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The second record of *Allagelena opulenta* (Araneae, Agelenidae) parasitized by the spider-ectoparasitoid, *Brachyzapus nikkoensis* (Hymenoptera, Ichneumonidae)

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Abstract — Parasitism by the ichneumonid ectoparasitoid, *Brachyzapus nikkoensis*, on the agelenid spider, *Allagelena opulenta* is recorded for the second time with the first voucher specimen. The attacked host was an adult in contrast to the exclusive utilization of juveniles of the main host, *Agelena silvatica*. All published records of parasitism upon *Agelena silvatica* are from spring to early summer, and therefore this finding of parasitism in the end of September, would be consistent with *B. nikkoensis* shifting its hosts in accordance with their body size, seasonal prevalence and their availability, as previously suggested.

Key words — cephalothorax, cocoon, funnel-sheet web, host shift, overwinter, the *Polysphincta* genus-group

Introduction

Brachyzapus nikkoensis (Uchida 1928) is a member of the *Polysphincta* genus-group (Hymenoptera, Ichneumonidae, Pimplinae, Ephialtini), all members of which are solitary koinobiont ectoparasitoid of spiders with high host specificity (Gauld & Dubois 2006; Matsumoto 2016). The genus *Brachyzapus* currently consists of fourteen species distributed in Eurasia and Africa (Gauld & Dubois 2006; Pham *et al.* 2012; Uchida 1928, 1941; Uchida & Momoi 1958; Varga *et al.* 2018; Yu *et al.* 2016) but the only species for which a host spider has been recorded is *B. nikkoensis*. It has been reared exclusively from Agelenidae spiders: *Agelena silvatica* Oliger 1983 (Iwata 1942; Matsumoto 2009; Takasuka *et al.* 2018; Tanaka 1992; Uchida 1941), *Allagelena opulenta* (Koch 1878) (Tanaka 1992) and *Tegenaria domestica* (Clerck 1757) (Uchida 1941).

Member of the family Agelenidae, called funnel web spiders, generally construct a funnel-sheet web with a tunnel (tubular retreat) to hide in. These are made variously on vegetation, among rocks or on manmade structures (Bee *et al.* 2017; Cowles 2018; Dalton 2008; Preston-Mafham 1991). They are members of the RTA-clade which are entirely cursorial spiders or 2D ground-web weavers (Wheeler *et al.* 2017).

The parasitoid *B. nikkoensis* seems to be exclusively associated with agelenid spiders, and its oviposition behaviour is highly adapted to the web structure of this spider, but has thus far only been observed *Ag. silvatica* with the female wasp diving into the funnel-sheet web to entice out the host and then sting the spider (Iwata 1942; Matsumoto 2009; Tanaka 1992).

