. & Thomson optime congruens, sed differt statura perpusilla. – Type: India, Garhwal Himalaya,

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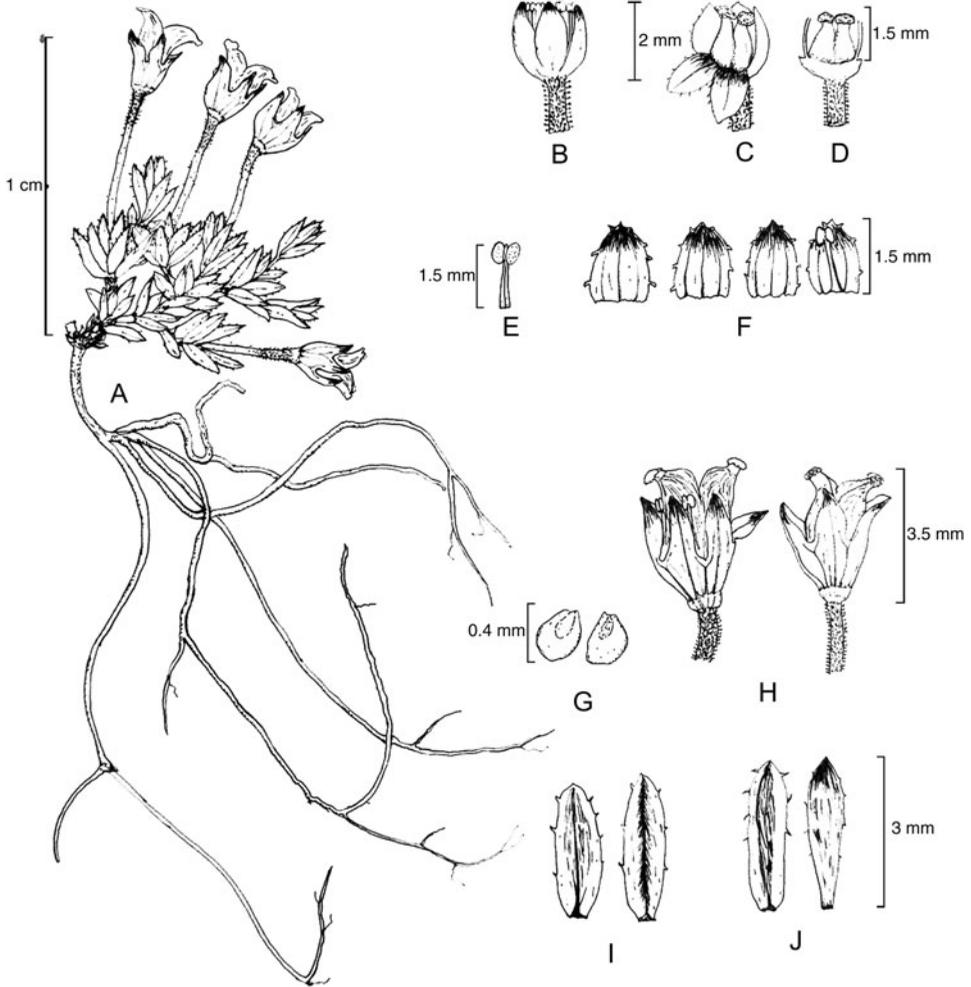


FIG. 1. *Saxifraga minutissima* D.S.Rawat, sp. nov. A, whole plant; B, flower; C–D, dissected flowers showing carpel and stamens; E, stamen; F, sepals, one showing antesepalous stamen; G, seeds; H, mature carpel; I, leaves from basal rosette; J, leaves from vegetative shoots. Drawn by Dharmendra S. Rawat.

Rudraprayag District, Vasuki Tal area near Kedarnath, in alpine zones with mosses, 4600–4800 m a.s.l., 30°44'27"N, 79°01'25"E, 10 ix 2001, *D.S. Rawat* GBPUH Acc. No. 442 (holo GBPUH (G.B. Pant University Herbarium, Pantnagar, Uttarakhand, India); iso BM).

