Carex tokuii (Sect. Mitratae, Cyperaceae), a New Species from Japan and Korea

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Carex tokuii J. Oda & Nagam. is described from Japan and Korea. This species is very similar to C. rugata Ohwi in having pale green scales, glabrous perigynia, and especially achenes concave at the middle of three faces. However, this species is easily distinguished from C. rugata by many quantitative characters. The length of staminate and pistillate scales, length of staminate and pistillate spikes, length of leaf blades of lowermost bract, number of pistillate spikes per culm, length of culms, leaf width and length of achenes are usually larger in C. tokuii than C. rugata. Moreover, C. tokuii and C. rugata showed different qualitative achene morphology. The stipes of achenes are nearly straight (rarely ascending) to the base in C. tokuii, while they are curved abruptly in C. rugata (rarely ascending). The central silica bodies on achene epidermis are large and well developed in C. tokuii, but are small and sometimes invisible in C. rugata. Habitat and habit of rhizomes also tend to differ from each other. Carex tokuii grows at mesic forest edge, while C. rugata grows in rather wet places near stream or marsh. The rhizomes are caespitose in C. tokuii, but are loosely tufted and sometimes long-ascending, forming matted populations in C. rugata. Carex tokuii is distributed in Shikoku (southwestern area of Ehime Pref.) and Kyushu (Tsushima, Nagasaki Pref., and Sakurajima, Kagoshima Pref.) in Japan, and Gwangju-shi and Jeollanam-do in South Korea.

Key words: Achene micromorphology, Carex rugata, Carex tokuii, Cyperaceae, new species.

Carex L. is the largest genus in Cyperaceae and is distributed worldwide consisting of over 2000 species (Reznicek 1990). In the genus, sect. Mitratae Kük. is much diversified in Eastern Asia especially in Far Eastern Asia including about 50 species (Akiyama 1955). In this section, six subsections were recognized by Akiyama (1955). Of them, subsect. Leucochlorae Akiyama comprising twelve species is characterized in having rather small plant size and pale staminate and pistillate scales (Akiyama 1955). Carex rugata Ohwi is the only species that has the achenes with three wrinkled faces in this subsection, so, is one of the species easily identified despite gross morphological similarities with other species of this subsection. Carex rugata had been thought to be endemic to Japan, north to Hokkaido and south to Kyushu (Akiyama 1955). This species was, however, reported from Anhui and Fujian, China (Tang 2000) and Gwangju-shi, Jeollabuk-do and Jeollanam-do, South Korea (Masaki et al. 2012,
Ji et al. 2014).

The late Mr. Osamu Tokui collected a strange sedge at the forest edge along the Sozu River, in Johen-cho, Minamiuwa-gun, Ehime Pref., Shikoku in 1989 (Fig. 1). There is no doubt that this plant is closely related to *Carex rugata* in having thin and glabrous perigynia and achenes wrinkled at the three faces. Mr. Tokui, however, showed some data comparing the plant with *C. rugata* and pointed out that the culm is higher, the bract is longer, and the staminate and pistillate spikes of the plant are longer than those of *C. rugata* (Tokui 2005). He annotated the plant as “nagabo-kusasuge” on the labels of his specimen which means the plant has longer spikes than those of *C. rugata* (Fig. 2B, E). We made some examinations to clarify the taxonomic status of “nagabo-kusasuge” and detected many significant differences in quantitative characters to distinguish *C. rugata* and “nagabo-kusasuge”. Moreover, the habitat, the habit of rhizomes, and the achene morphology were also different between them. Here, we propose a new species, *Carex tokuii* J. Oda & Nagam. named after the late Mr. Osamu Tokui.

**Materials and Methods**

The specimens of *Carex rugata* and the plants referable to *C. tokuii* deposited in FU, KYO, OKAY, SAPS, TUS were examined. Field surveys are also made to observe the habitat and the habit of *C. rugata* and *C. tokuii*. In our preliminary observations, specimens referable to *C. tokuii*, characterized by Tokui (2005) were found from Sakurajima (Kagoshima Pref.), Tsushima (Nagasaki Pref.), and South Korea (Gwangju-shi and Jeollanam-do). The plants from Korea were reported as *C. rugata* by Masaki et al. (2012). Considering morphological variations and geographical distributions, we selected 30 specimens of *C. rugata* including the type specimen and a specimen from China, and 17 specimens of *C. tokuii* for morphological analyses.

To evaluate quantitative characters, the following were measured and calculated: the length of culm, the width of leaf, the length of the blade of the lowermost bract, the length of staminate spike, the length of staminate scale, the number of pistillate spikes per culm, the length of the lowermost pistillate spike, the length of pistillate scale, and the length of achene. The number of pistillate spikes per culm were calculated as the mean value of ten flowering stems in a herbarium sheet.

