
PLANTS

TAXONOMY OF WILD ONIONS (*ALLIUM*) IN SASKATCHEWAN

Hyeok Jae Choi^{1,2}, Catherine Peters³, J. Hugo Cota-Sánchez^{2,3}

¹Division of Forest Biodiversity and Herbarium (KH), Korea National Arboretum, Pocheon, Gyeonggi 487-821, Korea

²Department of Biology, University of Saskatchewan, Saskatoon, SK, S7N 5E2

³W. P. Fraser Herbarium (SASK), University of Saskatchewan, Saskatoon, SK, S7N 5A8; E-mail: <hugo.cota@usask.ca>

Onions (*Allium species*) rank second in economic value after tomatoes in the list of cultivated vegetable crops worldwide.¹ For generations, humans have consumed over 20 *Allium* species other than the cultivated garden onion (*A. cepa* L.).² Both Old and New World *Allium* members are becoming popular worldwide, including edible and culinary species, e.g., Chinese chives (*A. tuberosum* Rottl. ex Spreng.) and attractive ornamental plants, such as nodding onion (*A. cernuum*) and giant onion (*A. giganteum* Regel). Similarly, consumers and researchers alike are more aware of the health benefits and medical properties of alliums.³ Despite the cultural, economic, nutritional, and health significance of *Allium* in human society, to date, its taxonomy remains complex due to the proliferation of synonyms and disagreement regarding taxonomic characters used in species boundaries. In fact, the complex taxonomic history of *Allium* involves 1400 specific epithets, some of which have been synonymised,⁴ but no comprehensive generic monograph has been compiled since that of Regel (1875).⁵

Allium is widely distributed only in the Northern hemisphere, especially in the temperate regions of Eurasia.⁶⁻⁸ The genus includes over 800 species, and

according to Raven and Axelrod (1978), *Allium* has been present in the New World since at least the Tertiary Period.⁹ Approximately 1/6 of the world's *Allium* diversity is represented in North America north of Mexico, that is, about 96 species, of which 12 are known from Canada.^{10,11}

Several criteria have been used in *Allium* classification. Among these, sexuality of flowers, structure and shape of the underground parts (including rhizome and bulb), anatomical features of root, leaf, scape, and ovary, as well as basic chromosome number have been valuable at the subgeneric and sectional levels.^{7,10,12-15} In turn, shape and size of floral organs, such as perianth, filament, pistil, capsule, and seed in addition to somatic chromosome number have taxonomic significance at the specific level.^{10,16,17}

In the past, the Canadian prairie landscape of the provinces of Alberta, Saskatchewan (SK), and Manitoba encompassed extensive grasslands, aspen parklands, and abundant wetland areas, all supporting a rich diversity of native biota.¹⁸ However, in the last decades, large prairie areas have been cleared and converted to cropland. Lamentably, the prairies now form the

largest expansion of agricultural land in Canada and represent one of the most human-altered and fragmented landscapes in the country.^{18–20} In addition to hosting unique prairie ecosystem biodiversity, the province of SK reportedly has numerous native plants, including five alliums, namely *A. schoenoprasum* var. *sibiricum*, *A. geyeri* var. *geyeri*, *A. textile*, *A. cernuum*, and *A. stellatum*.^{11,21} Among these, *A. geyeri* var. *geyeri* is included in SK's rare and endangered plant list, in addition to *A. cernuum* and *A. schoenoprasum*.^{21,22}

Although Harms (2003) provided an assessment regarding rarity status of species in SK,²¹ a formal taxonomic scheme including typification, nomenclatural history, and synonyms is lacking. It should be mentioned, however, that Scoggan (1978), Boivin (1979), and Budd (1987) treated all *Allium* species in SK, although not with the thoroughness of a detailed taxonomic monograph.^{23–25} Here, we present a taxonomic treatment of *Allium* in the province based on the combination of quantitative and qualitative data from vegetative and reproductive characters. The goals of this study were to expand the current knowledge of the morphology and distribution and to provide a taxonomic key for the species. This study provides sound foundations for updating provincial taxonomic treatments of *Allium* and the family Liliaceae.

