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ORIGINAL ARTICLE

Life histories of two ichneumonid parasitoids of *Cyclosa octotuberculata* (Araneae): *Reclinervellus tuberculatus* (Uchida) and its new sympatric congener (Hymenoptera: Ichneumonidae: Pimplinae)

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Abstract

In Japan, two species of the genus *Reclinervellus* were found to attack a single host spider, *Cyclosa octotuberculata* (Araneae). One of these, *Reclinervellus tuberculatus* comb. nov., winters as a tender larva and has at least two generations a year. This species laid its egg on the anterior face of the host's abdomen. Prior to laying an egg the female repeatedly rubbed her ovipositor over the dorsal and lateral surfaces of the host's abdomen near the base for more than 25 min. The hatched larva fixed itself at the position where the egg was laid, and developed by consuming the host's body fluids. The other species, *R. masumotoi* sp. nov., is closely related to *R. tuberculatus* but is easily distinguished from it by having a very weakly reclivous Cu vein in the hindwing, a less developed carina of the propodeum, a shorter ovipositor and more blackish coloration of the mesoscutum. Although this species is sympatric with *R. tuberculatus* and attacks the same host, the position of the egg and larva on the host's body is quite different from that of *R. tuberculatus*. The egg of this species was laid on the posterior surface of the host's abdomen and the larva matured 10–20 days earlier than those of *R. tuberculatus*. Via these modes of parasitism *R. masumotoi* seemed to escape from competition with *R. tuberculatus* at the stage of oviposition and out-competed it when a single host individual bore larvae of both species. Previous records of parasitoids reared from *C. octotuberculata* were reviewed and found to include records of both species.

Key words: Ephialtini, host, key, koinobiont, *masumotoi*, new species, parasitism.

INTRODUCTION

The *Polysphincta* group of genera is a monophyletic lineage of the tribe Ephialtini of the Pimplinae. All of the members of this group whose life history is known are koinobiont ectoparasitoids of active spiders. Parasitized spiders continue to lead a normal life until the parasitoid larva matures. Despite there being many host records, information on the immature stages of this group is scarce, and observations on oviposition behavior are not available except for a few detailed works including Nielsen (1923) and Eberhard (2000). The genus *Reclinervellus* He and Ye is a small Palearctic genus belonging to the *Polysphincta* group that contains two species (Gauld & Dubois 2006). One species, *Reclinervellus dorsiconcavus*, was described from China, and the other, *Reclinervellus nielseni*, is widely distributed in the Palearctic region and was recently transferred from the genus *Polysphincta* (Gauld & Dubois 2006). Nielsen (1923) recorded *Cyclosa conica* (Pallas) as being a host of *Polysphincta nielseni* and described its pupae and percentage parasitism. Fritzen (2005) recorded *P. nielseni* from Finland based on reared specimens from the same host. In Japan, Iwata (1942) noted that *Polysphincta tuberculata*, which was later synonymized

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with *P. nielseni* by Kasparyan (1977), was an external parasitoid of *Cyclosa octotuberculata* Karsch (Araneidae), and described its immature stages for the first time. Afterwards, several authors recorded *P. tuberculata* from the same host (Uchida & Momoi 1958; Hashimoto 1962, 1963).

Recently, two closely related species of the genus *Reclinervellus*, who position eggs and larvae quite differently on the host, were found to attack the same host spider, *C. octotuberculata* (T. Masumoto, pers. comm., 2003). The life histories of these parasitoids were investigated to establish whether they are in competition with each other and how they can coexist. Because another species of the genus has been found to be a parasitoid of *Cyclosa argenteoalba*, the Japanese species of the genus are reviewed.

MATERIALS AND METHODS

Both field observations and laboratory rearing were used. Field observations were mainly conducted at Baba (34°22′57″N, 135°23′16″E (WGS84), 110 m a.s.l.), in Kaizuka City, Osaka Prefecture, Japan, approximately once a week from April to June in 2004. The host spider, *C. octotuberculata* was abundant in the study area and was easily found by its characteristic orb-web with a vertical ribbon of detritus along the midline. All host spiders found along a path that ran through the study area were examined on site. All pupae and mature larvae on the host web and some host spiders bearing an egg or a larva of a parasitoid were taken to the laboratory for detailed observations and rearing. Some complementary field observations were performed in July, August and September. In order to investigate the percentage parasitism and distribution, the host spiders were also examined in other localities in 2003 and 2004. In addition, specimens of the genus reared from *C. argenteoalba* in Japan; the holotype of *P. tuberculata* preserved in the Laboratory of Systematic Entomology, Hokkaido University (SEHU); identified specimens of *R. nielseni* from Finland; and *R. nielseni* from Austria and England from the Natural History Museum (NHM) were also examined.

Final instar larvae were killed in hot water and washed using distilled water, then transferred to 70% ethanol and examined under a stereoscopic microscope. A scanning electron microscope (VE-7800; Keyence, Osaka, Japan) was used to perform detailed observations of the external morphology of larvae and adults. Larval specimens for scanning electron microscopy were prepared using the method of Heraty and Hawks (1998). Terminology follows Short (1978) for larval structures and Gauld (1991) for adult morphology. As a measure of the relative length of the ovipositor, the ovipositor–hind tibia index is used. This index is defined as the length of the ovipositor projecting beyond the apex of the metasoma divided by the length of the hind tibia. All examined specimens are preserved in the collection of the Osaka Museum of Natural History (OMNH) unless noted otherwise.

RESULTS

Descriptions

Reclinervellus tuberculatus (Uchida) comb. nov.

Polysphincta tuberculata, Uchida, 1932: 156.
Oxyrrhexis tuberculata, Townes & Townes, 1960: 242.
Polysphincta nielseni, Kasparyan, 1977: 460.

Female. Head. Flagellum consists of 33–35 segments; frons polished, impunctate; face between antennal socket and supraclypeal suture 1.1 times as long as its minimum width between eyes, with a pair of very shallow vertical sutures arising from supraclypeal suture; clypeus 2.7 times as wide as its length, with apical margin broadly and weakly truncate, covered with rather long pubescence; eye bare, inner margin almost straight, weakly concave a little above antennal socket; ocelli of moderate size, the distance between eye and lateral ocellus a little shorter than the maximum diameter of the latter; mandible with upper tooth distinctly longer than lower, at the middle about half as wide as the basal width, weakly turned inward at distal 0.3, outer face of mandible covered with rather long pubescence; palpi formula 5:4; malar space approximately as long as basal width of mandible, granulate between eye and mandible base; hypostomal carina weakly flanged between the lower articulation of mandible and junction of occipital and hypostomal carinae; vertex with interocellar area weakly raised, concave posteriorly in dorsal view; outline of gena straight in dorsal view; occipital carina complete.