Perennial herb, 8–13 mm tall, branched at base to form loose cushions up to 5 cm across. *Proximal axillary shoots* leafy, prostrate, with small, distal leaf rosettes. *Rosette leaves* sessile, linear to oblong-lanceolate, margin entire, glabrous or rarely with eglandular hairs, apex acute or obtuse, adaxial surface sometimes with

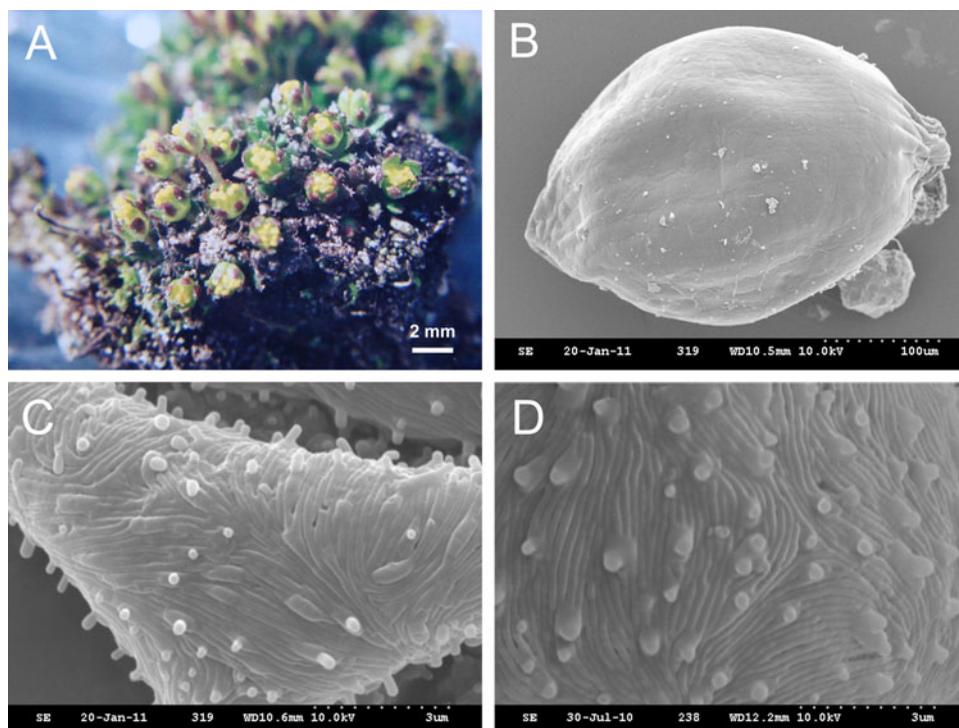


FIG. 2. A, *Saxifraga minutissima* growing with mosses; B, seed of *S. minutissima* showing its smooth surface; C, pollen exine of *S. minutissima* showing the finely striate pattern characteristic of section *Ciliatae*; D, pollen exine of *S. stella-aurea*, a putatively related species (Table 1).

eglandular hairs, $1.5\text{--}2.5 \times 0.5\text{--}1$ mm. *Horizontal stem leaves* sessile, linear to oblong-lanceolate, margin entire, glabrous or rarely with eglandular hairs, apex acute or obtuse, surface glabrous, $1.5\text{--}2 \times 0.5$ mm, somewhat fleshy. *Flowering stem* terminal, leafless, without bracts. *Flowers* solitary; pedicel (1)–3–6 mm, with brown-glandular hairs. *Sepals* 5, erect, $1\text{--}1.2 \times 0.6\text{--}1$ mm, ovate to oblong, apex reddish, acute or subacute, adaxial surface and margins glabrous, or rarely with a few brown-glandular hairs; veins 3, confluent. *Petals* 0. *Stamens* 5, rarely 6 (seen in only one out of 26 flowers dissected), antesealous, equalling sepals, filaments linear, c.0.7 mm, the dehiscent anthers c.0.3 mm, yellow, thecae parallel on dehiscence. *Ovary* semi-inferior at anthesis, ovoid to oblong, to 2.5 mm long in fruit; carpels tapered to short conical styles, styles 0.2–0.3 mm long, exceeding sepals, stigmas capitate. *Seeds* spherical to ovoid, shining brown, smooth, 0.3–0.4 mm.

Distribution. *Saxifraga minutissima* is restricted to a small area of the Garhwal Himalaya. Only two populations are currently known: one from the Vasuki Tal area, where the type was collected, and the other from 4–5 km away in Madhuganga Valley, also near Kedarnath. Specimens from the second locality are suitable

paratypes: India, Garhwal Himalaya, Rudraprayag District, Madhuganga Valley near Kedarnath, 4200–4500 m, 24 viii 2005, *D.S. Rawat* (BM); *ibid.*, 4 x 2007, *D.S. Rawat* (BM).

Ecology. The plant is very small, scarcely more than 1 cm tall, forming loose cushions reaching up to 5 cm in diameter. It grows in moist sandy places on scree slopes or along streams. Its immediate associates are mosses, from which to the casual observer it is scarcely distinguishable in its vegetative state. At both of its localities the species inhabits the higher alpine zone, being found at altitudes of 4600–4800 m in Vasuki Tal and slightly lower, 4200–4500 m, in the Madhuganga Valley (Fig. 3).