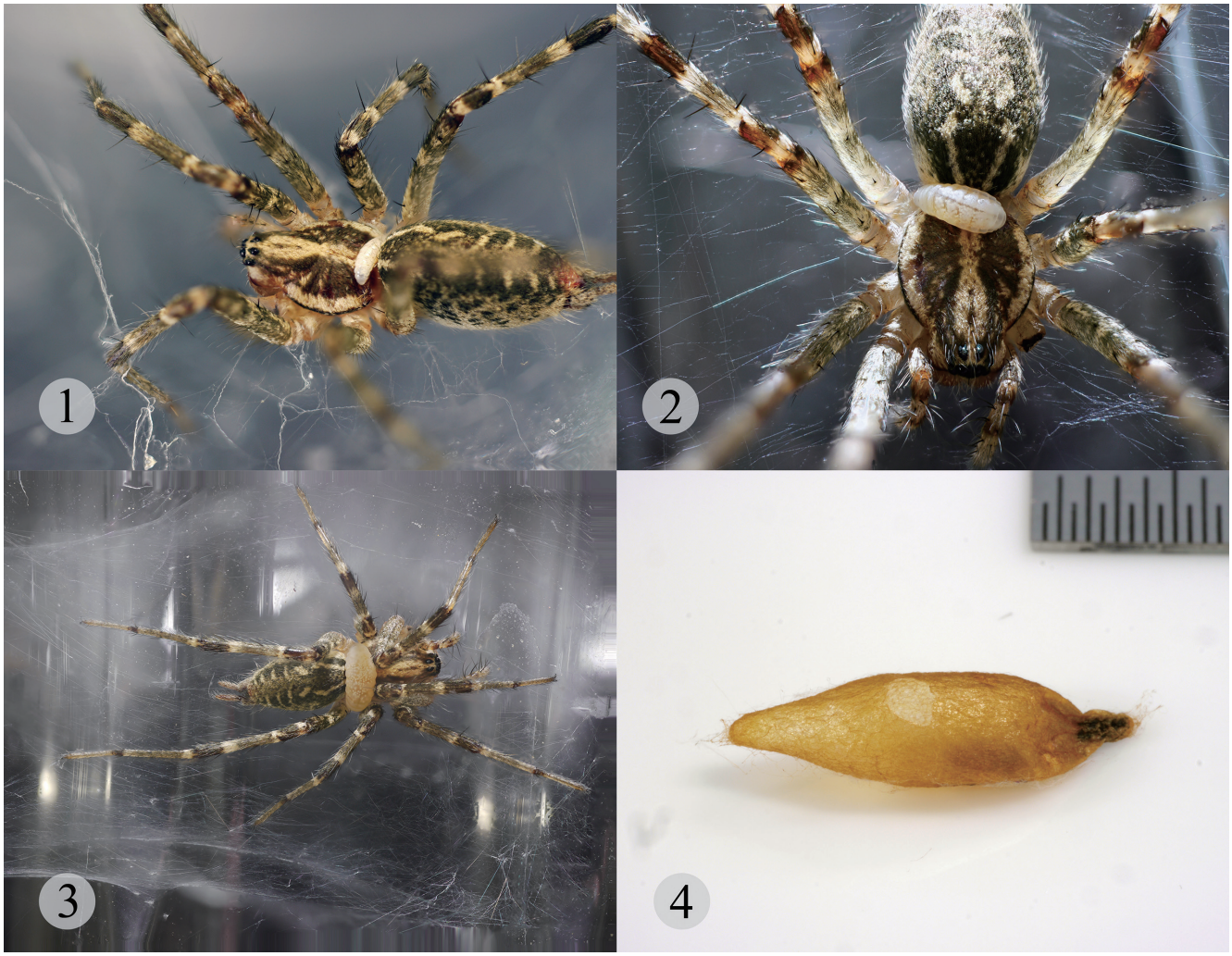
Although Tanaka (1992) mentioned its parasitism on *Al. opulenta* in an ecological paper, there seems to be no evidential specimen regarding this host record. Thus this study reports *B. nikkoensis* parasitizing *Al. opulenta* for the second time with the first voucher specimen. It discusses the probable natural history of the parasitoid as inferred from current knowledge. Reference to literature in Japanese (illustrated books) is done only when it mentions seasonal prevalence and body length of each spider species.

Materials and Methods

An adult female *Al. opulenta* parasitized by a young polysphinctine larva attached to the posterior margin of spider's cephalothorax (Fig. 1) was found in Kodaira-shi, Tokyo, Japan by Mr. Takeaki Ichikawa on 23 September 2016. The spider was placed into a 2 l PET bottle laid sideways and cut its one side to make an openable lid. The spider constructed a funnel-sheet web with a tunnel in this container as in the field. The spider was fed with flies or tiny caterpillars until the parasitoid larva killed her to complete its growth. The emerged wasp was identified by an ichneumonid taxonomist, Dr. Kyohei Watanabe (Kanagawa Prefectural Museum of Natural History, KPMNH). The specimen with a cocoon and the spider carcass is deposited in KPMNH with a depository number, KPM-NK 5006649.

Results

Based on morphology, the emerged wasp was identified to be a female *B. nikkoensis*, representing the second record of



Figs. 1–4. Larva of *B. nikkoensis* upon cephalothorax of *Al. opulenta* (1–3) and its cocoon (4). 1, young instar larva photographed on 26 September 2016; 2, middle instar larva photographed on 28 September 2016; 3, penultimate instar larva photographed on 30 September 2016; 4, cocoon.

Al. opulenta parasitized by the wasp.