Mesosoma. Pronotum with anterior margin reflexed, mediodorsally produced into a backwardly directed tooth which connects with a medio-dorsal longitudinal raised keel, polished, with distinct epomia; mesoscutum in front of scuto-scutellar groove 1.2–1.3 times as long as wide in dorsal view, covered with fine pubescence all over, with notauli moderately impressed; mesopleuron with epicnemial carina distinct, its upper end surpassing the level of the lower corner of the pronotum and rather far from the posterior margin of the pronotum; scutellum

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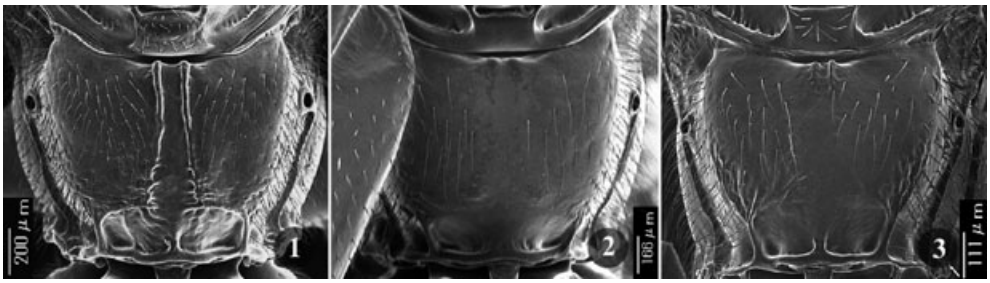
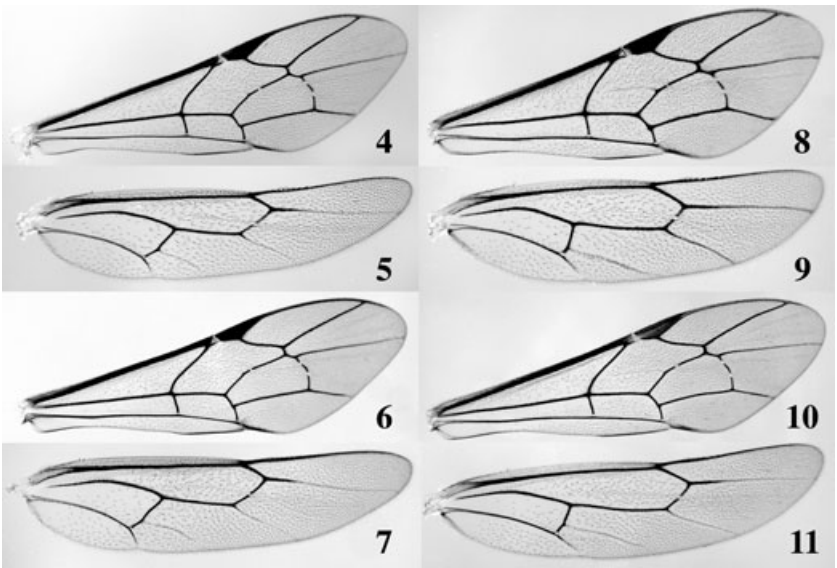


Figures 1–3 Female propodeum of *Reclinervellus* spp. **1** *Reclinervellus tuberculatus*; **2** *Reclinervellus masumotoi* sp. nov. (paratype); and **3** *Reclinervellus nielseni*.



Figures 4–11 Fore- and hindwings of *Reclinervellus tuberculatus* (**4–7**) and *Reclinervellus masumotoi* (**8–11**, paratypes). **4,8** Female forewing; **5,9** female hindwing; **6,10** male forewing; and **7,11** male hindwing.

convex; lateral part of propodeum moderately punctate, covered with rather dense pubescence, with areas basalis, superomedia, posterialis and postero-externa fused, carinae delimiting this combined area rather distinct (Fig. 1), lateromedian longitudinal carina sometimes weak or broken and replaced by oblique wrinkles between anterior and posterior transverse carinae; pleural carina complete; propodeal spiracle touching or almost touching pleural carina; submetapleural carinae complete; other carina of propodeum absent.

Wings. Forewing (Figs 4,6) with vein Rs+M opposite or a little basad of cu-a, 2rs-m approximately half as long as M between 2rs-m and 2m-cu; vein Cu1 of hindwing (Figs 5,7) present but usually obscure; vein Cu between Cu+M and Cu1 approximately twice as long as cu-a; vein Cu strongly reclivous, thus antero-dorsal corner of subbasal cell distinctly less than 90°.

Legs. Fore and middle femora inflated; hind femur 4.0–4.3 times as long as its maximum width; hind tibia 7.7–8.0 times as long as its apical width; first tarsal segment of hindleg as long as second and third segments combined; fifth segment as long as the third.

Metasoma. First to sixth metasomal tergites (T1–6) strongly punctate all over, weakly rugose on T1; postero-dorsal part of T1 moderately punctate; median dorsal carina of T1 strongly convergent in dorsal view; junction of dorso-lateral and median dorsal carinae projecting laterally above deep glymma; T2–6 (sometimes weak in T6) each with paired rounded swellings; first tergite as long as its apical width; second tergite 1.1 times as long as T1 and 1.3 times as long as its apical width. Ovipositor straight, slightly thickened medially and gradually tapered to a very sharp point; lower valve with a distally angulate swelling ventrally

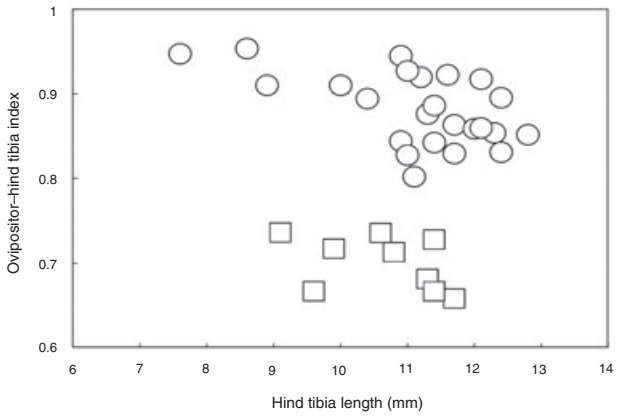


Figure 12 Ovipositor–hind tibia index in *Reclinervellus tuberculatus* (○) and *Reclinervellus masumotoi* (□).

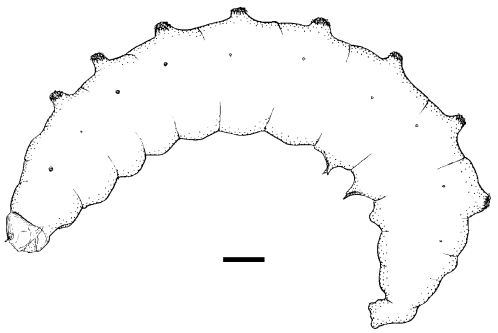


Figure 13 Final instar larva of *Reclinervellus tuberculatus*, lateral aspect (scale bar: 1.0 mm).

at extreme base; ovipositor–hind tibia index 0.80–0.95 (Fig. 12).