Materials and Methods

This study is based on specimens of collections from the following herbaria: ALTA, DAO, LINN, MO, NY, SASK, and WIN. All species were also field-collected by the authors in 2009. Morphological characters from vegetative (rhizome, bulb, leaf, and scape) and reproductive (perianth, stamen, pistil, fruit, and seed) structures were measured in a minimum of 30 and 20 specimens, respectively. Parts from the middle third of the second

leaf blade and a scape of a floriferous culm were used for observation of cross-sections. Leaf and scape tissues, fixed in 70% ethanol, were hand-sectioned, stained with safranin, washed with distilled water, observed, and photographed using a TESSOVAR Photomacrographic Zoom System with a Nikon D100.

A map depicting the distributional range was prepared for each species (Fig. 1) based on herbarium specimens. The maps were generated using a customized map development tool especially designed and based on the open-source code Google™ Maps API on-line development tool. The mapping software and data used can be found at the W. P. Fraser Herbarium (SASK) website (<http://herbarium.usask.ca>). A data table of *Allium* locations for SK was generated. When latitude and longitude were not provided on the voucher specimens, the coordinates were calculated based on the locality information using the Natural Resources Canada on-line Atlas of Canada reference maps (<http://atlas.nrcan.gc.ca/site/english/maps/topo/map>). Once the data table was linked to the mapping program, the maps were plotted. The Google™ map initially presented through the mapping program had the geographic boundaries of Canada. Afterwards, it was imported into Adobe Photoshop 7.01 as a JPEG graphic, and the boundaries were removed so that only SK remained.

Results and Discussion

The following taxonomic treatment is based on a wide array of morphological characters. Characters indicated within square brackets ([]) are absent in the species of SK but are used in the description of *Allium* in floras and monographs throughout the world.

Allium L., Sp. Pl. 1: 294 (1753).
Description: Herbs perennial, bulbiferous.

