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# Pollinators of *Arisaema thunbergii* subsp. *urashima* (Araceae) in Japan

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**Abstract** Pollinators of *Arisaema thunbergii* subsp. *urashima* (Araceae) were investigated at two sites in Japan. From inside 33 spathes, 109 insects were collected and identified to 17 families and 27 genera. Sixty-six percent were fungus gnats comprising Keroplatidae, Mycetophilidae, and Sciaridae. Although *Arisaema* has always been thought to be pollinated by fungus gnats, some other species of Diptera were shown to visit spathes of *A. thunbergii* subsp. *urashima* and are presumed to carry their pollen grains to female spathes.

**Key words**: *Arisaema thunbergii* subsp. *urashima*, Diptera, fungus gnat, pollination, pollinator.

## Introduction

The genus *Arisaema* (Araceae), consisting of ca. 180 species, is primarily distributed from eastern Africa to southeast Asia. Other three species occur from northeast North America south to Mexico (Murata, 2011). Many species of the genus produce male and female inflorescences successively from the same plant at different seasons, depending on the size of the plant (Schaffner, 1922; Maekawa, 1924; Takasu, 1987).

The pollination mechanism is well documented. Pollinators enter the spathe tube, holding on to the inflorescence by the upper mouth of the tube. After entering, the pollinators cannot escape from the mouth because wax particles cover both the inner wall of the tube and the surface of the spadix appendage (van der Pijl, 1953; Vogel and Martens, 2000). In the male spathe, pollinators can escape through the exit hole located in the lower part of the spathe. In contrast, female spathes lack an exit hole and trap pollinators.

Fungus gnats have been reported to be pollinators of several *Arisaema* spp. i.e. *A. negishii* Makino, *A. serratum* (Thunb.) Schott, and *A. yamatense* (Nakai) Nakai from Japan (Sasakawa, 1993, 1994a, 1994b), and *A. consanguineum* Schott, *A. costatum* Mart., *A. griffithii* Schott, *A. jaquemontii* Blume, *A. nepenthoides* Mart, *A. speciosum* (Wall.) Mart., *A. tortuosum* (Wall.) Schott, and *A. utile* Hook. f. ex. Engl. from Nepal (Vogel and Martens, 2000).

A species endemic to Japan, *A. thunbergii* Blume subsp. *urashima* (H. Hara) H. Ohashi & J. Murata, is characterized by a spadix appendage with a long flagellate thread. The pollinators of the species have never been reported. In this study, we observed which species of insects visited the spathe tube of *A. thunbergii* subsp. *urashima*.

## Study sites and Methods

Pollinators of *A. thunbergii* subsp. *urashima* were observed at two sites (Fig. 1A): 1) Bando:

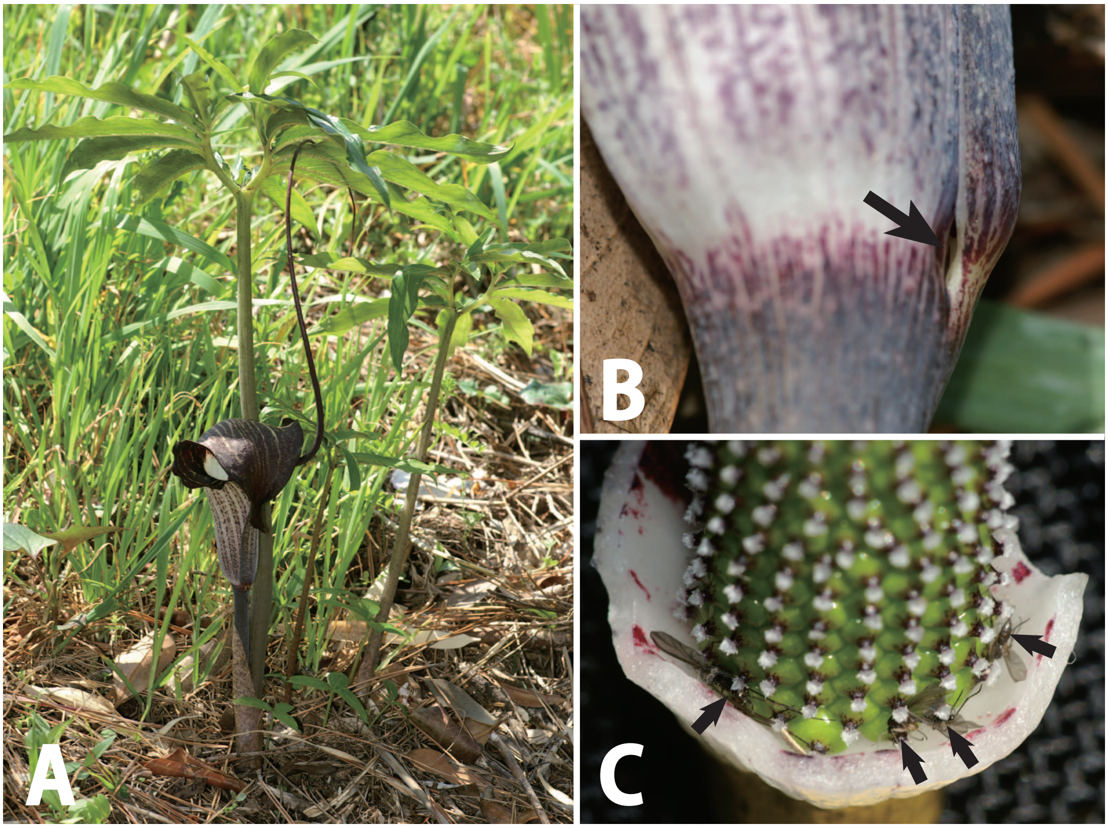


Fig. 1. *Arisaema thunbergii* subsp. *urashima* in Shimoda, Shizuoka Prefecture, Japan. A. An individual with an inflorescence. B. Exit hole (arrow) of male spathe. C. Insects (arrows) trapped around the bottom of spathe of the species.

Koizumi, Bando, Ibaraki Pref. Japan. Plants grow in the floor of the temperate deciduous broad-leaved forest, where *Quercus serrata* var. *serrata* Murray (Fagaceae) dominates. 2) Shimoda: Ebisu-Jima, Suzaki, Shimoda, Shizuoka Pref., Japan. Plants grow in the floor of the laurel forest that consists mainly of *Camellia japonica* L. (Theaceae) and *Podocarpus macrophyllus* (Thunb.) Sweet.

At the Bando site, collection of pollinators was carried out between April 8 and April 25, 2005. To collect insects visiting the spathe tubes of *A. thunbergii* subsp. *urashima*, the exit holes in the lower part of male spathes were plugged with cotton wool (Fig. 1B). A week later, the insects inside the spathes were collected. At the Shimoda site, collection was conducted on April 14, 2005, without plugging the exit holes of the male spathes.

## Results and Discussion

Insects were found inside of 14 (seven male and seven female spathes) of 45 spathes at the Bando site and 19 (five male and 14 female spathes) of 73 spathes at the Shimoda site (Fig. 1C). From the 33 spathes, 109 individual insects were collected. All were identified as Diptera, with the exception of one individual from the Order Thysanoptera. The insects were classified into 17 families and 27 genera. Seventeen species were clearly identified (Table 1).

Of the collected insects, 66% (72/109 individuals) were fungus gnats, comprising Keroplatidae, Mycetophilidae, and Sciaridae. Although *Arisaema* has always been thought to be pollinated by fungus gnats (Sasakawa, 1993, 1994a, 1994b; Vogel and Martens, 2000), Diptera species other than fungus gnats were found inside spathes in this study. Vogel and Martens (2000)

Table 1. Diptera species collected in spathes of *Arisaema thunbergii* subsp. *urashima* in this study