Coloration. Head mostly black, with the following parts yellow: pedicel, apical half of scape, face around antennal socket, clypeus, mandible except tip and palpi, flagellum brownish. Mesosoma mostly yellowish brown; propleuron and pronotum yellow, the latter dark brown posteriorly except upper and lower margins; mesoscutum black except yellow area around anterior end of notaulus and a pair of yellow longitudinal spots near posterior end of notaulus, median area between these paired spots reddish brown; tegula and subalar prominence yellow; epicnemium and upper half of mesopleuron dark brown, lower half reddish brown and this area extending upward along epicnemial carina and mesopleural suture, the dark brown area sometimes reduced; mesepimeron yellow; scuto-scutellar groove reddish brown; scutellum and post-scutellum yellowish brown; propodeum black to blackish brown above the pleural carina and in front of posterior transverse carina, sometimes paler medially, the rest yellowish brown except posterior end blackish brown. Legs yellowish brown; coxa, trochanter and trochantellus of fore- and midleg paler; hind coxa paler dorsally and darkened apico-ventrally; hind tibia with subbasal and apical black bands; the latter occupy the apical 0.4 of the tibia; tip of first to third tarsal segments and fourth and fifth segments wholly dark brown; dark brown part of first tarsal segment occupies basal 0.3 or less. Wings hyaline. Metasomal tergites black to blackish brown except following parts yellowish brown: extreme base and antero-lateral corners of T2–5, dorso-median area between paired swellings. Ovipositor brown, its sheath black.

Male. Very similar to the female but slightly smaller; flagellum 30–31 segmented; genitalia robust; gonosquama rather short, somewhat truncate and weakly rounded apically in lateral aspect, bearing dense pubescence all over except dorsal and basal part; subgenital plate semicircular, covered with rather dense pubescence.

Length. Forewing 5.8–9.5 mm in ♀, 4.4–7.8 mm in ♂.

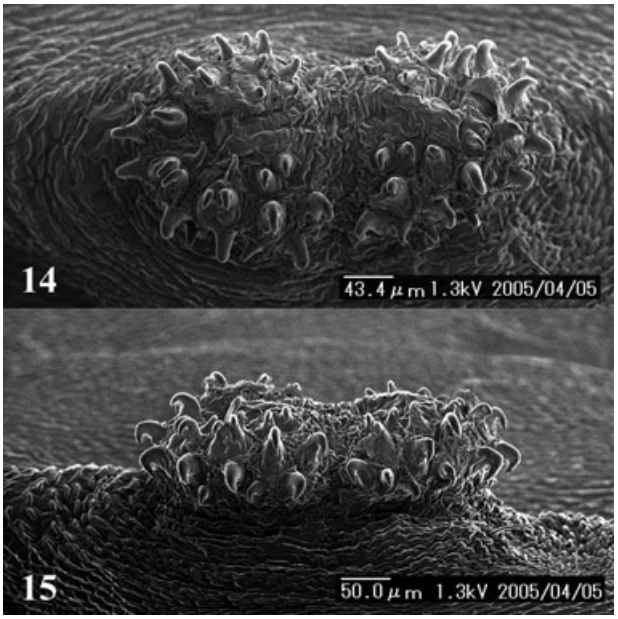
Variation. Seasonal variation occurs. Body color of second generation paler, blackish brown areas of pronotum and mesopleuron much reduced. Antero-median part of mesoscutum broadly yellowish.

Final instar larva (Fig. 13). Thirteen-segmented. Third thoracic and first to seventh abdominal segments with paired dorsal retractable swellings (Figs 14,15). These paired swellings of each segment are almost fused medially and bear a number of distinct hooks. Fifth and sixth abdominal segments each with a pair of taps ventrally. The larva is located on the anterior face of the host's abdomen.

Distribution. Japan: Honshu, Shikoku, Kyushu (new record), Tsushima (new record) (Fig. 16) .

Host. *Cyclosa octotuberculata* Karsch.

Remarks. A medium-sized ichneumonid, dark brown to black in color, with many parts yellow to brown-colored. This species was originally described from Japan by Uchida (1932). Although Kasparyan (1977) treated this species as a junior synonym of *Polysphincta nielseni*, the two species can be seen to be distinct when specimens of *R. tuberculatus* (including the holotype) are compared with those of *R. nielseni* from Europe and Japan. The distinct latero-median longitudinal carinae of the propodeum, relatively longer ovipositor (ovipositor–hind tibia index 0.80–0.95) and larger body size separate *R. tuberculatus* from *R. nielseni*. He and Ye (1999) established the genus *Reclinervellus* and



Figures 14,15 Dorsal swellings of final instar larva of *Reclinervellus tuberculatus*. **14** Dorsal aspect; **15** frontal aspect.

Gauld and Dubois (2006) transferred *P. nielseni* to this genus. Judging from the wing venation, *tuberculatus* should also belong to the genus *Reclinervellus*.

