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Paik, Jong-Cheol

Yukawa, Jun-ichi

Uechi, Nami

Sato, Shinsuke

他

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Gall-Inducing Species of the Family Cecidomyiidae (Diptera) Recorded from the Korean Peninsula and Surrounding Islands, in Comparison with the Gall-Midge Fauna of Japan*

Jong-Cheol PAIK

Department of Applied Biology, Sunchon National University, Jeonnam, 540-742 Korea

Junichi YUKAWA

Entomological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka, 812-8581 Japan

Nami UECHI, Shinsuke SATO

Entomological Laboratory, Graduate School of Bioresource and Bioenvironmental Sciences, Kyushu University, Fukuoka, 812-8581 Japan

and

Tomoko GANAHA

Entomological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka, 812-8581 Japan

Abstract. A total of 52 gall-inducing species of Cecidomyiidae (Diptera) (53 in the sorts of midge gall, because one polyphagous species was included) were recognized to occur in the Korean Peninsula (including surrounding islands) through literature survey, field surveys by Dr. K. Yamagishi and ourselves, and by examining photographs of arthropod galls taken by the late Prof. W.-H. Paik and one of us, JCP. The previous and current identification of these Korean gall midges relied largely upon their gall morph and host plant species that correspond to those of Japanese gall midges. The identification of these gall midges was considered to be mostly reliable, because recent DNA analysis suggested that some South Korean gall midges were identical with Japanese gall midges when they induce the same sorts of gall on the same host plants as those in Japan. At the moment, 47 (88.7 %) out of the 53 sorts of Korean midge galls were common to Japan. This means that more numerous midge galls will be detected in the

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Korean Peninsula on the plant species or genera that have been known as host plants of the Japanese gall midges.

Key words: Korea, Cecidomyiidae, gall, fauna, species richness.

Introduction

The Korean Peninsula has been playing an important role, as a bridge or a corridor, to connect the Japanese Archipelago to the Eurasian Continent, influencing strongly on the formation of entomofauna of Japan. Now the Japanese Archipelago is located about 150 km apart from the Korean Peninsula, but the distance still allows some insects to move from one side to another directly or indirectly through stepping stone islands such as Jeju Island, the Tsushima Islands, and Iki Island. Therefore, the entomofauna of the Korean Peninsula is naturally expected to show striking similarities to the Japanese entomofauna. Up to the present, a lot of information about entomofauna has been accumulated both in the Korean Peninsula including surrounding islands (Korea, hearafter) (e.g., ESK & KSAE, 1994) and in Japan (e.g., Hirashima *et al.*, 1989). However, entomofauna has seldom been compared extensively between the two areas, except for some taxa in restricted areas, e.g., Takeya (1962); Masumoto *et al.* (1986); Choi *et al.* (1993).

Because the galls are conspicuous in shape and numerous in sorts, they are easily found in field surveys. In many cases, each gall morph is unique to a galling arthropod species, and galling arthropod species are specific to a single plant species or genus. In addition, by dissecting galls we can obtain various sorts of information about galling-arthropods, such as taxonomic position, developmental stage, mortality rate (including percentage parasitism caused by different species of parasitoids), and population density. Thus, the galls are good targets for a faunistic study. Therefore, many faunistic data have been accumulated for a variety of gall-inducing arthropods (e.g., Yukawa & Partomihardjo, 1997; Price *et al.*, 1998; Yukawa *et al.*, 2000; Yukawa *et al.*, 2001a; Yukawa *et al.*, 2001b; Uechi *et al.*, 2003).

In Korea, the most extensive survey on gall-inducing organisms was performed by Saitô (1932, 1933a), who enumerated a total of 142 sorts of gall. Among them, galls induced by gall midges (Diptera: Cecidomyiidae) were most abundant (32 sorts), followed by gall mites (Acari: Eriophyoidea), aphids (Hemiptera: Aphididae and Pemphigidae taken together), gall wasps (Hymenoptera: Cynipidae), sawflies (Hymenoptera: Tentheredinidae), jumping plant lice (Hemiptera: Psylloidea), and other taxa.

As to midge galls, a few more sorts were reported in scattered papers (e.g., Saitô, 1933b; Yokoo, 1935; Ko, 1985). Based on these data, Yukawa & Masuda (1996)

demonstrated that 20 sorts of midge gall are distributed both in Japan and in Korea. Recently, several more species were added to the gall midge fauna of Korea by Kodoi *et al.* (2003) and Ganaha *et al.* (2004). In Korea, however, the total number in sorts of midge gall would be less than 40, which is distinctly smaller than 628 in Japan (Yukawa & Masuda, 1996). These data indicate that the gall-midge fauna has not been fully surveyed in Korea.

