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# Life cycle of *Aecidium araliae* and its new name

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Abstract — Field observations and inoculation experiments with the uredinial and telial stages of a rust on *Carex stenostachys* var. *cuneata* clarified that these were conspecific with the spermagonial and aecial stages of *Aecidium araliae* on *Aralia elata*. Based on uredinial and telial morphologies *A. araliae* is transferred to *Puccinia* as *P. caricis-araliae* nom. nov.

Key words — *Araliaceae, Cyperaceae, Pucciniaceae,* rust fungus, taxonomy

## Introduction

*Aecidium araliae,* initially published invalidly (Sawada 1943: lacking a Latin description), was subsequently validated by Ito & Murayama (1943). This rust fungus has been known to produce only spermogonial and aecial stages on plants within the *Araliaceae* and is widely distributed in Japan, Taiwan, and China: on *Aralia elata* (Miq.) Seem. in Japan (Ito & Murayama 1943, Ito 1950, Hiratsuka 1952, 1960, Kakishima et al. 1986, Harada 1994), Taiwan (Tai 1979, Hiratsuka & Chen 1991) and China (Tai 1979); on *A. decaisneana* Hance in Taiwan (Hiratsuka 1943, Ito & Murayama 1943, Sawada 1943, Ito 1950, Tai 1979, Hiratsuka & Chen 1991); on *A. chinensis* L. in China (Tai 1979); on *A. spinosa* L. in Taiwan (Hiratsuka & Chen 1991); on *Agalma lutchuense* Nakai [= *Schefflera heptaphylla* (L.) Frodin] in Japan (Hiratsuka 1952, 1960, Shimabukuro 1961, Hiratsuka et al. 1985); and on *Textoria trifida* (Thunb.) Nakai ex Honda [≡ *Dendropanax trifidus* (Thunb.) Makino ex Hara] in Japan (Hitatsuka 1952, 1960). Spermogonia and aecia were observed on leaves and petioles that were usually malformed and enlarged by the infections (Fig. 1A–D) with the surface of these infected tissues becoming yellow because of abundant aeciospore production.

In June 1992, the rust was observed in Yamagata Pref., Japan, in a field of *Aralia elata* cultivated to harvest its sprouts as an early spring vegetable (Fig. 1A,B). By midsummer the infection had almost disappeared. As other life stages of the rust could not be found, it was suspected that the rust was heteroecious and produced other stages on different host plants around these fields. We surveyed other rust fungi in the same vicinity and collected some candidates for this species. Inoculation experiments were carried out to confirm their connection. Finally, we found uredinial and telial stages on *Carex stenostachys* var. *cuneata* (Ohwi) Ohwi & T. Koyama and confirmed these were the other spore stages of this species. We present results of inoculation experiments and a taxonomic treatment of the species, based on morphology.

## Materials & methods

### Inoculations

Telia on dead leaves of *Carex stenostachys* var. *cuneata* were collected at Numasawa, Higashine-shi, Yamagata Pref., Japan on 30 April 1994 (Fig. 2A,B) and kept in a refrigerator at 5°C for use in inoculations. The leaves with telia were soaked in running tap water for several days to induce germination of teliospores (Fig. 2C). Once numerous basidiospores were produced from teliospores then inoculations to *A. elata* were carried out several times from May to June at University of Tsukuba, Tsukuba, Ibaraki Pref., Japan. For inoculation, leaves with germinating teliospores were cut into small pieces (ca. 5 $mm^2$) and placed on healthy leaves of *A. elata*. The *A. elata* plants were transferred from the field and grown in clay pods. The inoculated plants were kept in a moist chamber in darkness at about 20°C for 2 days and then transferred into a growth cabinet at about 20°C with artificial illumination for observations.