Specimens examined. Note that all immature and reared specimens were from *C. octotuberculata*. Holotype ♀ of *Polysphincta tuberculata* (SEHU), 30.v.1931, Gifu (S. Kariya). [Honshu] 1 larva and 1 egg, 1.x.2004 (on host), Kami-iida, Iida, Nagano Prefecture, R. Matsumoto (R.M.); 1 larva and 1 egg, 20.x.2003 (on host), Ogaki, Miyazu, Kyoto Prefecture (R.M.); 1 larva, 13.v.2000 (on host), Senjogahara, Oe, Kyoto Prefecture (R.M.); 1♀, 16.v.2001, Oujiyama, Otsu, Shiga Prefecture (T. Masumoto); 1♂, 6.vi.2000 (cocoon on host web, emer. 6.vi), Pon-pon-yama, Kyoto, Kyoto Prefecture (R.M.); 1 larva, 1.iv.2005 (on host), Kuroide, Uji, Nara Prefecture (R.M.); 2♂2♀, 28.iv.2004 (larva on host, cocooned 1.iv., emer. 7–18.iv), Takayama-cho, Ikoma, Nara Prefecture (R.M.); 1♂, 28.iv.2004 (cocoon on host web, emer. 8.v), same locality (R.M.); 1♂, 14.v.2005 (cocoon on host web, emer. 23.v), Yatacho, Yamatokoriyama, Nara Prefecture (R.M.); 1♀, 14.v.2005 (larva on host, emer. 25.v), same locality (R.M.); 2♀, 14.v.2004 (cocoon on host web, emer. 19–20.v), Hase, Sakurai, Nara Prefecture (R.M.); 1♂1♀, 14.v.2004 (cocoon on host web, emer. 17–18.v), Hase-dam, Sakurai, Nara Prefecture (R.M.); 1♀, 19.ix.2004 (cocoon on host web, emer. 26.ix), Izuhara, Ibaraki, Osaka Prefecture (R.M.); 1♀, 23.ix.2005 (larva on host, emer. 8.x), Saigahara, Minoo, Osaka Prefecture (R.M.); 1 larva, 23.iv.2005 (first instar, on host), Hiraoka, Higashiosaka, Osaka Prefecture (R.M.); 1♀, 18.v.2000 (cocoon on host web, emer. 22.v), Kawaidera, Kawachinagano, Osaka Prefecture (R.M.); 1♂, 17.vi.2003, Amami, Kawachinagano, Osaka Prefecture (R.M.); 1♂, 1.v.2003 (larva on host, emer. 11.v), Baba, Kaizuka, Osaka Prefecture (R.M.); 3♀, 13.v.2004 (cocoon, emer. 17–21.v), same locality (R.M.); 2♀, 19.vii.2005 (larva on host, emer. in July), same locality (R.M.); 1♂, 3.v.2005 (cocoon, emer. 8.v), same locality (R.M.); 1♀, 4.v.2004 (larva on host, emer. 11.v), same locality (R.M.); 1♂3♀, 13.v.2004 (cocoon on host web, emer. 15–19.v), Eiraku-dam, Kumatori, Osaka Prefecture (R.M.); 9♀, 13.v.2004 (cocoon, emer. 18–23.v), Kibitani, Kaizuka, Osaka Prefecture (R.M.); 1♀, 5.vii.2004 (larva on host, cocooned 12.vii., emer. 20.vii), same locality (R.M.); 2♀, 26.vi.2000 (larva on host, cocooned 29.vi., emer. 6.vii), Moyama, Izumisano, Osaka Prefecture (R.M.); 20♂10♀, 4.v.2004 (cocoon on host web, emer. 8–19.v), Shin-takinoike, Izumisano, Osaka Prefecture (R.M.); 1♂3♀, 4.v.2004 (larva on host, cocooned 4.v., emer. 14.v), same locality (R.M.); 1♀, 22.v.2000 (cocoon on host web, emer. 30.v), Ushitaki, Kishiwada, Osaka Prefecture (R.M.); 1♀, 23.v.2003 (cocoon on host web, emer. 27.v), Shinge, Sennan, Osaka Prefecture (R.M.); 1♂2♀, 13.v.2004 (cocoon on host web, emer. 19–21.v), Nakahata, Uchita, Wakayama Prefecture (R.M.); 1♀, 11.iv.2004 (larva on host, emer. 21.iv), Mitsuishiyama, Hashimoto, Wakayama Prefecture (R.M.); 1♂2♀, 6.v.2004 (larva on host, cocooned 6–7.v., emer. 17–18.v), Otani, Soja, Okayama Prefecture (R.M.). [Shikoku] 1♂, 15.iv.2004 (larva on host, cocooned 1.iv., emer. 11.v), Yanagiso, Tanbara, Ehime Prefecture (R.M.); 2♂, 15.iv.2004 (larva on host, cocooned 22–30.iv., emer. 2–11.v), Kurose-toge, Saijo, Ehime Prefecture (R.M.); 1♂1♀, 26.iv.2004 (larva on host, cocooned 5.v., emer. 14.v), Hiura, Kawauchi, Ehime Prefecture (R.M.); 1♀, 20.ix.2004 (cocoon on host web, emer. 23.ix), Kuma, Kuma, Ehime Prefecture (R.M.); 1♂, 8.ix.2003 (larva on host, emer. 8.x), Kanmon, Omogo, Ehime Prefecture (R.M.). [Kyushu] 1♀, 20.xi.1996, Nishiaburayama, Fukuoka, Fukuoka Prefecture (T. Iwai); 1♀, 28.v.2003 (cocoon on host web, emer. in June), Kiuragi, Kobayashi, Miyazaki Prefecture (R.M.). [Tsushima] 1♀, 11.v.2005 (larva on host, emer. 22.v), Kashitaki/Okubo, Kamiagata (R.M.); 1♂2♀, 11.v.2005 (cocoon on host web, emer. 17–19.v), same locality (R.M.).

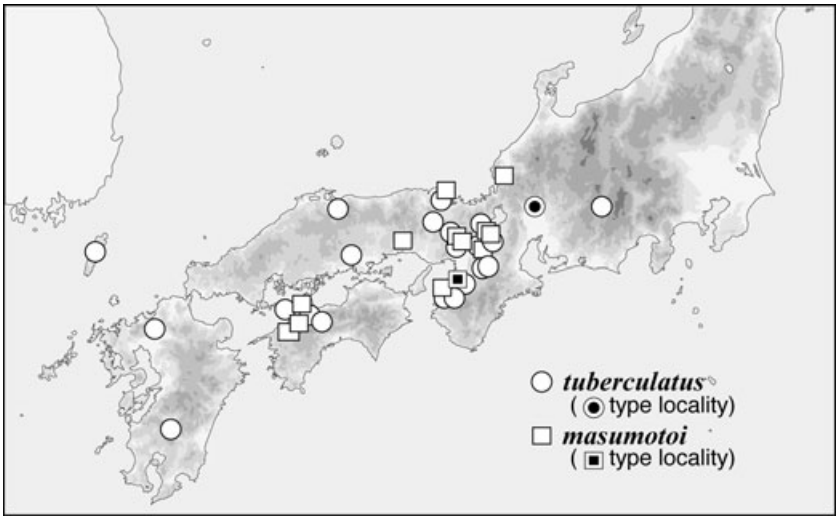


Figure 16 Distributions of *Reclinervellus tuberculatus* and *Reclinervellus masumotoi* in Japan.

Reclinervellus masumotoi Matsumoto & Konishi sp. nov.

Female. Generally very similar to *R. tuberculatus* but differs from it in the following respects. Lateral part of propodeum sparsely punctate, almost impunctate dorsally; propodeal carinae much reduced (Fig. 2), at most with very weak latero-median longitudinal carinae at the extreme base. Hindwing (Figs 9,11) with vein Cu less reclivous, thus antero-distal corner of subbasal cell approximately 90°. Hind femur 3.6–3.7 times as long as its maximum width; hind tibia 8.2–9.0 times as long as its apical width. Postero-dorsal part of T1 hardly punctate, shining at the middle; median dorsal carinae of T1 weakly to moderately convergent in dorsal view; junction of dorso-lateral and median dorsal carinae weakly or not projecting laterally above glymma; ovipositor–hind tibia index 0.65–0.75 (Fig. 12). Pale markings of body less developed; pronotum black, with narrow yellow band on upper and lower margins; mesoscutum black except yellow area around anterior end of notauli and a pair of small yellow longitudinal spots near posterior end of notauli, median area between these paired spots always black; tegula and subalar prominence yellow; epicnemium and upper half of mesopleuron black, the lower half reddish brown to yellow and this area extending upward along mesopleural suture; scutoscutellar groove blackish; scutellum and postscutellum yellowish brown, somewhat darkened antero-medially; propodeum black to brown above the pleural carina and in front of the posterior transverse carina (these carinae usually faint), sometimes paler medially; tarsal segments of hindleg dark brown to black, except basal half of first and second segments pale.