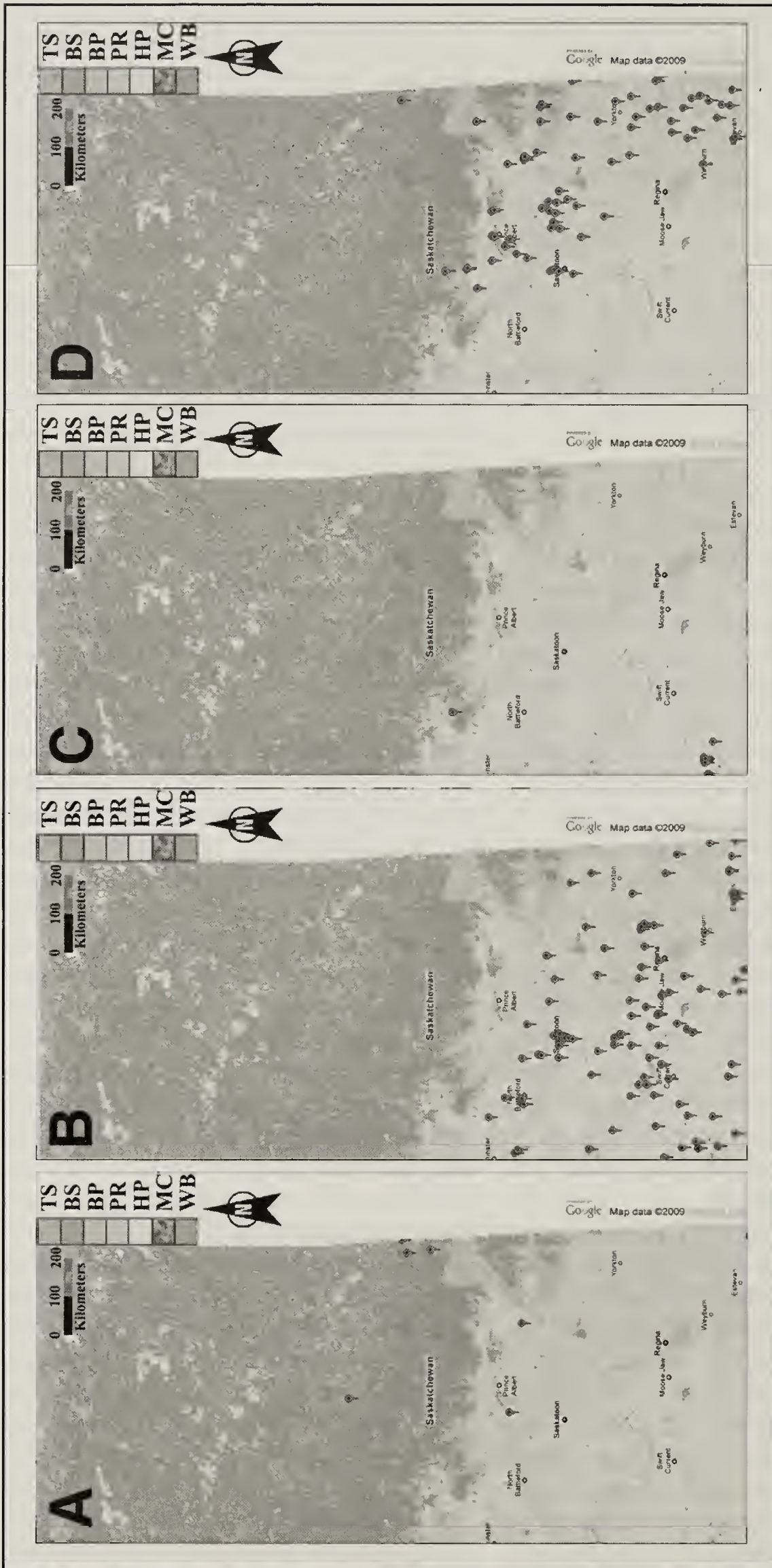


Figure 1. Geographic distribution of *Allium* species in Saskatchewan (WB: Water body; MC: Mountain Cordillera; HP: Hudson Plain; PR: Prairie; BP: Boreal Plain; BS: Boreal Shield; TS: Taiga Shield). A) *A. textile*; B) *A. schoenoprasum*; C) *A. cernuum*; D) *A. stellatum*.

Rhizomes condensed [or elongated], sometimes obsolete (not rhizomatous), erect to horizontal. Bulbs tunicate, solitary to clustered, [sometimes with basal bulbils], cylindrical to globose; tunicas membranous, papery, or fibrous, smooth to reticulate. Leaves alternate; leaf sheaths [buried] or exposed over ground; leaf blades linear [or rarely elliptical to oval], flat, angular, or terete, with 1 or 2 rows of vascular bundles, and solid or hollow in cross-section, sessile, attenuate, [or rarely narrowed into pseudo-petiole at base], acuminate [to rounded] in apex. Scapes usually central from bulbs, [slender or] stiff, erect to recurved at the upper parts, terete, angular, [or flattened-winged], with 1- to 3-circular vascular bundles, and solid or hollow in cross-section. Inflorescences terminal, usually an umbel, [sometimes replaced totally or partially by bulbils], wholly enclosed by a scarious spathe-like bract before flowering; umbels fascicled to globose; pedicels terete [or rarely angular], thinner [or rarely thicker] than the scapes, equal [to distinctly unequal] in length. Flowers bisexual [or rarely unisexual], regular, actinomorphic; perianth campanulate to stellately spreading, with greenish or reddish mid-vein abaxially; tepals 6, in 2 series, usually unequal, connate at base, persistent after flowering; inner ones oblong to ovate, acute to obtuse at apex; outer ones oblong to orbicular, acute to subrounded at apex; stamens 6; filaments adnate to the lower part of tepals, exserted or not, connate and usually dilated at base, entire [or toothed at margin]; anthers 2-locular, longitudinally dehiscent, usually elliptical, yellowish [or reddish]; ovary superior, greenish, [reddish, or brownish], trigonous [or not], sometimes with crest-like (apical) or hood-like (basal) appendages, locules 3, ovules usually 2 per locule, placenta axile; style 1, erect, filiform, exserted or not; stigma conically smooth, [capitate, or rarely trifid]. Fruits capsules, dehiscent, [subglobose],