When the spider was active, the wasp larva only fed from its cephalothorax (Figs. 1–3), but after the spider became completely immobile and was dying, the larva also fed from spider's abdomen. After killing the spider, it started to spin its cocoon (Fig. 4) on 1st October 2016 over the course of one day. Its meconium was excreted and stuffed in the distal end of the cocoon. The wasp emerged from the middle part of the cocoon (Fig. 4) on 12 October 2016, in contrast to the anterior end previously observed in the same species parasitic on *Ag. silvatica* (Matsumoto 2009).

Discussion

Although Tanaka (1992) already suggested that *B. nikkoensis* may shift its host spider between *Ag. silvatica* and *Al. opulenta* dependent on their body size and seasonal prevalence, I reconsider this hypothesis reviewing current knowledge.

All records of parasitism of *Ag. silvatica* so far are restricted to the period from late April to July (Iwata 1942; Matsumoto 2009; Takasuka *et al.* 2018; Tanaka 1992) and three generations of *B. nikkoensis* utilizing *Ag. silvatica* during this period is suggested (Tanaka 1992). From the previous observations, utilization of *Ag. silvatica* seems exclusively to involve immature spiders (instar 2–6) with the highest rate on instar 3 and no parasitism observed on adult hosts (Tanaka 1992); host immaturity can be clearly ascertained from the pictures in other papers (Matsumoto 2009; Takasuka *et al.* 2018). *Agelena silvatica* is univoltine in Aichi prefecture (Tanaka 1992) and reaches to adulthood from July (Shinkai 2017; Tanaka 1992; Tokyo Spider Study Group 2015). This means that suitable *Ag. silvatica* become no longer available for *B. nikkoensis* in the end of July. Utilization of immature spiders is the general tendency among polysphinctines probably because adult spiders are too big to attack or consume, and probably less

numerous.

The parasitism recorded here was in late September and as with Tanaka (1992), who observed it in summer and autumn, involved an adult host (Figs. 1–3). *Allagelena opulenta* becomes mature from late August to September, one and a half months later than *Ag. silvatica* (Kayashima 1967); thus, when suitably-sized *Ag. silvatica* begin to disappear *Al. opulenta* is still active in adulthood. Although the instar of attacked *T. domestica* is unclear, parasitism upon this species was also observed from August to October (Uchida 1941). Interestingly, utilization of these spiders as adults can be explained by their body sizes at maturity which are clearly smaller than that of *Ag. silvatica*; 6–12mm in body length of adult female *Al. opulenta* (Baba & Tanikawa 2015; Shinkai 2017), 7–12mm of *T. domestica* (Shinkai 2017) whereas 14–18mm of *Ag. silvatica* (Baba & Tanikawa 2015; Shinkai 2017). These records suggest that *B. nikkoensis* shifts host spider between spring/summer (*Ag. silvatica*) and summer/autumn (*Al. opulenta* and *T. domestica*) in accordance with the availability of suitably-sized individuals.

As a side note, because *T. domestica* is thought to be an exotic species in Japan, originating from Europe (Ono 2009), parasitization by *B. nikkoensis*, which is distributed in Japan and the Russian Far East, suggests this is a novel host-parasitoid relationship. This would probably arise due to similarity in web structure of *T. domestica* to that of its original host, resulting in an application of the oviposition behavior.

A remaining question concerns the overwintering stage of *B. nikkoensis* because *Al. opulenta* overwinters as eggs inside egg-sac (Chikuni 1989) and even *Ag. silvatica* overwinters as second instar spiderlings without emerging from the egg-sac until spring (Tanaka 1992). Although almost all polysphinctine wasps overwinter as minute larva on the overwintering host spider (Fitton *et al.* 1988; Fritzén 2010, 2014; Fritzén & Fjellberg 2014; Fritzén & Shaw 2014; Matsumoto & Takasuka 2010; Takasuka & Tanaka 2013), they would be unable to exploit the overwintering eggs and tiny spiderlings. As in a few very rare cases observed such as those of *Megaetaira madida* (Haliday 1838) (Fitton *et al.* 1988) and *Zatypota maculata* Matsumoto & Takasuka 2010 (Matsumoto & Takasuka 2010), overwintering as a prepupa or as an adult seems likely but remains to be verified.

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