[SHORT COMMUNICATION]

Parasitism of water mites (Acari: Hydrachnidiae) on caddisflies (Insecta: Trichoptera) in Hokkaido, Niigata, and Yamanashi Prefectures in Japan

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INTRODUCTION

In most cases, during the larval stage of their life cycle, prostigmatic aquatic mites parasitize the body surface of aquatic insects (Smith, 1988). Studies on water mites’ parasitism on aquatic insects in Japan primarily began as studies of biological control against malaria (e.g., Miyazaki, 1933). Therefore, most studies on water mite parasitism in Japan focus on dipteran hosts (Yamada, 1918; Miyazaki, 1933, 1935, 1936, 1945, 1947; Uchida and Miyazaki, 1935; Imamura, 1950c, 1951b, 1951d, 1952a; Hirabayashi and Fukunaga, 2007). Studies on parasitism on other insect taxa are rather limited: Hemiptera (Masuda, 1934, 1942; Imamura, 1952b; Nagasawa et al., 2008; Morimoto, 2012; Abé et al., 2015, 2017), Coleoptera (Masuda, 1934, 1935a, 1935b, 1942), Odonata (Miyazaki, 1936; Imamura, 1950a, 1951a, 1951c; Imamura and Mitchell, 1967; Kobayashi and Toda, 2005), Trichoptera (Nagasawa and Abé, 2015), and Plecoptera (Imamura, 1950b; Nagasawa and Abé, 2015). Recently, the authors had an opportunity to examine several water mite larvae attached to adult caddisflies collected in Hokkaido, Niigata, and Yamanashi Prefectures. Accordingly, this paper aims to obtain knowledge concerning the host–parasite correspondence and parasitic nature between water mites and caddisflies in these three districts.

MATERIALS AND METHODS

Imaginal caddisflies were collected by hand with a sweep net and by using a light trap in the seven study areas shown in Fig.1 during 1999 and 2018. Among caddisflies collected in the study area, eight individuals infested with water mite larvae were preserved in a glass vial filled with 70% ethanol. Caddisflies were identified by species, and their sexes were determined, referring to

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Tanida et al. (2018).

In the laboratory, the parasitic mites on each part of the body (Fig. 2), the head (including antenna), fore wing, hind wing, prothorax (including neck), mesothorax, metathorax, abdomen, fore leg, mid leg, and hind leg, were counted under a stereoscopic microscope. The mites that happened to fall from the host’s body during preservation were also counted. Then, one or two mite larvae on each host individual were used for taxonomic investigation. The genus of each mite was identified under a phase-contrast microscope based on morphological features as referred to by Prasad and Cook (1972) and Martin (2000, 2003, 2006).

In the present study, only host–parasite correspondence and parasitic nature of mites on host body parts are examined without statistical processing on account of small sample size (n=8). Due to the lack of data on background local populations including infested and non-infested host individuals, the preferences of mites regarding host species, host body size, and host sex are not analyzed here.
RESULTS AND DISCUSSION

During the survey, eight infested caddisflies of the seven species in three genera were collected from seven nearby lotic waters in three prefectures (Table 1). Parasitic mites were all in the larval stage and the morphological features of all of the examined mite larvae accorded well with the larval generic diagnosis of *Protzia* (Martin 2000, 2003, 2006). The diagnostic characteristics of the obtained larval mites were mentioned below based on a representative specimen attached to *Lepidostoma crassicorne* (Fig. 3) collected at Eniwa, Hokkaido.

Idiosoma somewhat long, globular in shape (Fig. 4A). Dorsal plate not clearly delimitated. Dorsal setae mostly serrated, except for mediopropodosomal setae. Eyes two pairs; each eye capsulated; frontal organ distinct (Fig. 4B). First coxal plate furnished with two setae, second and third coxal plates with one seta for each. Urostigma distinct between the first and second coxae. Excretory pore plate (provisional genital plate) nearly triangular in shape (Fig. 4C), with an excretory pore and 2 pairs of insertions of excretory plate setae. Gnathosoma nearly pentagonal in shape. Palp five segmented (Fig. 4D); attached laterally to gnathosoma base; second segment furnished with one seta; third segment furnished with two setae; fourth segment furnished with three setae and claw-like structure; fifth segment conical, bearing seven fine setae. Chelicera with nearly straight claw (Fig. 4E). Legs three pairs, six segmented, with many serrated setae; tarsus...
longer than the other segments. Empodial claw falciform (Fig. 4F); lateral claws curved (Fig. 4F).