ellipsoid, or cordiform, trigonous [or not]. Seeds black, elliptical to circular, flat to circular in cross-section.

In this study, we recognize four *Allium* species for SK, namely: *A. cernuum*, *A. schoenoprasum*, *A. stellatum*, and *A. textile*, which are the same recognized by McNeal and Jacobsen (2002) and Harms (2003),^{11,21} except that our study excludes *A. geyeri*. The existing herbarium specimens of *A. geyeri* var. *geyeri* in SK^{11,21} are misidentifications and correspond to *A. textile*.²⁶ Therefore, and even though *A. geyeri* is listed as endangered (END)²¹ and S1 (five or fewer occurrences and particularly vulnerable to extinction) in SK,²² this species should be excluded from the rare list as well as from the provincial flora.

Key to the *Allium* species of Saskatchewan

1. Leaf blades terete, hollow in cross-section; scapes hollow in cross-section; tepals 10.0–15.0 mm long; ovary ellipsoid, with hood-like appendages at base; capsules ellipsoid; seeds elliptical, angular in cross-section -----

----- **1. *A. schoenoprasum***
(Fig. 2, see inside front cover)

1. Leaf blades flat, channelled, semiterete, or V-shaped, solid in cross-section; scapes solid in cross-section; tepals 3.8–8.8 mm long; ovary subglobose, without appendages or with crest-like appendage at apex; capsules cordiform; seeds oval to broadly oval, semiterete in cross-section.

2. Rhizomes obsolete, erect, 0.5–2.7 mm long; tunicas of bulbs fibrous, reticulate; leaves 2–4 (usually 2); outer filaments non-exserted; ovary without appendage at apex; styles non-exserted; seeds broadly oval; flowering from April to July -----**2. *A. textile***
(Fig. 3, see inside front cover)

2. Rhizomes condensed, oblique, 2.0–7.7 mm long; tunicas of bulbs membranous, smooth; leaves 3–7; outer filaments exserted; ovary with crest-like appendage at apex; styles exserted; seeds oval; flowering from June to September.

3. Leaf blades nearly flat in cross-section; scapes recurved at the upper parts before and after anthesis; perianth campanulate (tepals erect), pink to white, with greenish midveins, inner tepals ovate, 5.0–6.7 mm long, 3.0–4.3 mm wide; outer tepals oval to orbicular, subrounded at apex, 3.8–4.8 mm long, 3.1–4.2 mm wide; inner filaments exserted -----

-----**3. *A. cernuum***
(Fig. 4, see inside front cover)

3. Leaf blades nearly channelled to V-shaped in cross-section; scapes recurved at the upper parts before anthesis and becoming erect during flowering; perianth stellate (tepals spreading), deep pink, with reddish midveins, inner tepals elliptical-lanceolate, 7.2–7.7 mm long, 2.3–3.5 mm wide; outer tepals elliptical, acute at apex, 6.0–6.2 mm long, 2.8–3.0 mm wide; inner filaments non-exserted -----**4. *A. stellatum***
(Fig. 5, see inside front cover)

1. *Allium schoenoprasum* L., Sp. Pl. 1: 301 (1753). Fig. 2 (see inside front cover)

= *A. sibiricum* L., Mant. Pl. Altera: 562 (1771).

= *A. schoenoprasum* L. var. *lautentianum* Fernald, Rhodora 28: 167 (1926).