Recently, we had opportunities to gather further information of Korean gall midges through field surveys conducted by Dr. K. Yamagishi (Meijo University, Nagoya, Japan) and ourselves, and by examining photographs of midge galls taken by the late Prof. W.-H. Paik (previously Professor of Entomology in Seoul National University, Suweon, Korea) and one of us, JCP. Therefore, we enumerate in this paper the latest list of gall midges that have been found in Korea. For future evolutionary and biogeographical studies, it is worth comparing the gall-midge fauna of Korea with that of Japan, although there is a big difference at present in the intensity of field survey between the two areas.

As to the scientific names of gall midges, we followed R. J. Gagné's publication, *A Catalog of the Cecidomyiidae (Diptera) of the World* (Gagné, 2004).

Materials and Methods

To enumerate gall midges that had been found in Korea, we surveyed the following literature: Saitô (1932, 1933a, 1933b), Yokoo (1935, 1940), Ko (1985), Yukawa & Masuda (1996), Kodoi *et al.* (2003), and Ganaha *et al.* (2004). We also obtained a private list of gall midges that had been found chiefly in Kyongsagpuk-do by Dr. K. Yamagishi in June-August 1977, September 1979, and May 1982.

On 26-28 May 2003, three of us, JCP, JY, and NU, collected some gall midges from Sunchon, Jeonnam and its vicinity, the southern part of the Korean Penisula. Some of these gall midges were identified based on adult and pupal morphological features, host plant, gall morph, and DNA information (Ganaha *et al.*, 2004). In addition, we identified Korean gall midges by photographs that had been taken from 1960 to 2000 by the late Prof. W.-H. Paik and JCP.

Results and Discussion

In this study, we recognized a total of 53 gall-inducing species of Cecidomyiidae to be distributed in Korea (54 in the sorts of midge gall, because one *Asphondylia* species induces two sorts of gall on different host plants) (Tables 1, 2). The previous and current identification of these Korean gall midges relied largely upon their gall morph and host-

plant species that correspond to those of Japanese gall midges. Recent DNA analysis suggested that some South Korean gall midges were identical with Japanese gall midges when their gall morph and host-plant species were the same as those of Japanese species (Ganaha *et al.*, 2004). Therefore, the identification of Korean gall midges presented in this study is considered to be mostly reliable, although several species require the reconsideration of generic position and many species are awaiting species identification (Table 1). In addition, polyphagous gall midges cannot be identified based only on gall and host-plant information because they utilize host plant belonging to different families (Yukawa *et al.*, 2003; Uechi *et al.*, 2004).

There are 228 and 237 butterfly species in Korea (ESK & KSAE, 1994) and Japan (H. Matsuka, 2003, personal communication), respectively. In contrast, the number of midge-gall sorts was 54 in Korea (Table 2), which was much fewer than 628 in Japan (Table 2; Yukawa & Masuda, 1996), although the area of Korea is about 220,000 km^2, which corresponds to 58 % of 378,000 km^2 in Japan. This means that gall midges have never been extensively surveyed in Korea.

The genera *Lasioptera*, *Rabdophaga*, and *Rhopalomyia* contained more numerous species than the other genera, as has been noted in Japan (Yukawa & Masuda, 1996), Europe (Skuhravá, 1997), and North America (Gagné, 1989). In contrast, only one and two species were included, respectively, in the genera *Asphondylia* and *Contarinia*, both of which contain many species elsewhere in the world (Gagné, 2004). Much more species of these genera will be discovered from Korea in the future.

The morphological study revealed that a gall midge that is responsible for leaf bud galls on *Weigela* species (Caprifoliaceae) in Japan had been misidentified as a North American species, *Asphondylia diervillae* Felt and was identified as *Asphondylia baca* Monzen (Uechi *et al.*, 2004). This is one of the examples of polyphagous and host-alternating gall midges (Yukawa *et al.*, 2003; Uechi *et al.*, 2004). Similarly, the Korean gall midge on *Weigela* is also likely to identical with *A. baca*, hence *A. diervillae* would be better to exclude from the list of Korean gall midges.

It should be mentioned here that no midge galls were found on *Fagus multinervis* Nakai (Fagaceae) that grows on Ulleung Island, South Korea (Sato & Yukawa, 2001), although at least 28 sorts of midge gall have been known to occur in Japan on the leaves of *Fagus crenata* Blume and *Fagus japonica* Maximowicz taken together (Yukawa & Masuda, 1996). For further discussion about the absence of *Fagus* gall midges from Ulleung Island, see Sato & Yukawa (2001).

The Korean midge galls are induced on at least 59 plant species across 20 families (Table 2). It seems quite natural that some plant families, such as Asteraceae, Salicaceae, Fabaceae, bear more numerous sorts of midge gall than the other families as has been noted in Japan (Table 2), while there are no *Fagus* gall midges as mentioned

Table 1. A list of the gall midge species distributed in Korea.