Phenology. Flowering: July–September; fruiting: September–October.

Conservation status. Data Deficient (apparently rare).

Etymology. The specific epithet refers to the impressively small size of the plants; the species is among the smallest known saxifrages.

Taxonomic relationships. The new species is assigned to *Saxifraga* on account of its alternate, exstipulate leaves, and flowers with five sepals, absence of a free hypanthium, presence of two carpels, and axile placentation. Its pollen exine is characterised by fine parallel lirae with granular suprategal processes or verrucae (Fig. 2C), a pattern that is a synapomorphy for *Saxifraga* section *Ciliatae*, for example *S. stella-aurea* (Fig. 2D) (Ferguson & Webb, 1970; Kaplan, 1981). The monophyletic status of the section also has statistically significant support from ITS sequence data (Zhang *et al.*, 2008). Within *Saxifraga* section *Ciliatae*, the presence in the new species of somewhat fleshy leaves and prostrate axillary leafy shoots, and the absence of rosette leaves and rufous, crisped hairs, indicates a position in subsection *Serpyllifoliae* (Gornall, 1987). Within that subsection, the only other very tiny species,

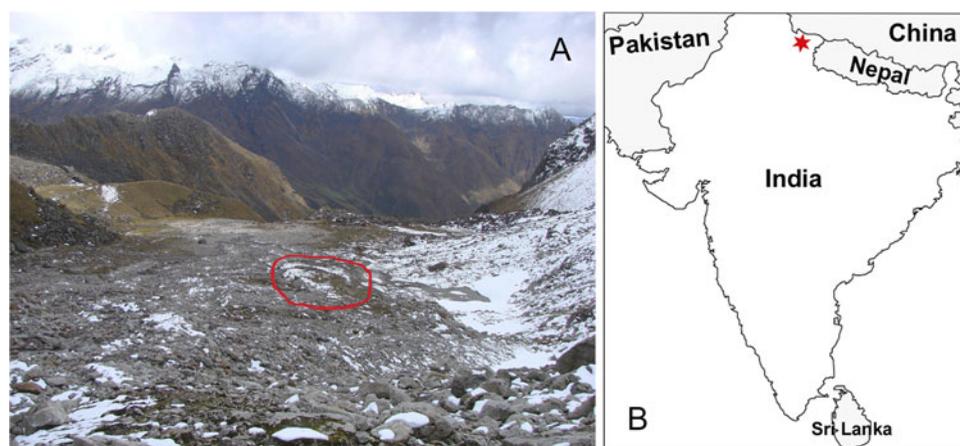


FIG. 3. Habitat (A) of *Saxifraga minutissima* (marked by a ring) in the Madhuganga Valley, Garhwal Himalaya (B, marked by a star), India.

TABLE 1. Main morphological differences between *Saxifraga minutissima* and its closest putative relatives in section *Ciliatae* subsection *Serpyllifoliae* and *S. bicuspidata*

Species	Basal leaves	Pediceal hairs	Sepals	Petals	Stamen number
<i>S. minutissima</i>	Linear to oblanceolate, 1.5–2.5 × 0.5–1 mm, apex acute to obtuse, adaxial surface and margin glabrous or rarely with eglandular hairs	Brown-glandular pubescent	Erect, apex acute to subacute	Absent	5
<i>S. inconspicua</i>	Elliptic, 1.5–3 × 0.3–1 mm, apex obtuse, glabrous	Glabrous	Erect, apex obtuse	Present, 1.5 × 0.6–0.7 mm	10
<i>S. stella-aurea</i>	Ovate to elliptic, 2–5 × 1–2 mm, apex obtuse, margin brown-glandular hairy, adaxial surface glabrous	Brown-glandular pubescent	Reflexed, apex acute to obtuse	Present, 4–7 × 1.5–3.4 mm	10
<i>S. bicuspidata</i>	Linear-spathulate, (2.5–)3–5(–7.5) × 0.7–1.4 mm, apex deeply emarginate with acute sinus, glabrous	Glabrous	Erect, apex deeply emarginate	Absent	5

which may be related, are *Saxifraga stella-aurea* and *S. inconspicua* W.W.Sm. These differ from our new species as outlined in Table 1.