This is the first notation of the larval morphology of Protzia outside of Europe. It is quite difficult to make an exact species identification based only on the larval stage. All obtained larval mites had quite similar diagnostic morphological features. However, we cannot rule out the possibility that these larval mites include several species. Therefore, larval mites attached to the obtained caddisflies are provisionally recorded as Protzia spp.

Parasitic mites were found on the head, prothorax, mesothorax, metathorax, and abdomen of the caddisfly, and no mites were found on the legs and wings (Table 2). From this result, even after taking the mite larvae’s falling off of the host body into consideration, it is probable that the Protzia larvae generally do not settle on legs and wings of the caddisfly. Böttger (1972) reported that larvae of Protzia eximia attached mainly on the neck and prothorax and partly on the abdomen of caddisflies. Ullrich (1978) also observed that larvae of P. eximia clung to the leg of the host at the beginning and finally settled on the prothorax of the host for engorgement. Martin (2000) noted that larvae of P. eximia attached variably to the wings, thorax, and abdomen of caddisflies. As mentioned in a review of parasitic associations of water mite larvae with host insects by Smith and Oliver (1986), Protzia larvae tend to parasitize to the thorax and abdomen of caddisfly hosts. In contrast, their parasitism to wings of caddisflies (Martin, 2000) would probably be quite rare, and there is no record of their parasitism to legs of caddisflies. This
Table 1. Caddisflies collected during the present survey.

| Family          | Species               | No. of inds. | Stage | Sex | Collecting date (mm.dd.yyyy) | Collecting area                                      | Area No. in Fig.1 | Collector     |
|-----------------|-----------------------|--------------|-------|-----|----------------------------|-----------------------------------------------------|-------------------|---------------|
| Lepidostomatidae| *Lepidostoma speculiferum* | 1            | Adult | ♂   | 07. 27. 1999                | Ibeshibetsu River, Akan, Hokkaido                    | 1                 | Ito, T. & Ohkawa, A. |
|                 | *L. crassicorn*        | 1            | Adult | ♂   | 06. 11. 2004                | Yukanboshi River, Einiwa, Hokkaido                   | 2                 | Ito, T.       |
|                 | *L. stellatum*         | 2            | Adult | ♂   | 06. 11. 2004                | Yukanboshi River, Einiwa, Hokkaido                   | 3                 | Ito, T.       |
|                 | *L. japonicum*         | 1            | Adult | ♂   | 09. 21. 2004                | Oo River, Yamakita, Niigata                          | 4                 | Ito, T.       |
|                 | *L. bipertitum*        | 1            | Adult | ♀   | 09. 26. 2003                | Aimata River, Minobu, Yamanashi                      | 5                 | Hattori, T.   |
| Glossosomatidae | *Glossosoma ussuricum* | 1            | Adult | ♂   | 09. 03. 2005                | Rarumanai River, Einiwa, Hokkaido                    | 6                 | Ito, T.       |
| Rhyacophilidae  | *Rhyacophila transqua* | 1            | Adult | ♂   | 05. 28. 2018                | Abira River, Abira, Hokkaido                         | 7                 | Ito, T.       |

Table 2. Number of individuals of *Protzia* spp. parasitic on caddisfly hosts.

