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Radiation of gall midges (Diptera: Cecidomyiidae) in Japan

Junichi Yukawa[a,*], Nami Uechi[a], Makoto Tokuda[b], Shinsuke Sato[c]

[a]*Entomological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka 812-8581, Japan*
[b]*Institute for Biological Resources and Functions, National Institute of Advanced Industrial Science and Technology, Tsukuba 305-8566, Japan*
[c]*Laboratory of Ecology, Graduate School of Natural Science and Technology, Kanazawa University, Kanazawa 920-1192, Japan*

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Summary

Based on literature surveys and morphological and DNA sequencing data, we examined patterns of host association at the generic level for the Japanese gall midges. Many examples of association of a gall midge genus with a particular host plant genus are known. We found that associations exist between *Rabdophaga* and *Salix*, *Hartigiola* and *Fagus*, *Rhopalomyia* and *Artemisia*, and *Daphnephila* and *Machilus*, whereas the host range of some large genera, such as *Asphondylia*, *Contarinia*, *Dasineura*, and *Lasioptera* spans different plant families.

Most *Rabdophaga* and some *Rhopalomyia* species seem to have colonized the Japanese Archipelago after radiation in the Eurasian Continent. *Daphnephila* came to Japan from the Oriental Region where they radiated on *Machilus*. Most *Fagus* gall midges seem to have diversified on relic *Fagus* species in the eastern Palearctic Region. Some *Hartigiola* species appear to have radiated in the Japanese Archipelago.

Although *Asphondylia* has a wide host range at the generic level, most Japanese *Asphondylia* species and segregates are close to each other genetically, which means they are now spreading to various plant genera.

Zusammenfassung

Basierend auf Literaturrecherchen, morphologischen und DNA-Sequenz-Daten untersuchen wir die Muster der Wirtsassoziationen für japanische Gallmücken auf dem Gattungsniveau. Es sind viele Beispiele für Assoziationen von Gallmückengattungen mit bestimmten Wirtspflanzengattungen bekannt. Wir fanden, dass Assoziationen zwischen *Rabdophaga–Salix, Hartigiola–Fagus, Rhopalomyia–Artemisia* und *Daphnephila–Machilus*

*Corresponding author. Present address: Matsuzaki 1-5-12, Higashi-ku, Fukuoka-shi 813-0035, Japan. Fax: +81 92 673 3522.
E-mail address: JZS02305@nifty.ne.jp (J. Yukawa).

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bestanden, während die Wirtsspanne von einigen großen Gattungen wie *Asphondylia, Contarinia, Dasineura* und *Lasioptera* verschiedene Pflanzenfamilien einschließen. Die meisten *Rabdophaga*- und *Rhopalomyia*-Arten scheinen das japanische Archipel nach einer Radiation auf dem eurasischen Kontinent besiedelt zu haben. *Daphnephila* kam aus der orientalen Region nach Japan, wo sie einer Radiation auf *Machilus* unterlag. Die meisten *Fagus*-Gallmücken scheinen sich auf *Fagus*-Reliktarten der östlichen palaearktischen Region diversifiziert zu haben. Einige *Hartigiola*-Arten scheinen auf dem japanischen Archipel einer Radiation zu unterliegen. Obwohl *Asphondylia* eine große Wirtsspanne auf dem Gattungsniveau hat, sind sich die meisten japanischen *Asphondylia*-Arten und -Segregationen genetisch ähnlich, was bedeutet, dass sie sich jetzt auf verschiedene Pflanzengattungen ausbreiten.

Introduction

Galling cecidomyiids (Diptera: Cecidomyiidae) are one of the most abundant groups among galling arthropods (Yukawa & Rohfritsch, 2005). At the species level, many galling cecidomyiids are either monophagous or oligophagous (e.g., Gagné, 2004; Skuhravá, 1986; Yukawa & Masuda, 1996), whereas at the generic level they are polyphagous particularly in large genera such as *Asphondylia*, *Contarinia*, *Dasineura*, *Lasioptera*, and *Neolasioptera* (e.g., Gagné, 2004; Skuhravá, 1986). In contrast, association of a gall midge genus with one particular host plant genus has been noted in many instances. More than five gall midge congeners are frequently associated with one or a few host plant genera in a single plant family (e.g., Gagné, 2004; Skuhravá, 1986); for example, *Baldratia* on *Anabasis* and *Salsola* (Chenopodiaceae), *Caryomyia* on *Carya* (Juglandaceae), *Procontarinia* on *Mangifera* (Anacardiaceae), *Psectrosema* on *Tamarix* (Tamaricaceae), *Rabdophaga* on *Salix* (Salicaceae), *Rhopalomyia* on *Artemisia*, *Chrysanthemum*, and *Solidago* (Asteraceae), *Semudobia* on *Betula* (Betulaceae), and *Thecodiplosis* on *Pinus* (Pinaceae). These associations suggest adaptive radiation of gall midges within a relatively narrow host plant range.

In Japan, 628 sorts of midge gall exist on 66 plant families (Yukawa & Masuda, 1996). However, the inducers of some of these galls have yet to be named or identified, hence they were not listed in the world catalog of Cecidomyiidae (Gagné, 2004). We recently identified some of these inducers at the species or generic levels based on morphological and DNA sequencing data, and obtained information on their host plants. In this paper, we analyze the patterns of host plant association in the Japanese gall midge fauna and compare those patterns with known associations. In the light of this analysis, adaptive radiation of the Japanese gall midges is discussed in relation to the faunistic contribution of elements of the Palearctic and Oriental Regions, to the Japanese Archipelago located in the eastern-most part of the Palearctic Region.

Materials and methods

We obtained information on host plants, distribution, and other ecological traits of the Japanese gall midges, and their exotic congeners through literature surveys and our 1997–2004 field surveys in Japan, the eastern Palearctic Region, and Southeast Asian countries. A majority of the host plant records were obtained from Skuhravá (1986), Yukawa and Masuda (1996), and Gagné (2004). We identified gall midges based on morphological characters. In constructing a new NJ tree of *Asphondylia* species and segregates, we combined DNA sequencing data that we had registered with DNA data banks in our previous studies (Fig. 1).

Results

The number of gall midge species associated with a particular plant family varied from 0 to 80, but was uncorrelated with the size of plant family (Tables VII-2, 3 in Yukawa & Masuda, 1996). Many gall midges are associated with several plant families such as Salicaceae, Fagaceae, Lauraceae, Rosaceae, Fabaceae, Caprifoliaceae, Asteraceae, and Poaceae (Table 1). In these families, we found some examples of association of a gall midge genus with a single plant genus; e.g., *Rabdophaga–Salix*, *Hartigiola–Fagus*, and *Rhopalomyia–Artemisia* (Table 2). In addition, we noted that four nominal species and at least 10 segregates of *Daphnephila* gall midges have radiated on *Machilus* (Lauraceae). We discuss the associations of *Rabdophaga*, *Hartigiola*, *Rhopalomyia*, and *Daphnephila* with their