### Morphological observations

Dry specimens collected in the field or obtained from inoculations were observed morphologically by light (LM) and scanning electron microscopy (SEM). The spores or thin sections of sori were mounted in lactophenol solution on glass slides for LM observations. For SEM, sori and spores obtained from specimens were attached to specimen holders by double-sided adhesive tape and coated with gold in high vacuum with an Eiko IB-3 Ion Coater. They were examined with a Hitachi S-430 SEM operated at 20kV. All specimens were deposited in the fungal herbarium of the Department of Botany, National Museum of Nature and Science, Tsukuba, Japan (TNS).

## Results & discussion

### Life cycle

Seven to eight days after inoculation with basidiospores produced by teliospores on *C. stenostachys* var. *cuneata,* small yellow spots of spermogonia appeared on the surface of leaves and stems of *A. elata.* The infected tissues were malformed and discolored. About 10 days later, cupulate aecia with aeciospores were produced on the same leaves and stems (Fig. 1C). The results

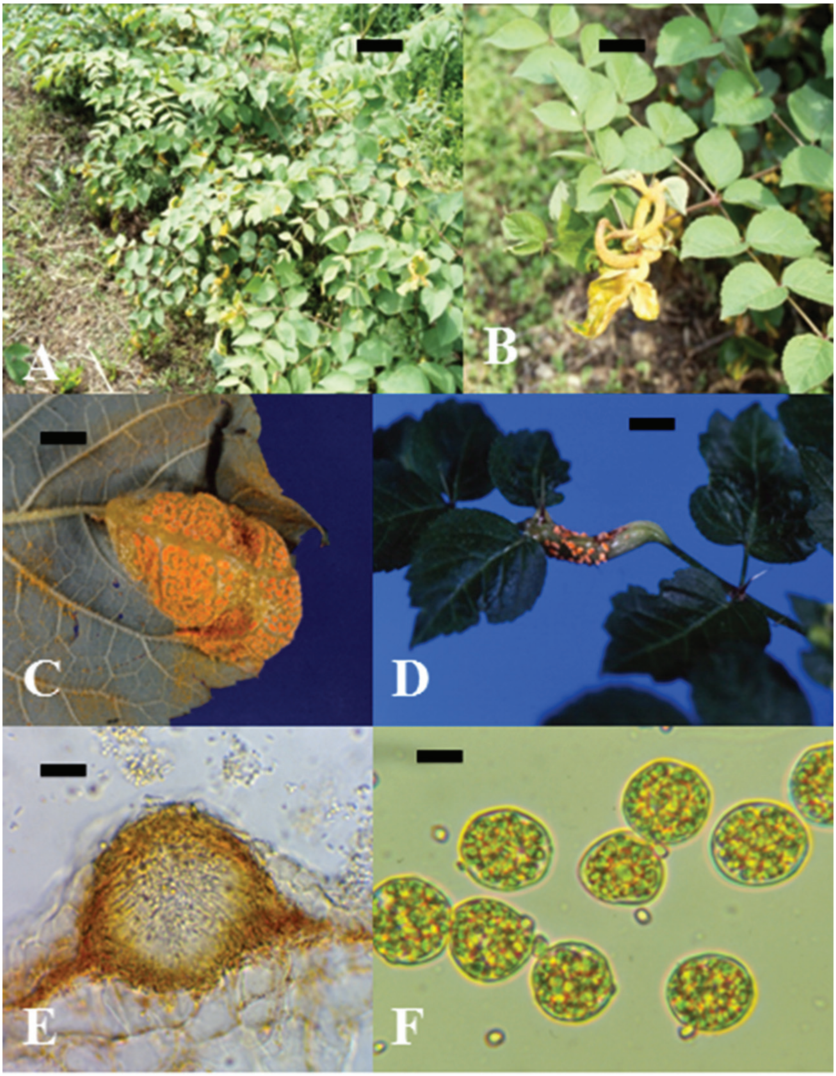


Figure 1. Spermogonial and aecial stages of *Puccinia caricis-araliae* on *Aralia elata*. A: Symptoms of *A. elata*. B: Aecia produced on malformed stems. C: Aecia with aeciospores. D: Aecia produced by the inoculation. E: Vertical section of a spermogonium. F: Aeciospores. Scale bars: A = 10 cm; B = 5 cm; C = 1 cm; D = 3 cm; E = 2 µm; F = 20 µm.

of inoculations confirmed that the telial stage on *C. stenostachys* var. *cuneata* and the aecial stage on *A. elata* are produced by the genetically same species.