| Host species         | Attachment sites on the host | Detached |
|----------------------|-----------------------------|----------|
|                      | Head | Prothorax | Mesothorax | Metathorax | Fore leg | Mid leg | Hind leg | Fore wing | Hind wing | Abdomen |          |
| *Lepidostoma speculiferum* | 0    | 0         | 1          | 0          | 0        | 0       | 0        | 0         | 0         | 0       | 1        |
| *L. crassicorn*      | 0    | 9         | 7          | 7          | 0        | 0       | 0        | 0         | 0         | 0       | 10       |
| *L. stellatum* (1)   | 0    | 1         | 0          | 0          | 0        | 0       | 0        | 0         | 0         | 0       | 1        |
| *L. stellatum* (2)   | 0    | 1         | 0          | 0          | 0        | 0       | 0        | 0         | 0         | 0       | 0        |
| *L. japonicum*       | 0    | 0         | 0          | 1          | 0        | 0       | 0        | 0         | 0         | 0       | 0        |
| *L. bipertitum*      | 1    | 0         | 0          | 0          | 0        | 0       | 0        | 0         | 0         | 0       | 0        |
| *Glossosoma ussuricum* | 0    | 2         | 0          | 0          | 0        | 0       | 0        | 0         | 0         | 0       | 6        |
| *Rhyacophila transqua* | 0    | 1         | 0          | 0          | 0        | 0       | 0        | 0         | 0         | 0       | 0        |
Fig. 4. Protzia sp. attached on Lepidostoma crassicorne: A. dorsal aspect; B. dorsal aspect of the anterior part of idiosoma; C. the genital region (phase-contrast image); D. lateral aspect of the palp; E. lateral aspect of the chelicera; F. lateral aspect of the tarsus of the second leg. Scale bars: 50 μm in A and B, 10 μm in C–F.
property is rather reasonable, because the wings and legs are considered to be inadequate for settlement and engorgement for the water mite larvae, due to the unstable environment created by the physical activities of host insects.

Up to now, imaginal caddisflies in 15 families have been known as hosts for larval water mites from around the world (Table 3). Among them, 15 genera in 13 families have been recorded as water mite hosts in Japan (Abé and Ohba, 2016), and 11 caddisflies in 10 genera were identified to species. In the present study, seven caddisfly species were recorded as being hosts for Protzia spp., and five of them – *Lepidostoma crassicorne* (Ulmer, 1907), *L. stellatum* (Ito, 1984), *L. japonicum* (Tsuda, 1936), *L. bipertitum* (Kobayashi, 1955), and *Glossosoma ussuricum* (Martynov, 1934) – were newly recorded hosts in Japan. Host insects for Protzia larvae are limited to caddisflies in Japan (Abé and Ohba, 2016). In other countries, however, several dipterans (e.g., Psychodidae, Simuliidae, Empididae, and Chironomidae) are also known as hosts for Protzia (Jones, 1967; Ulrich, 1978; Smith and Oliver, 1986; Martin, 2000). Therefore, it is possible that dipteran hosts for Protzia may also be found in Japan.

### Table 3. Caddisfly hosts and attachment sites recorded for *Protzia*.

| Family of Trichoptera (*incl. record in Japan*) | Attachment sites on host | References |
|-------------------------------------------------|--------------------------|------------|
| Apataniidae                                      | –                        | Böttger (1972), Ulrich (1978), Di Statino et al. (2010) |
| Brachycentridae                                  | Thorax and abdomen        | Smith and Oliver (1986) |
| Glossosomatidae*                                | Wing, thorax, and abdomen | Böttger (1972), Ulrich (1978), Smith and Oliver (1986), Martin (2000), Nagasawa and Abé (2015), Present study |
| Hydrobiosidae*                                  | –                        | Nagasawa and Abé (2015) |
| Hydroptilidae*                                  | Wing, thorax, and abdomen | Martin (2000), Nagasawa and Abé (2015) |
| Hydroptilidae*                                  | –                        | Nagasawa and Abé (2015) |
| Lepidostomatidae*                               | Head, thorax, and abdomen | Smith and Oliver (1986), Nagasawa and Abé (2015), Present study |
| Limnephilidae*                                  | Thorax and abdomen        | Ulrich (1978), Smith and Oliver (1986) |
| Odontoceridae*                                  | –                        | Nagasawa and Abé (2015) |
| Philopotamidae*                                 | Thorax and abdomen        | Smith and Oliver (1986), Nagasawa and Abé (2015) |
| Phryganopsychidae*                              | –                        | Nagasawa and Abé (2015) |
| Polycentropodidae*                              | Thorax and abdomen        | Ulrich (1978), Smith and Oliver (1986), Nagasawa and Abé (2015) |
| Psychomyiidae*                                  | Wing, thorax, and abdomen | Ulrich (1978), Smith and Oliver (1986), Martin (2000), Nagasawa and Abé (2015) |
| Rhyacophilidae*                                 | Thorax and abdomen        | Ulrich (1978), Smith and Oliver (1986), Nagasawa and Abé (2015), Present study |
| Sericostomatidae*                               | Thorax and abdomen        | Ulrich (1978), Smith and Oliver (1986) |
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