| Family | Species | Number of individuals[*1] | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Bando | | | Shimoda | | | |
| | | ♂ | ♀ | ? | ♂ | ♀ | ? | |
| Bibionidae | *Bibio* sp. | | | | | 0, 1 | | 1 |
| Cecidomyiidae | Cecidomyiidae gen. | | | 3, 1 | | | | 4[*2] |
| Chironomidae | *Chironomus* sp. | | 0, 1 | | | | 0, 1 | 2 |
| Chloropidae | *Cadrema minor* (Meijere, 1908) | | | | | 0, 1 | | 1 |
| Coenomyiidae | Coenomyiidae gen. | | | | | | 1, 0 | 1 |
| Drosophilidae | *Mycodrosophila poecilogastra* Loew, 1874 | | 0, 1 | 0, 1 | | | | 2 |
| Fanniidae | *Fannia edentula* Nishida, 1973 | | | 2, 0 | 1, 0 | | 3, 5 | 11 |
| Keroplatidae | *Neoplatyura kunashiriensis* Zaitzev, 1994 | 3, 0 | | | | | | 3 |
| Lauxaniidae | *Minettia longipennis* (Fabricius, 1794) | | | | | 0, 1 | | 1 |
| Muscidae | Muscidae gen. | | | | | | 1, 0 | 1 |
| Mycetophilidae | *Anatella* sp. | | 1, 0 | | | | | 1 |
| | *Boletina dispecta* Dziedzicki, 1885 | 3, 0 | | 1, 0 | | | | 4 |
| | *Boletina nitida* Grzegorzek, 1855 | 1, 0 | | | | | | 1 |
| | *Brevicornu* sp. | 1, 0 | | | | | | 1 |
| | *Exechia* sp. | 1, 0 | | | 0, 1 | | 0, 1 | 3[*2] |
| | *Leia winthemi* Lehmann, 1822 | | | | | 0, 1 | | 1 |
| | *Mycetophila abbreviata* Landrock, 1914 | | 0, 2 | | | | | 2 |
| | *Mycetophila luctuosa* Meigen, 1830 | 1, 0 | | | | | | 1 |
| | *Mycetophila perpauca* Lastovka, 1972 | 0, 1 | | | | | | 1 |
| | *Mycetophila ruficollis* Meigen, 1818 | | 1, 0 | | | | | 1 |
| | *Mycetophila* sp. (type 1) | | 4, 2 | | | | | 6 |
| | *Mycetophila* sp. | 1, 0 | 0, 1 | | | 0, 1 | | 3[*2] |
| | *Rymosia* sp. | | 1, 0 | | | | | 1 |
| | *Trichonta* sp. | | 0, 1 | | | | | 1 |
| Phoridae | *Megaselia* sp. | 2, 0 | 1, 0 | | 0, 4 | | | 7[*2] |
| Psychodidae | *Psychoda itoco* Tokunaga & Etsuko, 1954 | 1, 0 | | | | | | 1 |
| Sciaridae | *Sciaridae* gen. | 0, 1 | 2, 1 | 1, 1 | | 0, 1 | 0, 2 | 9[*2] |
| | *Bradysia trispinifera* Mohrig & Krivosheina, 1979 | | | | 0, 1 | | | 1 |
| | *Bradysia* sp. | 0, 1 | 9, 1 | 0, 1 | 0, 1 | 0, 9 | 0, 1 | 23[*2] |
| | *Ctenosciara insolita* Sasakawa, 1994 | 2, 0 | | | | | | 2 |
| | *Phytosciara* sp. | | | | | 0, 7 | | 7[*2] |
| Stratiomyidae | *Allognosta vagans* (Loew, 1873) | | | | 0, 1 | | | 1 |
| Tephritidae | *Paragastrostzona japonica* Shiraki | 1, 0 | | | | | | 1 |
| Tipulidae | *Limonia* sp. | | | | | 0, 1 | | 1 |

[*1] Left number shows number of insects found in male spathe and right one in female spathe.

[*2] Number of species included is unknown.

stated that other kinds of insects will occassionally be captured and may even confer pollination; most, however, are able to escape prematurely using the "wrong" exit or lack the appropriate size and mobility to achieve pollination. In this study, insects were collected from inside spathes and most of the insects were found at the bottoms of spathes. This indicates that some insects other than fungus gnats cannot escape from the "wrong" exit. Most of the collected insects had pollen grains attached to them, and can therefore be considered to be valid pollinators in terms of attachment of pollen grains to body.

Fungus gnats (ca. 1 mm in width) can pass through the exit hole (ca. 2 mm internal diameter) of the male spathe. *Fannia edentula* (Fannidae), whose width is ca. 2 mm and larger than the other collected species, is presumed to not be able to escape from the spathe through the hole. *F. edentula* were only found in the male spathes at the Shimoda site, where the exit holes had not been plugged with cotton wool (Table 1). This result indicates that *F. edentula* cannot escape through the exit holes of the male spathes; it therefore cannot transport pollen grains out of the male spathes and cannot contribute to pollination. By contrast, the most other small insects were not collected in male spathes of Shimoda site (Table 1), where we had not plugged the exit hole. This indicates that the holes of male spathes of the *A. thunbergii* subsp. *urashima* play a role of pollinator's exit from the trap.

From the female spathes, 19 individual insects were collected from the 7 spathes (2.7 individuals/spathe) at the Bando site and 42 individuals from the 14 spathes (3.0) at the Shimoda site. Nishizawa *et al.* (2005) used microsatellite DNA analysis to show that the seeds in a fruit had been fertilized by multiple male parents. The visits of multiple insects to a spathe observed in this study support the molecular genetic data.

Some pollinators were found at only one of the two sites. Chironomidae, Drosophilidae, Keroplatidae, Psychodidae, and Tephritidae were collected only at the Bando site. In contrast, Bibionidae, Chloropidae, Coenomyiidae, Lauxaniidae, Muscidae, Stratiomyidae, and Tipulidae were only at the Shimoda site. However, the sample size in this study were too small to permit discussion of the differences between the two sites.

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