The achene morphology and micromorphology were also examined. Stipes of achenes was observed after removing from perigynia. Observation of the perigynia and enclosed achene and achene micromorphology followed Oda and Nagamasu (2011).

**Results and Discussion**

*Carex tokuii* J. Oda & Nagam., **sp. nov.**

[Figs. 1, 2A–C, 3A–B, 4]

Affinis *Carici rugato* cum superficiebus acheniorum rugatis, sed rhizomatibus caespitosis, squamis femineis longioribus (2.0–2.5 mm), spicis femineis pluribus (4–5), longioribus (imis 15–30 mm longis), stipitibus acheniorum fere rectis differt.


Perennial herbs. Rhizomes tufted rarely shortly ascending in large plant. Culms central and lateral, many, obtusely trigonous, 30–55 cm tall, 1–2 mm thick. Leaves linear as long as culms, (3–)3.5–5 mm wide, basal sheaths light brown. Inflorescence racemose; terminal spike staminate and lateral spikes pistillate with leafy bract sheathing at the base. Stamineate spike solitary, linear, (10–)15–25 mm long, 1 mm thick, pale green. Staminate scales 3-nerved, pale green with greenish center, oblong, acute, (3.3–)3.5–4.5(–4.7) mm long. Stamens 3. Pistillate spikes (3–)4–5, oblong to linear,
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Table 1. Comparison of qualitative characters between Carex tokuii and C. rugata

<table>
<thead>
<tr>
<th>Character</th>
<th>C. tokuii</th>
<th>C. rugata</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat</td>
<td>in mesic place of forest edge</td>
<td>in rather wet place near streams or marshes</td>
</tr>
<tr>
<td>Rhizomes</td>
<td>tufted</td>
<td>loosely tufted to ascending</td>
</tr>
<tr>
<td>Achene stipe</td>
<td>nearly straight (rarely ascending)</td>
<td>curved abruptly (rarely ascending)</td>
</tr>
<tr>
<td>Central bodies of achene epidermis</td>
<td>well developed</td>
<td>small and sometimes invisible</td>
</tr>
</tbody>
</table>

(12–)15–30(–35) mm long, 2 mm thick, dull green. Pistillate scales 3-nerved, pale green with greenish center, obovate, shortly aristate, (1.9–) 2.0–2.5(–2.6) mm long excluding awn (awn 0.2–0.5 mm long). Perigynia obovate, glabrous, 10–13-nerved, membranous, subabruptly tapering to shortly bidentate beak, 2.5–3.2 mm long, dull green. Achenes light brown, three ridged, oblong, wrinkled at the middle of three faces, 1.6–2.0(–2.1) mm long, 0.8–0.9 mm wide; stipes usually straight to the base; base of style with an appendage; silica bodies on epidermal
cells concave with well developed central body and sinuate anticlinal wall. Stigmas 3.

Japanese name: Nagabo-kusasuge (O. Tokui in sched.). Distribution: Japan (Shikoku and Kyushu) and South Korea (Fig. 4).

Habitat: On mesic forest edge along the streams in low mountains.

Other specimens examined for analyses (including t-test): JAPAN. Ehime Pref., Midoriotsu, Ainan-cho, Minamiuwa-gun, O. Tokui 5042 (KYO); Shimokajisato, Midori, Johen-cho, Minamiuwa-gun, O. Tokui 1195, 1359, 5046 (KYO); Toyota, Johen-cho O. Tokui 1232 (KYO); Kamikajisato, Midori, Johen-cho, Minamiuwa-gun, O. Tokui 1355 (KYO). Kyushu. Nagasaki Pref., Izuhara, Izuhara-cho, Tsushima-shi, Y. Hayashi s.n. (KYO), T. Hoshino & al. 21289 (KYO). Kagoshima Pref., Sakurajima, Y. Doi 40 (KYO).


Habitat and habit of rhizomes

In our observations in Japan and Korea, Carex rugata often grows in wet places along streams or in marshes, but C. tokuii grows in mesic places at forest edge even if they occur near the streams. Carex rugata is usually loosely tufted and sometimes the aerial shoots arise from ascending rhizomes (Fig. 2D), forming a matted population, while C. tokuii is caespitose (Fig. 2A) although there are cases where it grew to large size, rhizomes shortly elongate to get space for the aerial shoot. Matted populations of C. tokuii have not been found so far (Table 1).