We do not consider *A. schoenoprasum* L. var. *sibiricum* (L.) Hartm. treated in the SK flora by Harms (2003)²¹ as a valid name because it is not included in the International Plant Names Index database and the original publication

cannot be found.

Description: Rhizomes condensed, distinctly oblique, 5.0–10.0 mm long. Bulbs cylindrically conical, 7.0–15.0 mm in diam.; tunicas papery, smooth, dark brown. Leaves 1 or 2; leaf sheaths 7.0–20.0 cm high; leaf blades terete, hollow in cross-section, acuminate at apex, 15.0–40.0 cm long, 2.0–9.0 mm wide. Scapes erect before and after flowering, terete, hollow in cross-section, 12.0–50.0 cm long, 2.0–8.0 mm wide. Umbels subglobose, 20.0–35.0 mm high, 25.0–40.0 mm wide, without bulblets, 16–80 flowered; pedicels 5.0–10.0 mm long; bracts 11.0–20.0 mm long. Perianth campanulate, reddish pink, with reddish midveins, inner tepals nearly equal to outer ones, oblong-lanceolate, acute at apex, 11.0–15.0 mm long, 2.5–3.5 mm wide; outer tepals oblong-lanceolate, acute at apex, 10.0–15.0 mm long, 2.7–3.5 mm wide; filaments non-exserted, 3.7–7.0 mm long; anthers 1.3–1.5 mm long; ovary ellipsoid, with hood-like appendages at base, 2.3–2.8 mm long, 1.8–2.4 mm wide; style non-exserted. Capsules ellipsoid, 4.1–4.3 mm long, 3.2–3.5 mm wide. Seeds elliptical, angular in cross-section, 3.3–3.6 mm long, 1.5–1.8 mm wide.

Phenology: Flowering from June to August.

Distribution: Europe, Asia, and North America.

SK: Boreal areas, taiga shields, and lake shores of central and northern provincial areas (Fig. 1A).

Remarks: According to Choi and Cota-Sánchez (in press), this species is easily distinguished from the other *Allium* species in SK by the ovary with basal hood-like appendages and the hollow leaves and scapes.²⁶

2. *Allium textile* A. Nelson & J.F. Macbride, Bot. Gaz. 56: 470 (1913). Fig. 3 (see inside front cover)

≡ *A. geyeri* S. Watson var. *textile* (A.

Nelson & J.F. Macbride) B. Boivin, *Naturaliste Canad.* 94: 521 (1967).
= *A. aridum* Rydb., *Fl. Rocky Mts.* 159: 1061 (1917).

Description: Rhizomes nearly obsolete, erect, 0.5–2.3 mm long. Bulbs ovoid, 7.0–25.0 mm in diam.; tunicas fibrous, reticulate, gray to light brown. Leaves 2–4; leaf sheaths 3.5–10.0 cm high; leaf blades adaxially channelled to semiterete, solid in cross-section, acuminate to acute at apex, 8.0–20.0 cm long, 1.0–3.0 mm wide. Scapes curved before anthesis and becoming erect in flowering, terete, solid in cross-section, 10.0–37.0 cm long, 0.8–3.0 mm wide. Umbels subfascicled to hemispheric, 12.0–42.0 mm high, 18.0–55.0 mm wide, without bulblets, 7–41 flowered; pedicels 4.0–20.0 mm long; bracts 7.5–16.0 mm long. Perianth campanulate to urceolate, white, with reddish midveins, inner tepals narrower than outer ones, oblong, obtuse at apex, 4.5–8.8 mm long, 2.0–2.8 mm wide; outer tepals broadly ovate to lanceolate, acute to obtuse at apex, 4.0–7.8 mm long, 2.5–3.9 mm wide; filaments non-exserted, 2.7–5.3 mm long; anthers 0.9–1.5 mm long; ovary subglobose, without appendages, 1.3–2.0 mm long, 1.4–1.9 mm wide; style non-exserted. Capsules cordiform, 3.5–4.6 mm long, 3.6–5.2 mm wide. Seeds broadly oval, semicircular in cross-section, 2.5–3.0 mm long, 1.8–2.1 mm wide.