Table 1. Comparison of *Puccinia* species on *Carex* with two germ pores at each urediniospore base.

| Species | Urediniospores Size (µm) | Urediniospores Wall | Teliospores Size (µm) | Teliospores Apical thickness (µm) | Aecial hosts |
|---|---|---|---|---|---|
| *P. caricis-araliae* [1] | 17–25.5 × 16–24 | Pale brown; echinulate | 30.5–47 × 10–16.5 | 4–13 | *Aralia elata* (*Araliaceae*) |
| *P. kawakamiensis* [2] | 17–26 × 13–20 | Brown; echinulate | 32–55 × 10–18 | 5–18 | *Circaea erubescens* (*Onagraceae*) |
| *P. pulchella* [3] (nom. illeg.) | 20–32 × 15–23 | Pale brown; echinulate | 27–47 × 11–19 | 7–13 | *Viola* spp. (*Violaceae*) |
| *P. yokogurae* [4] | 21–29 × 16–21 | Pale brown; echinulate | 29–45 × 16–21 | 9–13 | ? |
| *P. yokotensis* [4] | 20–26 × 18–21 | Pale brown; echinulate | 29–39 × 12–18 | 11–13 | ? |

References— [1] This paper; [2] Kakishima & Sato (1983); [3] Ono & Kakishima (1981); [4] Ito (1950)

**Morphology**

Spermogonia and aecia on *A. elata* produced by inoculations were morphologically similar with those of specimens collected in the field. As the morphological characteristics matched those previously described for *A. araliae* (Ito & Murayama 1943, Ito 1950), these spermogonial and aecial stages were identified as *A. araliae.*

Telial morphology and the two-celled teliospores confirm that the rust on *C. stenostachys* var. *cuneata* belongs to the genus *Puccinia* (Cummins & Hiratsuka 2003). Many *Puccinia* species have been reported on *Carex* spp. in Asia (Ito 1950, Tai 1979, Hiratsuka & Chen 1991, Hiratsuka et al. 1992). They are separated based on position of urediniospore germ pores, as teliospores are morphologically variable and similar to each other. The *Puccinia* on *C. stenostachys* var. *cuneata* collected in Yamagata Prefecture has two germ pores at the base of the urediniospores. It differs morphologically from four other species on *Carex* that have two basal germ pores (Table 1). Two of these species have recorded aecial hosts, but these are in *Onagraceae* and *Violaceae* (and not *Araliaceae*). *Puccinia* species producing spermogonia and aecia on *Aralia* have not been reported anywhere in the world. Morphological details of this species are given below.

**Taxonomy**

Its telial morphology supports the transfer of *A. araliae* to *Puccinia.* However, as the name *P. araliae* has already been published for a different species producing telia on *Aralia,* we propose a replacement name in *Puccinia* for *Aecidium araliae.*