Quantitative characters

In nine quantitative characters (see Table 2), significant differences were detected. Of them, the length of pistillate scales is 1.9–2.6 mm (mean ± SD: 2.20 ± 0.18 mm) in Carex tokuii, while 1.5–2.1 mm (mean ± SD: 1.74 ± 0.14 mm) in C. rugata (Fig. 2C, F). The length of pistillate scales showed the lowest p value in t-test (p < 0.001). Number of pistillate spikes showed the second lowest p value (p < 0.001). Length of leaf blade of lowermost bract, and length of pistillate spikes also showed low p value (p < 0.001, Fig. 2B, E). Achene length, length of staminate spikes, leaf width, length of culms and length of staminate scales were also distinguishable (p < 0.01).

Shape of achene stipe

The stipe of achenes curved abruptly almost at a right angle (Fig. 3C) in 28 of 30 plants of Carex rugata including the type specimen and the specimen from China, while those tend to be nearly straight to the base (Fig. 3A) in 14 of 17 plants of C. tokuii.
Ascending stipes were observed in five of 47 plants, however, straight stipe in \textit{C. rugata} and abruptly curved stipe in \textit{C. tokuii} was not found, so, shape of the stipe is an important character to distinguish \textit{C. tokuii} and \textit{C. rugata}.

\textbf{Achene micromorphology}


In both \textit{C. rugata} and \textit{C. tokuii}, silica bodies of achene epidermis have sinuate anticlinal wall, concave platform, and a central body, supporting the close relationship between \textit{C. rugata} and \textit{C. tokuii}. However central bodies are small and sometimes invisible in \textit{C. rugata} (Fig. 3D), while central bodies are all well developed in \textit{C. tokuii} (Fig. 3B). No exception was found in this character.

\textbf{Distribution}

\textit{Carex tokuii} is disjunctively distributed in Japan, southwestern area of Ehime Pref., Kagoshima Pref., and Tsushima, Nagasaki Pref. Ji et al. (2014) reported ten localities of \textit{C. rugata} from Jeollabuk-do and Jeollanam-do in Korea. The decision if these specimens reported by Ji et al. (2014) are referable to \textit{C. tokuii} or not could not be made at present because we could not exactly judge from their description and drawings.

We are grateful to the late Mr. Osamu Tokui for giving us valuable information and material of \textit{Carex tokuii} and \textit{C. rugata} from Ehime Pref. We are also deeply grateful to Xiao-Feng Jin,
Hangzhou Normal University for giving us excellent material from China, Dr. Hyong-Tak Im, Chonnam National University, Korea for coordinating field survey in Korea and curator of FU, OKAY, SAPS, and TUS for permitting our herbarium examination. We also thank Mr. Tatsunari Noguchi, Tochigi Pref., Mr. Yoshitaka Hayashi, Tokyo Pref. and Mr. Katsutoshi Maruno, Kagoshima Pref. for giving us useful information.

References

Appendix

China. Zhejiang. Mt. Baishamzu, X. F. Jin 0117. (All specimens are deposited in KYO)
織田二郎\textsuperscript{a}, 正木智美\textsuperscript{b}, 永益英敏\textsuperscript{c}: スゲ属ヌカスゲ節（カヤツリグサ科）の新種ナガボクサスゲ

スゲ属ヌカスゲ節 Carex sect. Mitratae（カヤツリグサ科）の新種ナガボクサスゲ Carex tokuii J. Oda & Nagam. を記載した。本種は白緑色の花穂、無毛の果胞を持ち、特に穂果の3面が中央部で凹むことでクサスゲ C. rugata Ohwi ときわめて類似しているが、多くの量的形質において相違が認められる。地理的、形態的変異を考慮して選んだナガボクサスゲ 17 個体、クサスゲ 30 個体を調べたところ、雌花穂の長さ、雌花穂の数、最下苞葉の葉身部の長さ、最下雌花穂の茎の高さに対する相対的高さ、雌花穂の長さなど9形質について有意に異なり、ナガボクサスゲとクサスゲは別種であると判断された。穂果の柄がほぼ真っ直ぐである（クサスゲではほぼ直角に曲がる）、穂果表面のケイ酸体の中央体がよく発達している（クサスゲでは発達が悪く、時に見えない）点など穂果の形態における質的な相違も重要な判別形質である。また、生育環境についても、ナガボクサスゲはクサスゲよりは湿り気の少ない場所で生育している場合が多く、根茎も叢生し、クサスゲのようにマット状に広がることは無いなどの相違点が見られる。日本では四国（愛媛県南東端）、九州（長崎県・対馬、鹿児島県・桜島）、韓国では南部の光州市や全羅南道での分布が明らかになった。ナガボクサスゲは愛媛県の故 得居 修氏によって発見され、その後の研究を我々が引き継いだものである。韓国では最近多くのクサスゲの産地が報告されているが、それらもナガボクサスゲであるかどうかについて今後の解明が望まれる。

\textsuperscript{a}奈良県香芝市\textsuperscript{b}岡山理科大学生物地球学部、\textsuperscript{c}京都大学総合博物館