Phenology: Flowering from April to July.

Distribution: North America.

SK: Dry grasslands, hills, and riversides of central to southern parts of the province (Fig. 1B).

Remarks: *Allium textile* is the most widespread species of the genus in SK (Fig. 1B) and exhibits extreme variability in plant length, leaf number, and floral size.²⁶ Although most plants have two leaves, some specimens have three or four. Our field observations indicate that individuals with three or four leaves tend

to develop a longer perianth than those individuals with two leaves. Specimens of *A. textile* with more than three leaves have been misidentified as *A. geyeri* var. *geyeri* in various Canadian herbaria, but the former is easily distinguished by its white perianth (as opposed to pink in *A. geyeri*; see Fig. 3, inside front cover) and nearly absent crest-like appendage in the ovary (as opposed to distinct appendage in *A. geyeri*) as well as longer pedicel and shorter scape.²⁶ Similarly, the type specimen of *A. geyeri* var. *geyeri* from the Rocky Mountains filed at NY shows several differences from the SK specimens labeled "*A. geyeri* var. *geyeri*", especially in inflorescence size and perianth colour. In addition, *A. textile* is clearly distinguished by granulate seed testa periclinal cell walls from *A. geyeri* var. *geyeri*, which have verrucate walls.²⁶

3. *Allium cernuum* Roth, *Arch. Bot.* (Leipzig) 1: 40 (1798). Fig. 4 (see inside front cover)

= *A. allegheniense* Small, *Bull. New York Bot. Gard.* 1: 279–280 (1899).

= *A. recurvatum* Rydb., *Mem. New York Bot. Gard.* 1: 94 (1900).

Description: Rhizomes condensed, oblique, 2.0–7.7 mm long. Bulbs ovoid, 8.3–22.0 mm in diam.; tunicas membranous, smooth, gray to brown. Leaves 3–7; leaf sheaths 3.0–10.0 cm high; leaf blades nearly flat, solid in cross-section, acuminate to obtuse at apex, 5.0–27.5 cm long, 1.2–8.0 mm wide. Scapes recurved at the upper parts before and after anthesis, terete to angular, solid in cross-section, 13.5–48.0 cm long, 1.1–4.0 mm wide. Umbels hemispheric to globose, 17.0–42.0 mm high, 21.0–46.3 mm wide, without bulblets, 12–42 flowered; pedicels 6.0–20.0 mm long; bracts 9.0–13.5 mm long. Perianth campanulate, pink to white, with greenish midveins, inner tepals unequal to outer ones, ovate, acute at apex, 5.0–6.0 mm long, 3.0–4.3 mm wide; outer tepals oval

to orbicular, subrounded at apex, 3.8–4.8 mm long, 3.1–4.2 mm wide; filaments exerted, 3.5–9.0 mm long; anthers 1.8–2.0 mm long; ovary subglobose, with crest-like appendages at apex, 2.2–3.0 mm long, 2.4–3.0 mm wide; style exerted. Capsules cordiform, 3.8–6.5 mm long, 4.3–6.5 mm wide. Seeds oval, semicircular in cross-section, 2.5–3.8 mm long, 2.0–2.4 mm wide.

Phenology: Flowering from June to August.

Distribution: North America.

SK: Dry hills and arid slopes in central-western and south-western regions (Fig. 1C).