DISCUSSION

The striking features of the plant are the lack of petals (instead of five) and the presence of only five stamens (instead of eight or the more usual ten), with the antepetalous whorl missing. The genus *Saxifraga* contains some 450 species, which display a remarkably constant floral morphology, viz. pentamerous, diplostemonous, bicarpellate flowers with axile placentation and lacking a free hypanthium. Deviations from this combination of characters are remarkably few but include a small group of species belonging to subsection *Kabschia* which possess tetramerous flowers with eight stamens. The occurrence of only five stamens is found otherwise

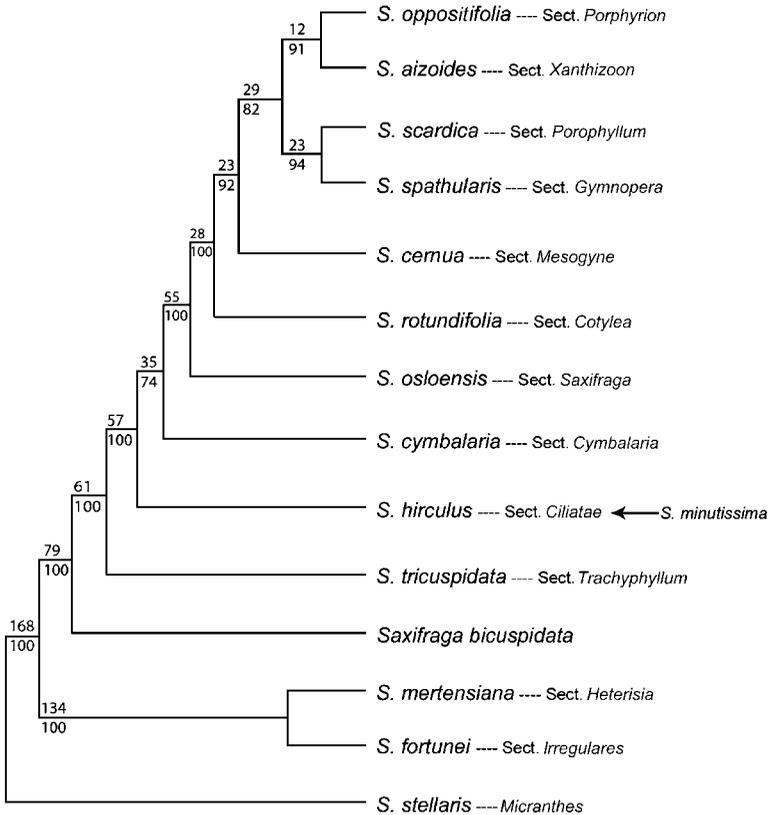


FIG. 4. Phylogenetic tree of *Saxifraga*, redrawn from the six-gene analysis by Soltis *et al.* (2001). Percentages below branches are bootstrap values; numbers above branches are the number of base substitutions. The figure shows the position of *Saxifraga bicuspadata* and the putative position of *S. minutissima* (indicated by an arrow) inferred from the pollen synapomorphy it shares with section *Ciliatae*.

only in *Saxifraga bicuspidata* (Table 1), in which they are also antesealous and which, interestingly, is similarly apetalous (Moore, 1983). Apetaly is found in two other species, namely *Saxifraga eschscholtzii* Cham. ex DC. (*Saxifraga* section *Ciliatae* subsection *Hemisphaericae*), and *S. cespitosa* f. *apetala* Engl. (*Saxifraga* section *Saxifraga* series *Caespitosae*). *Saxifraga bicuspidata* comes from the southern tip of South America, in an area around Tierra del Fuego. Although it was originally assigned to *Saxifraga* (Hooker, 1846), it was soon segregated as the monotypic genus *Saxifragella* (Engler, 1891), on account of the reduced stamen number. This arrangement has been accepted by botanists ever since (Moore, 1969), that is until Soltis *et al.* (2001) demonstrated by means of a phylogenetic analysis of six DNA regions (four chloroplast and two nuclear sequences) that the species was nested within *Saxifraga*, albeit near the base alongside species of *Saxifraga* section *Irregulares* (which have uniquely zygomorphic corollas) and *S. mertensiana* Bong. (Fig. 4).

Any notion of increasing the homogeneity of *Saxifraga* by redrawing its boundaries to exclude these basal groups clearly now has much less appeal. If our sectional assignment of the haplostemonous, apetalous *Saxifraga minutissima* is phylogenetically correct, then it is nested so deeply in the genus (Soltis *et al.*, 2001; Zhang *et al.*, 2008) that we must accept that *Saxifraga*, on occasion, may lack petals and may even have as few as five stamens. It seems probable that the very rare (for *Saxifraga*) mutations causing apetaly and five stamens in both the Himalayan *Saxifraga minutissima* and the Fuegian *S. bicuspidata* are the result of parallel evolution.

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