Male. Similar to the female but slightly smaller. No morphological differences were detected between this species and *R. tuberculatus* with respect to male genitalia.

Length. Forewing 7.2–10.1 mm in ♀, 4.8–7.2 mm in ♂.

Variation. The body color is quite stable within the examined specimens.

Final instar larva. Very similar to *R. tuberculatus*. No morphological differences were detected between them. The only and distinct difference is the location of the larva on the host's body. The larva of *R. masumotoi* is located on the posterior end of the host's abdomen, between the apical tubercles.

Remarks. A medium-sized ichneumonid, predominantly blackish with some yellow to brown markings. This species is named in honor of Dr Toshiya Masumoto (Otsu City), who first noticed the unusual position of the larva on the host and provided some of the paratype specimens. Gauld and Dubois (2006) noted that *Reclinervellus* may be recognized by the fact that all species have the subbasal cell in the hindwing rather broad, with Cu1 and cu-a strongly oblique so that the antero-distal corner of the subbasal cell is acute. Although the vein Cu1 and cu-a are not strongly oblique and the antero-distal corner of the subbasal cell is less acute in *masumotoi*, the following character states of this species indicate that *masumotoi* belongs to the genus *Reclinervellus*: pronotum medio-dorsally with a longitudinal flange from fore margin to collar, tergite III with prominent latero-median convexities and with a single postero-median convex area behind these and the ovipositor strongly broadened basally. This species can be

distinguished from all other species of the genus by the vein Cu of the hindwing being less reclivous. In general, this species particularly resembles *R. tuberculatus*, but is distinguishable from it by having a relatively shorter ovipositor and a black area between paired yellow markings at the posterior ends of notauli in addition to the above-mentioned character.

Host. *Cyclosa octotuberculata* Karsch.

Distribution. Japan: Honshu, Shikoku (Fig. 16).

Type series. All specimens were reared from *C. octotuberculata*.

Holotype ♀, "3.v.2005 (cocoon on web of *C. octotuberculata*, emer. 11.v), Baba (34°22′57″N, 135°23′16″E (WGS 84), 110 m a.s.l.), Kaizuka, Osaka Prefecture, Japan (R. Matsumoto), [OMNH, TI-210]."

Paratypes [Honshu] 1♂1♀, 10.vi.2002 (by rearing), Otani-cho, Otsu, Shiga Prefecture (T. Masumoto); 1♂, 5.iv.2004 (Larva on host, cocooned 5.iv., emer. 18.iv); 1♂, 17.iv.2004 (Larva on host, cocooned 17.iv., emer. 27.iv), 1♀, 24.iv.2004 (Cocoon on host web, emer. 6.v), 1♀, 3.v.2005 (cocoon on host web, emer. 13.v), same locality as holotype (R.M.); 1♀, 13.v.2004 (cocoon, emer. 14.v), Kibitani, Kaizuka, Osaka Prefecture (R.M.); 1♀, 29.iv.2004 (larva on host, cocooned 1.v., emer. 9.v), Tonohara-cho, Kaizuka, Osaka Prefecture (R.M.); 1♂, 20.iv.2004 (larva on host, cocooned 20.iv., emer. 28.iv), same locality (R.M.); 1♀, 15.v.2006 (cocoon on host web), O-ichi-naka, Himeji, Hyogo Prefecture (R.M.). [Shikoku] 1♀, 14.iv.2004 (larva on host, cocooned 16.iv., emer. 27.iv), Kariba, Saijo, Ehime Prefecture (R.M.); 4♀, 14.iv.2004 (cocoon on host web, emer. 3–5.v), Hiura, Kawauchi, Ehime Prefecture (R.M.); 1♂1♀, 15.iv.2004 (larva on host, cocooned 22–30.iv., emer. 3–12.v), Odoi, Saijo, Ehime Prefecture (R.M.).

Specimens other than type materials examined. [Honshu] 1 egg and 1 larva, 20.x.2003 (on host), Ogaki, Miyazu, Kyoto Prefecture (R.M.); 1 larva, 1.iv.2005 (on host), Baba, Kaizuka, Osaka Prefecture (R.M.). [Shikoku] 1 larva, 17.iv.2005 (on host), Sugezawamachi, Matsuyama, Ehime Prefecture (R.M.); 1 larva, 17.iv.2005 (on host), Sanegawa, Matsuyama, Ehime Prefecture (R.M.); 1 larva, 16.iv.2005 (on host), Sugou, Kuma, Ehime Prefecture (R.M.).

Reclinervellus nielseni (Roman)

Remarks. A small ichneumonid with a rather short ovipositor. Dark brown to black in color, with many parts yellow to brown-colored. This species was originally described under the genus *Polysphincta* from Denmark and is known to be distributed widely in the Palearctic region. Gauld and Dubois (2006) transferred this species to *Reclinervellus*. Because *P. tuberculatus* Uchida had been treated as a junior synonym of this species (Kasparyan 1977), *P. nielseni* was recorded as Japanese (Yu & Horstmann 1997). In this study these two species were recognized as separate. Recently *R. nielseni* itself was discovered from Japan as a parasitoid of *C. argenteoalba*.

Host. *Cyclosa argenteoalba* (Bosenberg & Strand) (new record) in Japan, *Cyclosa conica* (Pallas) in Europe (Nielsen 1923; Fritzen 2005).

Distribution. Japan: Honshu (new record); Palaearctic.

Specimens examined. All Japanese reared specimens were from *C. argenteoalba*. One male from Austria and the Finnish specimens were reared from *C. conica*.