Remarks: Taxonomically, *A. cernuum* is closely related to *A. stellatum*.¹¹ The character most commonly used to differentiate these two species is the orientation of the umbel-shaped inflorescence. In both species, the inflorescence may often be nodding (recurved) in the budding stage, but in *A. stellatum*, the inflorescence usually becomes erect during anthesis (Fig. 5, see inside front cover). In *A. cernuum*, the scape remains permanently curved near the apex (Fig. 4, see inside front cover), but sometimes the inflorescence may become erect or nearly so.¹¹ In addition, the perianth shape in *A. cernuum* is campanulate with ascending tepals (Fig. 4, see inside front cover), while in *A. stellatum* it is stellate with apically spreading tepals (Fig. 5, see inside front cover). Also *A. cernuum* differs from *A. stellatum* in having verrucate periclinal cell walls of seed testa.²⁶

4. *Allium stellatum* Ker Gawler, Bot. Mag. 38: 1576 (1813). Fig. 5 (see inside front cover)

Description: Rhizomes condensed, oblique, 2.0–7.0 mm long. Bulbs ovoid, 8.0–17.7 mm in diam.; tunicas membranous, smooth, gray to brown. Leaves 3–7; leaf sheaths 5.0–11.0 cm high; leaf blades channelled to V-shaped,

solid in cross-section, acuminate to acute at apex, 15.0–36.0 cm long, 1.0–3.6 mm wide. Scapes usually recurved at the upper parts before anthesis and becoming erect in flowering, terete to dully angular, solid in cross-section, 25.0–62.0 cm long, 1.3–2.8 mm wide. Umbels subfascicled to hemispheric, 16.0–34.0 mm high, 24.0–48.2 mm wide, without bulblets, 10–54 flowered; pedicels 8.5–20.2 mm long; bracts 9.3–19.7 mm long. Perianth stellate, deep pink, with reddish midveins, inner tepals unequal to outer ones, elliptical-lanceolate, acute at apex, 7.2–7.7 mm long, 2.3–3.5 mm wide; outer tepals elliptical, acute at apex, 6.0–6.2 mm long, 2.8–3.0 mm wide; filaments exerted (outer) or not (inner), 7.0–7.5 mm long; anthers 2.0–2.4 mm long; ovary subglobose, with crest-like appendages at apex, 2.7–3.2 mm long, 3.0–4.0 mm wide; style exerted. Capsules cordiform, 4.0–5.0 mm long, 4.1–5.0 mm wide. Seeds oval, semicircular in cross-section, 2.5–3.3 mm long, 1.5–2.2 mm wide.

Phenology: Flowering from July to September.

Distribution: North America.

SK: Open plains and wooded areas of central-eastern to south-eastern parts (Fig. 1D).

Remarks: This species is widely distributed and relatively common in the prairies and adjacent boreal plains of south-eastern SK. Its closely related species, *A. cernuum*, occurs allopatrically in the boreal shield areas of two isolated areas (Cypress Hills and Meadow Lake) of SK (Fig. 1C, D).

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1. Food and Agriculture Organization of the United Nations (FAO) (2001) Agrostat database. Available at: <http://fao.org/>.

2. van der Meer QP (1997) Old and new crops within edible alliums. *Acta Horticulturae* 433:17-31.

3. Keusgen M (2002) Health and alliums. In: Rabinowitch HD, Currah L (eds) *Allium crop science: recent advances*. CABI Publishing, New York, NY, p 357-378.

4. Gregory M, Fritsch RM, Friesen N, Khassanov FO, McNeal DW (1998) Nomenclator Alliorum: *Allium* names and synonyms - a world guide. Royal Botanic Gardens, Kew, Richmond, Surrey.

5. Regel E (1875) *Alliorum adhuc cognitorum monographia*. Petropolis.

6. Xu JM, Kamelin RV (2000) *Allium* L. In: Wu ZY, Raven PH (eds) *Flora of China*. Vol. 24. Science Press and Missouri Botanical Garden Press, Beijing and St. Louis, MO, p 165-202.

7. Friesen N, Fritsch RM, Blattner FR (2006) Phylogeny and new intrageneric classification of *Allium* (Alliaceae) based on nuclear ribosomal DNA ITS sequences. *Aliso* 22:372-395.

8. Neshati F, Fritsch RM (2009) Seed characters and testa sculptures of some Iranian *Allium* L. species (Alliaceae). *Feddes Repertorium* 120:322-332.