Gall midge	Host plant in Korea and Japan	Galled portion	Source of information[1)]
Ametrodiplosis acutissima (Monzen)	**Fagaceae**: *Quercus acutissima*	Twig	4, 5
Aschistonyx eppoi Inouye	**Cupressaceae**: *Juniperus chinensis* var. *globosa*	Bud	5
Asphondylia baca Monzen	**Vitaceae**: *Ampelopsis brevipedunculata*, *Vitis vinifera*, *Cayratia japonica*	Fruit	2
[*Asphondylia diervillae* Felt][2)]	**Caprifoliaceae**: *Weigela hortensis*, *W. decora*, *W. coraeensis*	Bud	5
Asteralobia humuli (Shinji)	**Cannabaceae**: *Humulus scandens*, *H. lupulus* var. *cordifolius*	Leaf	9
Asteralobia sasakii (Monzen)	**Aquifoliaceae**: *Ilex crenata*, *I. integra*	Bud	5
Cecidomyia viticola Osten Sacken[3)]	**Vitaceae**: *Vitis coignetiae*, *V. ficifolia*, *V. vinifera*, *Ampelopsis brevipedunculata*	Leaf	1
Clinodiplosis corylicola (Shinji)[3)]	**Betulaceae**: *Corylus heterophylla*	Leaf	9
Clinodiplosis rosaefoliae (Shinji)[3)]	**Rosaceae**: *Rosa multiflora*	Petiole	5
Contarinia matusintome Haraguti & Monzen	**Pinaceae**: *Pinus densiflora*, *P. thunbergii*	Bud	1
Contarinia sp.	**Caprifoliaceae**: *Weigela hortensis*, *W. decora*	Leaf	9
Daphnephila machilicola Yukawa	**Lauraceae**: *Machilus thunbergii*	Leaf	9
Dasineura asteriae (Shinji)[3)]	**Asteraceae**: *Aster scaber*	Leaf	5
Diplosis mori Yokoyama[3)]	**Moraceae**: *Morus alba*	Bud	1, 3, 5
Lasioptera achyranthii Shinji	**Amaranthaceae**: *Achyrantes bidentata*, *A. japonica*, *A. longifolia*	Stem	9
Lasioptera astericola Shinji	**Asteraceae**: *Aster scaber*	Stem	5
Lasioptera lespedezae Shinji	**Fabaceae**: *Lespedeza bicolor*, *L. cyrtobotrya*	Twig	10
Lasioptera puerariae Shinji	**Fabaceae**: *Pueraria thunbergiana*	Vein	5
Lasioptera rubi Heeger	**Rosaceae**: *Rubus* spp.	Stem	2, 5
Lasioptera sp.	**Dioscoreaceae**: *Dioscorea opposita*, *D. tokoro*	Stem	2
Lasioptera sp.	**Styracaceae**: *Styrax japonicus*	Twig	9
Masakimyia pustulae Yukawa & Sunose	**Celastraceae**: *Euonymus japonicus*, *E. fortunei*	Leaf	10
Obolodiplosis robiniae (Haldemann)	**Fabaceae**: *Robinia pseudoacacia*	Leaf	6, 9
Orseolia miscanthi (Shinji)	**Poaceae**: *Miscanthus sinensis*	Bud	5, 9
Pitydiplosis sp.	**Fabaceae**: *Pueraria lobata*, *P. montana*	Leaf	1, 8
Pseudasphondylia neolitseae Yukawa	**Lauraceae**: *Neolitsea sericea*	Leaf	9
Rabdophaga clavifex (Kieffer)	**Salicaceae**: *Salix* spp.	Bud	8
Rabdophaga rigidae (Osten Sacken)	**Salicaceae**: *Salix* spp.	Twig	1, 5, 8
Rabdophaga rosaeformis Kovalev	**Salicaceae**: *Salix* spp.	Bud	5
Rabdophaga rosaria (H. Loew)	**Salicaceae**: *Salix* spp.	Bud	1, 5
Rabdophaga salicis (Schrank)	**Salicaceae**: *Salix* spp.	Twig	1, 5
Rabdophaga sp.	**Salicaceae**: *Salix* sp.	Leaf	9