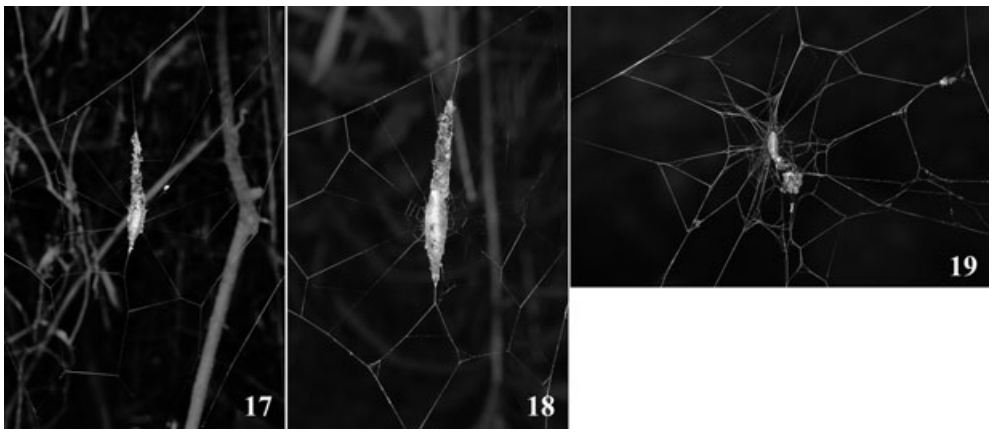
[Honshu] 1♂, 28.iv.2004 (larva on host, cocooned 4.iv., emer. 14. iv), Takayama-cho, Ikoma, Nara Prefecture (R.M.); 1♀, 29.viii.2005 (cocoon on host web, emer. 6.ix), Izuhara, Ibaraki, Osaka Prefecture (R.M.); 1♂1♀, 24.v.2004 (cocoon on host web, emer. 28–30.v), Minoo, Minoo, Osaka Prefecture (R.M.); 1♀, 24.iv.2004, Rokko-Yahatajinja, Kobe, Hyogo Prefecture (K. Murakami); 1♂, 16.v.2003 (cocoon on host web, emer. 4.v), Himeji, Hyogo Prefecture (K. Funabiki). [England] 1♂, emer. 1.vii., Kent near Faversham, Perry Woods (J. Badmin), identified by Dr M.G. Fitton (NHM). [Austria] 1♀, 8.vi.1965 (larva on *Cyclosa conica*, emer. 28.vi), W. Tysol near Fiss (J.A.J. Clark), identified by Dr M.G. Fitton (NHM). [Finland] 1♂, 25.iii.2005 (larva on host, emer. 2.v), Kristinestad, Hogasen (N.R. Fritzen); 1♀, 10.v.2005 (larva on host, emer. 1.vi), Korsholm, Jungsund (N.R. Fritzen), identified by N. R. Fritzen on the basis of comparison with the specimens identified by Dr M.R. Shaw.

Key to Japanese species of the genus *Reclinervellus*

1 Hindwing with Cu vein strongly reclivous (Figs 5,7), antero-distal corner of subbasal cell distinctly less than 90°; egg is laid on anterior face of host's abdomen, with the larva in the same position……2

– Hindwing with Cu vein weakly reclivous (Figs 9,11), antero-distal corner of subbasal cell approximately 90°; egg is laid on posterior face of host's abdomen between apical tubercles, with the larva in the same position.

Ovipositor–hind tibia index 0.65–0.75; latero-median longitudinal carinae of propodeum almost absent (Fig. 2), mesoscutum with the median area between paired yellow markings near the posterior end of notauli black; tarsal



Figures 17–19 Modified webs of host spider and cocoons of parasitoid. **17** *Cyclosa octotuberculata* (*Reclinervellus tuberculatus*); **18** *Cyclosa octotuberculata* (*Reclinervellus masumotoi*); and **19** *Cyclosa argenteoalba* (*Reclinervellus nielseni*).

segments of hindleg dark brown to black, except basal half of first and second segments pale.....*masumotoi* sp. nov.

2 Lateromedian longitudinal carinae of propodeum distinct (Fig. 1) in female (sometimes replaced by oblique wrinkles medially between anterior and posterior transverse carinae); ovipositor–hind tibia index 0.80–0.95; larger species, forewing 10–12 mm; parasitoid of *C. octotuberculata*. .....*tuberculatus* (Uchida)

– Lateromedian longitudinal carinae of propodeum much reduced (Fig. 3), present only at extreme base in female; ovipositor–hind tibia index 0.58–0.70; smaller species, forewing 5–6 mm; parasitoid of *C. argenteoalba* in Japan.....*nielseni* (Roman)

Immature stages of *R. tuberculatus*

The egg of *R. tuberculatus* is laid on the host's abdomen near the base, dorso-laterally. The first instar larva pokes the anterior end of its body out of the egg, with the posterior part of its body remaining lodged inside the chorion. The second instar larva possibly emerges from the egg chorion and fixes itself at the position where the egg was laid. Host spiders bearing a parasitoid larva continue life as normal. Larval development is very slow and gradual at first, but later becomes more rapid, especially at the end of development. The final instar larva has a series of dorsal swellings bearing numerous minute hooks (Figs 14,15). One to 2 days before spinning a cocoon, the larva suspends itself from the host web by means of these hooks, and sucks dry and discards the host. The larva seems to induce the host spider to modify its web form (Fig. 17) prior to cocoon construction (Nielsen 1923; Eberhard 2000). The modified web is more robust and better designed to sustain the wasp's cocoon than the normal web (T. Masumoto, unpubl. data, 2004). This kind of modification of the web form was also observed in *R. masumotoi* (Fig. 18) and the Japanese *R. nielseni* (Fig. 19). The cocoon is pale brown and spindle-shaped, and is placed along a vertical radius at the hub of the web in the vertical ribbon of detritus. The larva and pupa orient with the head upward in the cocoon. A caudal hole is found at the lower end of the cocoon.

Life cycles of *R. tuberculatus* and its host

The life cycle of the host spider of *R. tuberculatus*, *C. octotuberculata*, is shown diagrammatically in Figure 20 (inner, pale circle). The host spider is univoltine and overwinters as an immature. Spiders appear in early March and begin to form webs in low vegetation. They mature by June and begin to lay eggs. Adults are active for the whole summer. Rarely, adult females are found in October. The hatched juveniles grow to approximately 6–8 mm in length by December. Most individuals discontinue building their web and disappear in early to mid-December, seeming to overwinter under fallen leaves.

The life cycle of the parasitoid, *R. tuberculatus*, is shown diagrammatically in the outer, darker circle in Figure 20. The larva of the parasitoid overwinters as an early instar larva, attached to the subbasal part of the host's abdomen, dorso-laterally. After wintering it develops by consuming the body fluids of the host spider. Development of the larva is slow and gradual during earlier instars, and but later becomes rapid, especially in the final instar. The larva of the parasitoid matures and

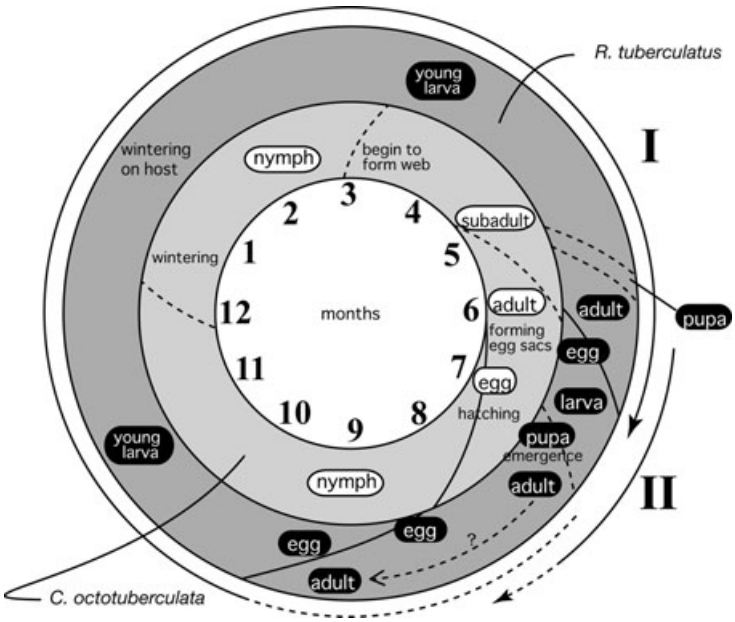


Figure 20 Life cycles of *Reclinervellus tuberculatus* and its host, *Cyclosa octotuberculata*. (**I**: First generation, **II**: second generation). Numbers in the center of the circles correspond to months.

spins a cocoon by early May. The adult emerges between May and June and immediately begins to attack the host spider, which belongs to the same generation as the spider the parasitoid developed on. This finding was confirmed via observation of egg-laying females and the discovery of host spiders that bore an egg or a young larva of a parasitoid at this time. Larvae of the second generation grow rather rapidly and mature and emerge by the end of July. Immature hosts bearing parasitoid eggs were rarely found in late August. Based on this and the discovery of three cocoons from which adults emerged in mid-September, a third generation might occur.

