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Full paper

Puccinia galiiuniversa, a new caricicolous rust fungus systemically inhabiting *Galium aparine* in its spermogonial–aecial stage☆

Izumi Okane [a,*], *Yuichi Yamaoka* [a], *Makoto Kakishima* [a], *Junichi Peter Abe* [a], *Kazuo Obata* [b]

[a] *Faculty of Life and Environmental Sciences, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8572, Japan*

[b] *Ibaraki Nature Museum, 700 Osaki, Bando, Ibaraki 306-0622, Japan*

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ABSTRACT

Field observations and inoculation experiments revealed that spermogonia and aecia produced on systemically infected plants of *Galium aparine* and uredinia and telia on *Carex maackii* are different stages of the life cycle of a *Puccinia* fungus. By comparative morphology with allied species, the fungus was concluded to be a new species and named as *Puccinia galiiuniversa*.

1. Introduction

Systemically infected plants of *Galium aparine* L. [= *G. spurium* L. var. *echinospermon* (Wallr.) Hayek] were found in the riparian vegetation along the Tone River and along Sugao Marsh, Ibaraki, Central Honshu, Japan. All leaves of the infected plants had spermogonia (type 4 of Hiratsuka and Cummins 1963) and aecia (aecidium type of Sato and Sato 1985). Based on morphological observations, this rust seemed to be a spermogonial–aecial stage of a heteroecious species of *Puccinia* or *Uromyces*. An undescribed *Puccinia* species with hyaline teliospores germinable without dormancy was collected on *Carex maackii* Maxim, in the same riparian vegetation.

Seventy-two caricicolous rusts have been reported in Japan (Kakishima and Sato 1980; Kakishima and Sato 1982; Harada 1986; Hiratsuka et al. 1992; Okane and Kakishima 1992; Kakishima et al. 1999; Ono 2001; Ono et al. 2001). Among them, 70 species producing uredinial and/or telial stages on *Carex* species belong to the genus *Puccinia* Pers., and the other two are *Uromyces caricis-brunneae* Y. Morimoto and *Uredo caricis-incisae* S. Ito ex S. Ito et Murayama. No caricicolous–heteroecious rust fungi producing spermogonial–aecial stages on *Galium* and other rubiaceous species have been reported

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* *Corresponding author*. Tel./fax: +81 29 853 6687.
E-mail address: okane.izumi.fw@u.tsukuba.ac.jp (I. Okane).

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Table 1 – Results of the field observation.

Locality	Date of survey	Presence of host plant/rust sorus[a]	
		G. aparine	*C. maackii*
Tone River, Togashira, Toride, Ibaraki Pref.	29 Apr 2010	+/I	+/–
	14 Nov 2010	+/–	+/II, III
	10 Jan 2011	+/–	+/II, III
	3 May 2011	+/I	+/–
	5 Jun 2011	+/I	+/II
	16 Nov 2011	+/–	+/II, III
	4 Dec 2011	+/–	+/II, III
	22 Apr 2012	+/I	+/–
Sugao Marsh, Osaki, Bando, Ibaraki Pref.	11 Apr 2009	+/I	+/–
	19 Dec 2010	+/–	+/II, III
	7 May 2011	+/I	+/–

[a] +: Host present, I: aecial stage, II: uredinial stage, III: telial stage, –: no sorus.

previously, not only in Japan, but also in other regions (Saccardo 1888, 1899, 1905; Cunningham 1924; Arthur 1934; McKenzie 1998; Wang and Zhuang 1998; Kuo and Chen 1999; Kim et al. 2004; Azbukina 2005; Kazeroni et al. 2010; Singh and Palni 2011; Bahcecioglu and Kabaktepe 2012).

In the present study, we carried out a field survey and inoculation experiments to confirm the life cycle connection between the rust fungus on *C. maackii* and *G. aparine*. We performed morphological analysis of the rust fungus in comparison with related *Puccinia* and/or *Aecidium* species reported from *Carex*, *Galium*, and other rubiaceous plants to determine its taxonomy. This rust is described as a new heteroecious species belonging to the genus *Puccinia*.

2. Materials and methods

2.1. Field survey

We visited the riparian vegetation along the Tone River, Togashira, Toride, Ibaraki, and that along Sugao Marsh, Osaki, Bando, Ibaraki and Otsukado-machi, Jyoso, Ibaraki, Central Honshu, Japan between Apr 2009 and Apr 2012 (Table 1). Spore production of the rust on *C. maackii* and *G. aparine* was observed.

2.2. Inoculation experiments with aeciospores collected in the field

Aeciospores on systemically infected *G. aparine* were collected from the riparian vegetation along the Tone River, Togashira, and that along Sugao Marsh, Osaki, and Otsukado-machi (Table 2).

Carex maackii was collected from the riparian vegetation along the Tone River, Togashira and that along Sugao Marsh, Osaki. They were planted in plastic pots and grown in a growth cabinet at a controlled temperature of ca. 20 °C under 16 h light (50 μmol m^{-2} s^{-1}): 8 h dark photoperiod. Young fresh leaves of *C. maackii* in the pots were inoculated with aeciospores using a small (ca. 3 × 3 mm) filter paper dusted with spores using a scalpel and then placed on the lower surface of the leaves. After keeping in a moist chamber overnight, the plants were incubated in a growth cabinet under the above conditions. They were observed continuously for 3 week after inoculation.

2.3. Inoculation experiments with basidiospores

Teliospores produced on *C. maackii* were collected from the riparian vegetation along the Tone River, Togashira on 16 Oct 2011 and 4 Dec 2011 (Table 3). They were also collected from the riparian vegetation along Sugao Marsh, Osaki and Otsukado-machi.

Small seedlings of *G. aparine* were collected from a field in Azuma, Tsukuba, Ibaraki, Japan. This field is located in an urban area far from large rivers and ponds. It was used to survey the rust flora between 2006 and 2008 (Yamaoka et al. 2009), and also occasionally since then. No rust infection on *G. aparine* had been detected previously. The collected seedlings were planted in plastic pots and incubated in a growth cabinet under the same conditions as described for *C. maackii*. When inoculated on 28 Oct 2011, the seedlings had two to three verticillate leaves.

Leaves of *C. maackii* with telia were cut into segments ~5 mm in length, which were placed on top of the shoots of

Table 2 – Aeciospores on *Galium aparine* used in inoculation experiments and results of inoculation experiments with the aeciospores.

No.	Aeciopsores as inoculum			Inoculation experiments with aeciospores to *Carex maackii*		
	Locality of collection	Date of collection	Voucher specimen no.	Date of inoculation	Date of the first appearance of uredinia (days after inoculation)	Voucher specimen no.
As-1	Tone River, Togashira, Toride, Ibaraki Pref.	3 May 2011	TSH-R 11875	3 May 2011	16 May 2011 (13 days)	TSH-R 11898
As-2	Tone River, Togashira, Toride Ibaraki Pref.	3 May 2011	TSH-R 11876	3 May 2011	16 May 2011 (13 days)	TSH-R 11899
As-3	Sugao Marsh, Osaki, Bando, Ibaraki Pref.	7 May 2011	TSH-R 11891	7 May 2011	25 May 2011 (18 days)	TSH-R 11904
As-4	Sugao Marsh, Otsukado-machi, Jyoso, Ibaraki Pref.	7 May 2011	TSH-R 11892	7 May 2011	25 May 2011 (18 days)	TSH-R 11905