9. Raven PH, Axelrod DI (1978) Origin and relationships of the Californian flora. *University of California Publications in Botany* 72:1-134.

10. McNeal DW (1992) Taxonomy of North American species of *Allium*. In: Hanelt P, Hammer K, Knupffer H (eds) *The genus Allium – taxonomic problems and genetic resources*. Proceedings of an International Symposium, Gatersleben, 11–13 June 1991, p 195-204.

11. McNeal DW, Jacobsen TD (2002) *Allium* L. In: Editorial Committee of Flora of North America (eds) *Flora of North America*. Vol. 26. NYBG Press, New York, NY, p 224-276.

12. Fritsch RM (1992) Sepal nectarines in the genus *Allium*. In: Hanelt P, Hammer K, Knupffer H (eds) *The genus Allium – taxonomic problems and genetic resources*. Proceedings of an International Symposium, Gatersleben, 11–13 June 1991, p 77-85.

13. Hanelt P, Schulze-Motel J, Fritsch RM, Kruse J, Maass H, Ohle H, Pistrick K (1992) Infrageneric

grouping of *Allium* - the Gatersleben approach. In: Hanelt P, Hammer K, Knupffer H (eds) *The genus Allium – taxonomic problems and genetic resources*. Proceedings of an International Symposium, Gatersleben, 11–13 June 1991, p 107-123.

14. Gurushidze M, Fritsch RM, Blattner FR (2008) Phylogenetic analysis of *Allium* subg. *Melanocrommyum* infers cryptic species and demands a new sectional classification. *Molecular Phylogenetics and Evolution* 49:991-1007.

15. Choi HJ (2009) Systematics of the genus *Allium* (Alliaceae) in Korea and northeastern China. Ph.D. thesis, Department of Biology, Chungbuk National University, Cheongju, Chungbuk, Korea.

16. Choi HJ, Jang CG, Lee YM, Oh BU (2007) A taxonomic study of Korean *Allium* L. based on morphological characters. *Korean Journal of Plant Taxonomy* 37:275-308.

17. Ko EM, Choi HJ, Oh BU (2009) A cytotoxic study of *Allium* (Alliaceae) sect. *Sacculiferum* in Korea. *Korean Journal of Plant Taxonomy* 39:170-180.

18. Pasitschniak-Arts M, Messier F (1999) Status of small mammals on the prairies: research priorities and implications for conservation. In: Thorpe J, Steeves TA, Collop M (eds) *Provincial Museum of Alberta National History Occasional Paper 24*. Proceedings of the 15th Prairie Conservation and Endangered Species Conference, Saskatoon, SK, 19–22 February 1998. Curatorial Section Provincial Museum of Alberta, Edmonton, AB.

19. Acton DF, Padbury GA, Stushnoff CT (1998) *The ecoregions of Saskatchewan*. Hignell Printing Limited, Winnipeg, MB.

20. Fung KI (1999) *Atlas of Saskatchewan*. PrintWest, Saskatoon, SK.

21. Harms VL (2003) Checklist of the vascular plants of Saskatchewan and the provincially and nationally rare native plants of Saskatchewan. University Extension Press, University of Saskatchewan, Saskatoon, SK.

22. Saskatchewan Conservation Data Centre (SCDC) (2010) Saskatchewan vascular plant species list. Regina, SK. Available at: <<http://www.biodiversity.sk.ca/Docs/ranking.pdf>> [accessed 5 May 2010].

23. Scoggan HJ (1978) *The flora of Canada*. Part 2. National Museums of Canada. Ottawa, ON. pp. 488–492.

24. Bovin B (1979) *Flora of the prairie provinces*. Part IV. Ottawa, ON.

25. Budd AC (1987) *Budd's flora of the Canadian prairie provinces*. Canada Communication Group, Ottawa, ON.

26. Choi HJ, Cota-Sánchez JH (2010). A taxonomic revision of *Allium* (Alliaceae) in the Canadian Prairie Provinces. *Botany* 88: in press.