Percentage parasitism of hosts

Percentage parasitism of hosts by *R. tuberculatus* and *R. masumotoi*, in localities where more than 20 hosts were examined, is shown in Table 1. Parasitism by *R. tuberculatus* was comparatively high, sometimes above 30%, although the value varied depending on the locality. In contrast, parasitism by *R. masumotoi* was less common. Taking into consideration cases in which smaller numbers of hosts were examined, *R. tuberculatus* was the commoner of the two species in Honshu. Conversely, on Shikoku *R. tuberculatus* was less common, and the percentage parasitism by *R. masumotoi* was often higher than that in Honshu and Kyushu. In six cases at four localities, host spiders bearing larvae of both *R. tuberculatus* and *R. masumotoi* were found. Host spiders were never found to be super-parasitized by the same species.

Differences in mode of parasitism and life cycle between *R. tuberculatus* and *R. masumotoi*

The most distinct difference between *R. tuberculatus* and *R. masumotoi* observed in the immature stage was the position of the egg and larva on the host's body. The egg of *R. tuberculatus* was laid on the anterior and dorsal to lateral face of the host's abdomen, at which point the hatched larva fixes itself. In contrast, the egg of *R. masumotoi* was on the posterior end of the host's abdomen. The hatched larva consumed the host's body fluids by inserting its mouth parts into the surface of the host's abdomen. The grown larva bent its body over the posterior end of the host's body so the feeding scars were distributed on the ventral side of the host's abdomen.

Although the life cycle of *R. masumotoi* is unknown, it was obvious that at least its first generation overwintered on the host in the larval stage. Figure 21 shows the development of *R. tuberculatus* and *R. masumotoi* at two localities. The larvae of *R. masumotoi* matured 10–20 days before those of *R. tuberculatus* at each locality. Adults also emerged earlier in *R. masumotoi*. The distribution of *R. masumotoi* overlapped with that of *R. tuberculatus* in Honshu and Shikoku (Fig. 16). At some localities, host spiders bearing the larvae of both species were found (Fig. 22). In these cases the larvae of *R. masumotoi* alone succeeded in developing, because they completed growth earlier. A host spider bearing a *R. tuberculatus* larva that was not yet fully grown was

Table 1 Percentage parasitism of hosts by *Reclinervellus tuberculatus* and *Reclinervellus masumotoi* in localities where more than 20 host spiders were examined

Locality	Date	No. hosts examined	No. hosts bearing egg/larva of *R. tuberculatus* (%)	No. hosts bearing egg/larva of *R. masumotoi* (%)
Honshu				
Iida (Nagano Prefecture)	30 Sept.–1 Oct. 2004	58	3 (5.2%)	0 (0%)
Fujio-cho/Onitori-cho (Nara Prefecture)	9 Apr. 2004	31	4 (12.9%)	0 (0%)
Baba (Osaka Prefecture)	21 Nov. 2003	98	42 (42.9%)	0 (0%)
Baba (Osaka Prefecture)	15 Mar. 2004	34	11 (32.4%)	0 (0%)
Baba (Osaka Prefecture)	9 Apr. 2004	53	17 (32.1%)	3 (5.7%)[†]
Baba (Osaka Prefecture)	15 Aug. 2004	24	1 (4.2%)	0 (0%)
Takinoike (Osaka Prefecture)	17 Nov. 2004	63	11 (17.5%)	0 (0%)
Otani (Okayama Prefecture)	6 May 2004	32	8 (25.0%)	0 (0%)
Shikoku				
Shimohatanogawa (Ehime Prefecture)	30 Oct. 2003	25	0 (0%)	7 (28.0%)
Yanagiso (Ehime Prefecture)	15 Apr. 2004	30	2 (6.7%)	0 (0%)
Odoi (Ehime Prefecture)	15 Apr. 2004	34	3 (8.8%)	2 (5.9%)
Kyushu				
Hamanose (Miyazaki Prefecture)	25–26 Oct. 2003	85	9 (10.6%)	0 (0%)
Kataji (Miyazaki Prefecture)	26 Oct. 2003	23	2 (8.7%)	0 (0%)

[†]Two of these hosts also bore a larva of *R. tuberculatus*.

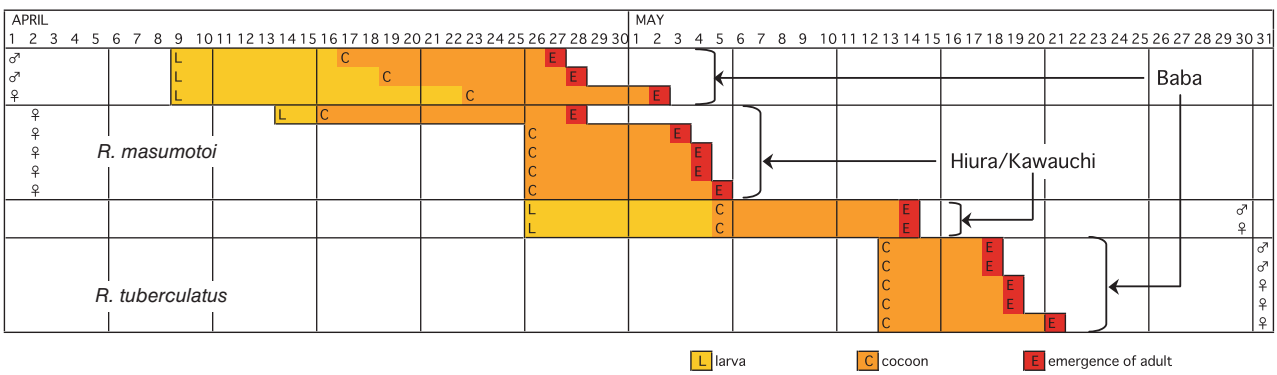


Figure 21 Development of the parasitoids *Reclinervellus tuberculatus* and *Reclinervellus masumotoi* at two localities, Hiura in Ehime Prefecture and Baba in Osaka Prefecture in 2004.

sucked dry and discarded when the *R. masumotoi* larva became mature.