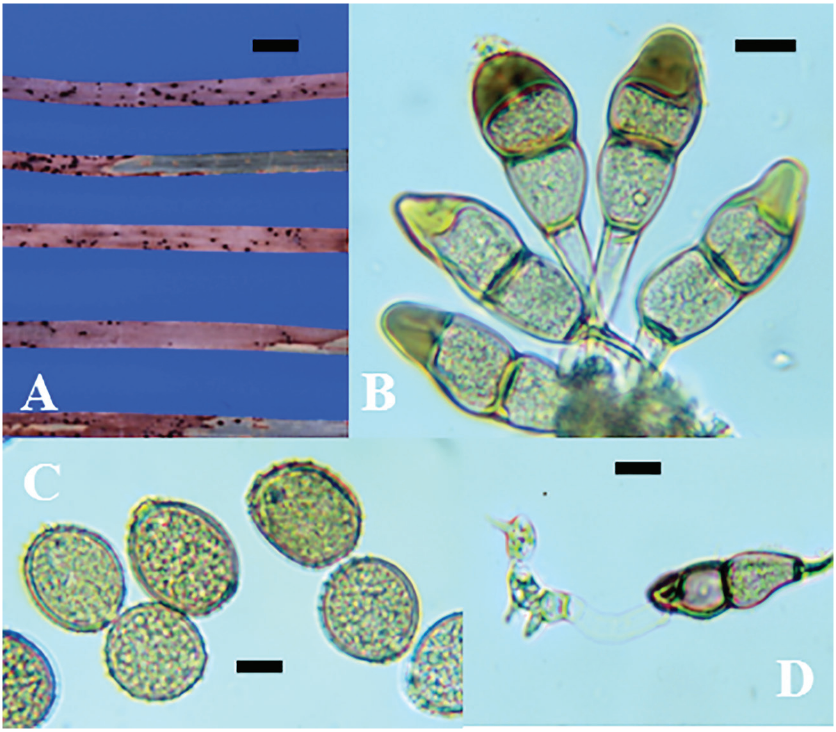


Figure 2. Uredinial and telial stages of *Puccinia caricis-araliae* on *Carex stenostachys* var. *cuneata*. A: Telia on *C. stenostachys* var. *cuneata*. B: Teliospores. C: Urediniospores. D: Germination of a teliospore. Scale bars: A = 5 cm; B, C = 10 µm; D = 15 µm.

***Puccinia caricis-araliae*** Kakish. & Q. Wang, **nom. nov.** Figs 1–3

MycoBank MB 807046

≡ *Aecidium araliae* Sawada ex S. Ito & Muray., Transactions of the Sapporo Natural History Society 17: 171, 1943, non *Puccinia araliae* Ellis & Everh. 1891.

Type: Japan, Yamagata Pref., Higashine-shi, on *Aralia elata*, stages 0, I, May 1992 (**Neotype designated here**, TNS-F-57726). Japan, Yamagata Pref., Higashine-shi, Numasawa, on *Carex stenostachys* var. *cuneata*, stages II, III, 30 April 1994 (**Epitype designated here**, TNS-F-57724).

"*Aecidium araliae*" Sawada, Journal of the Natural History Society Taiwan 33: 97, 1943, nom. inval. (no Latin).

Spermogonia epiphyllous, surrounded by discolored lesions, yellow to brown, flask-shaped (type 7 of Cummins & Hiratsuka 2003). Aecia hypophyllous, densely grouped, cupulate with peridia, pale yellow. Aeciospores globose to subglobose, often angular, 18–35 × 16–24 µm, wall 2.0–2.5 µm thick, hyaline, verrucose with large granules. Uredinia hypophyllous, scattered, erumpent,