Rhopalomyia caterva Monzen	**Asteraceae**: *Artemisia capillaris*, *A. japonica*, *A. feddei*	Bud	5, 8
Rhopalomyia giraldii Kieffer & Trotter	**Asteraceae**: *Artemisia princeps*, *A. montana*, *A. feddei*, *A. vulgaris* var. *indica*	Stem	1, 5, 8
Rhopalomyia struma Monzen	**Asteraceae**: *Artemisia princeps*, *A. montana*	Stem	1, 5, 7, 8
Rhopalomyia yomogicola (Matsumura)	**Asteraceae**: *Artemisia princeps*, *A. japonica*, *A. montana*	Leaf	1, 5, 7
Rhopalomyia sp.	**Asteraceae**: *Artemisia princeps*	Leaf	8, 10
Rhopalomyia sp.	**Asteraceae**: *Artemisia princeps*	Bud	7, 9
Rhopalomyia sp.	**Asteraceae**: *Artemisia capillaris*	Bud	7
Rhopalomyia sp.	**Asteraceae**: *Artemisia capillaris*	Bud	9
Sitodiplosis mosellana Géhin	**Poaceae**: *Triticum aestivum*, *T. turgidum*, *Agropyron* spp., *Hordeum vulgare*	Fruit	5
Thecodiplosis japonensis Uchida & Inouye	**Pinaceae**: *Pinus densiflora*, *P. thunbergii*	Leaf	1
Gen. sp. *	**Salicaceae**: *Salix* sp.	Flower	9
Gen. sp.	**Fagaceae**: *Quercus dentata*, *Q. acutissima*, *Q. serrata*, *Q. mongolica* var. *grosseserrata*	Leaf	1
Gen. sp.	**Rosaceae**: cultivated *Rosa* spp.	Leaf	1
Gen. sp. *	**Rosaceae**: *Prunus grayana*	Leaf	9
Gen. sp.	**Fabaceae**: *Lespedeza* spp.	Leaf	10
Gen. sp.	**Vitaceae**: *Vitis coignetiae*, *V. ficifolia*	Leaf	8
Gen. sp.	**Vitaceae**: *Vitis coignetiae*, *V. flexuosa*?, *V. amurensis*?	Petiole	2
Gen. sp.	**Araliaceae**: *Aralia cordata*	Fruit	9
Gen. sp.	**Caprifoliaceae**: *Viburnum dilatatum*, *V. phlebotrichum*	Leaf	9
Gen. sp. *	**Caprifoliaceae**: *Lonicera japonica*	Leaf	9
Gen. sp. *	**Asteraceae**: *Artemisia princeps*	Leaf	9
Gen. sp. *	**Asteraceae**: Gen. sp.	Leaf	9

* The names of gall midges with an asterisk mean that the gall midges were recorded from Korea but have never been from Japan.

1) 1: Saitô (1932), 2: Saitô (1933a), 3: Yokoo (1935), 4: Yukawa (1971), 5: ESK & KSAE (1994), 6: Kodoi *et al.* (2003), 7: Ganaha *et al.* (2004), 8: K. Yamagishi personal communication (1977), 9: Photographs taken by W.-H. Paik & J.-C. Paik, 10: The current data.

2) *Asphondylia diervillae* Felt should be excluded from this list. See text.

3) The generic position of these species should be reexamined.

above and only a few subtropical species on evergreen trees of Lauraceae, Theaceae, and Aquifoliaceae (Yukawa & Masuda, 1996).

However, it is remarkable that, at the moment, 48 (88.9 %) out of the 54 sorts of

Table 2. Numbers in the sorts of midge gall in Korea and Japan on different plant families, and the percentage of Korean midge galls that are common to Japan.

Plant family	Korea	Japan	Common (%)
Asteraceae	11	80	9 (81.8)
Salicaceae	7	39	6 (85.7)
Fabaceae	5	36	5 (100)
Caprifoliaceae	4	27	3 (75.0)
Rosaceae	4	30	3 (75.0)
Vitaceae	4	15	4 (100)
Fagaceae	2	50	2 (100)
Lauraceae	2	26	2 (100)
Pinaceae	2	10	2 (100)
Poaceae	2	32	2 (100)
Amaranthaceae	1	3	1 (100)
Aquifoliaceae	1	3	1 (100)
Araliaceae	1	3	1 (100)
Betulaceae	1	9	0 (0)
Cannabaceae	1	1	1 (100)
Celastraceae	1	3	1 (100)
Dioscoreaceae	1	4	1 (100)
Moraceae	1	13	1 (100)
Styracaceae	1	10	1 (100)
Cupressaceae	1	1	1 (100)
Others	0	233	-
Total	54	628	48 (88.9)

Korean midge galls are common to Japan. This means that more numerous gall midges will be found in Korea by the search for midge galls on plant species known as host plants in Japan. Comparison of closely related gall midges on the same host plant-species or genus, at the DNA level, between Korea and Japan will provide us with useful information to discuss which of the factors, geographical isolation or host plant

shift, primarily affect speciation of gall midges (Ganaha *et al.*, 2004).

Obolodiplosis robiniae (Haldemann) is a North American gall midge and induces leaf-margin roll galls on *Robinia pseudoacacia* Linnaeus (Fabaceae). This gall midge is likely to have entered South Korea and Japan together with its host plant. We must pay attention to such an alien species in faunistic study.

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