Oviposition behavior of *R. tuberculatus*

In two cases, oviposition behavior was observed in the field, once at Baba in Osaka and once at Sanda in Hyogo. The oviposition sequences were quite similar in both cases, although the first steps were not observed. The host spider had already been paralyzed at the time of observation. The parasitoid held the host spider in her legs at the hub of the host web, turning to face in the opposite direction from the host, with her forelegs on the host's abdomen, and her middle and hindlegs on the cephalothorax (Fig. 23). In this posture the abdomen was bent ventrally and the ovipositor was thrust into the base of a coxa several times. The female then inclined her body forward and set her ovipositor along the antero- lateral face of the host's abdomen. In this posture she repeatedly rubbed her ovipositor over the dorsal and lateral surfaces of the host's abdomen near the base for more than 25 min. Then she laid an egg on the antero-lateral surface of the host's abdomen with the

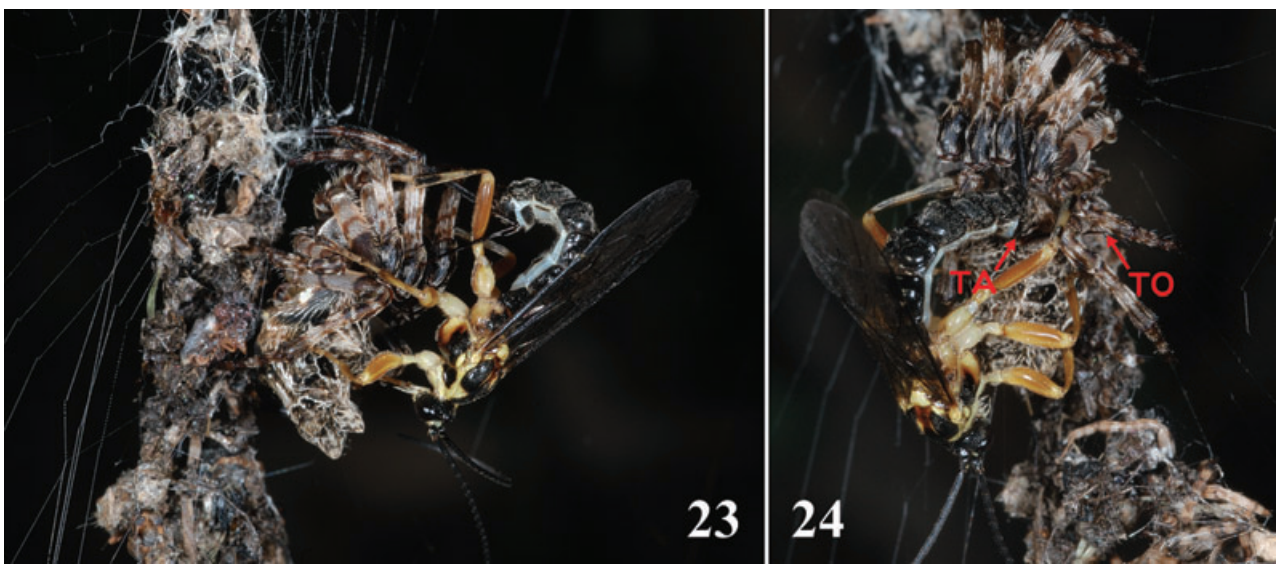
Figure 22 A host spider, *Cyclosa octotuberculata*, parasitized by both *R. tuberculatus* (immature larva on the right) and *Reclinervellus masumotoi* (mature larva on the left).

tip of her abdomen pressed on the host's abdomen in front of the basal tubercle (Fig. 24). The egg emerged from the tip of the abdomen (TA), not from the tip of the ovipositor (TO), as is also the case in *Hymenoepimecis argyraphaga* Gauld (Eberhard 2000). The egg was tightly glued on the host's abdomen. The female stayed on the host for about 1 min after the egg was laid, and then flew away. The observed oviposition sequences took approximately 45 min and 35 min, respectively.

DISCUSSION

Identity of *R. tuberculatus* previously recorded from *C. octotuberculata*

Iwata (1942) reported *P. tuberculata* reared from *C. octotuberculata*. On this basis, Uchida and Momoi (1958) listed the host association. Hashimoto (1962) observed and illustrated larvae of a parasitoid consuming *C. octotuberculata*, a cocoon and an emerged adult. The emerged adult was identified by Iwata as *Zabrachypus tuberculatus* (=*R. tuberculatus*). Photos of these immatures and the adult appeared in Hashimoto (1963) with those of other hymenopterous parasitoids of spiders. In Iwata (1942), descriptions and illustrations of a parasitoid larva located on the posterior end of the host's abdomen were provided. Although the material was identified by Uchida as *P. tuberculata*, judging from the location of the larva, Iwata's material was not *R. tuberculatus* but *R. masumotoi*. However, in Hashimoto (1962, 1963) the parasitoid larva was shown to be located on the anterior face of the host's abdomen, and vein Cu of the adult hindwing was strongly reclivous. These features indicate that Hashimoto's material was *R. tuberculatus*.



Figures 23,24 Oviposition behavior of *Reclinervellus tuberculatus*. **23** Stinging the host; **24** laying an egg on the antero-dorsal surface of the host's abdomen, arrows indicate the tip of the abdomen (TA) and the tip of the ovipositor (TO).

Advantages of the life history of *R. masumotoi*

In Japan, *C. octotuberculata* is attacked by two species of the genus *Reclinervellus*. The distribution of *R. tuberculatus* overlaps that of *R. masumotoi*, and a single host sometimes even bears the larvae of both species. These two parasitoids are morphologically very similar, and have been confused for a long time. Interestingly, these two closely related sympatric parasitoids utilize the same host, but with a significant difference in the positions of their eggs and larvae.

Prior to laying an egg, the *R. tuberculatus* female persistently jabbed and rubbed her ovipositor over the anterior part of the host's abdomen. This behavior seems very similar to that of *H. argyraphaga*. Females of *H. argyraphaga* were observed to lever off an egg or a larva from the host's abdomen using this behavior (Eberhard 2000), and it was concluded that infanticide frequently occurred based on the patterns of scars on host spiders' abdomens. Although infanticide by *R. tuberculatus* was not observed in the present study, judging from the behavior of the ovipositing female, it may occur in this species, especially at localities where this parasitoid is abundant. In such a situation, the habit of laying an egg at the posterior end of the host's abdomen, as observed in *R. masumotoi*, might make it possible for the parasitoid to escape from competition with *R. tuberculatus*, which is sympatric and utilizes the same host. The earlier completion of larval development by *R. masumotoi* in spring seems to confer an advantage on this parasitoid.

The position in which the egg is laid also tends to be specific in many other species, in which possible competition with other species on the same host has never been seen. The reason for this consistency in oviposition site is not clear.

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