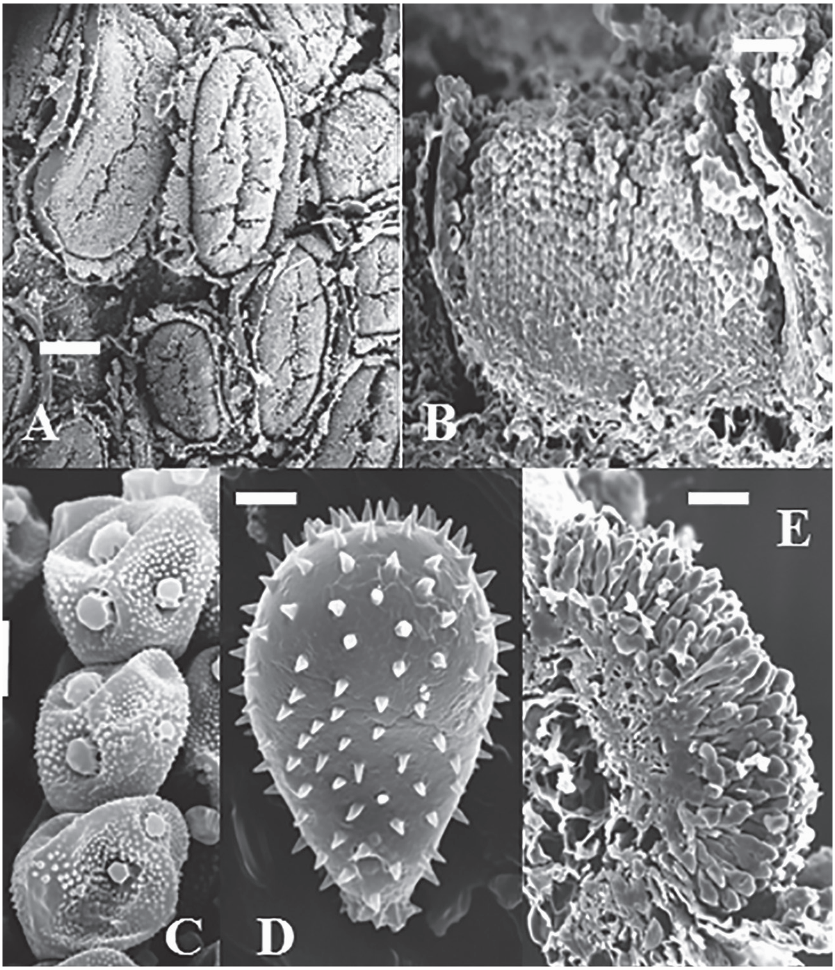


Figure 3. Morphology of *Puccinia caricis-araliae* observed by SEM. A: Aecia on *Aralia elata*. B: Vertical section of an aecium on *A. elata*. C: Aeciospores with large granules. D: Urediniospore. E: Vertical section of a telium on *Carex stenostachys* var. *cuneata*. Scale bars: A = 200 µm; B = 50 µm; C = 5 µm; D = 3 µm; E = 25 µm.

brown to pale brown. Urediniospores obovoid or broadly ellipsoid, 17–25.5 × 16–24 µm (av. 21.0 × 18.5 µm), wall ca. 1.5 µm thick, hyaline to pale brown, echinulate, germ pores 2 at base. Telia hypophyllous, scattered, ellipsoid, erumpent, dark brown. Teliospores clavate to oblong with round and obtuse apices, attenuate towards the base, constricted at the septa, 30.5–47 × 10–16.5 µm, wall pale brown to brown, thickened at apex (4–13 µm), smooth; pedicel short, persistent.

Other Specimens examined: **On *Carex stenostachys* var. *cuneata*: JAPAN, Yamagata Pref.**, Higashine-shi, Numasawa, stage II, 18 June 1994 (TNS-F-57725).

**On *Aralia elata*: JAPAN, Gunma Pref.**, Kanra-gun, Nanmoku-mura, stages 0, I, May 2002 (TNS-F-57728); **Ibaraki Pref.**, Tsukuba-shi, stages 0, I, 18 May 1994 (TNS-F-57727); Tsukuba-shi, University of Tsukuba, stages 0, I, post-inoculation, 13 June 1994 (TNS-F-57729); stages 0, I, post-inoculation, 18 June 1994 (TNS-F-57730).

Comments: The type specimen of *A. araliae* was not designated when Ito & Murayama (1943) validated this species, although they described two *Aralia* species as host plants. Because their specimens also could not be found in the herbarium of Hokkaido University, Japan (SAPA), we have selected a neotype specimen for this species.

Spermogonial and aecial stages of this rust fungus were confirmed by inoculation only on *A. elata*. However, several species of *Araliaceae* have been reported as host plants of *A. araliae,* which is widely distributed in Japan, China, and Taiwan. Therefore, we suspect that other *Carex* species also serve as uredinial and telial hosts because *C. stenostachys* var. *cuneata* is mainly distributed in northern area of Honshu Island of Japan.

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