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A new flower bug of the genus *Montandoniola* (Hemiptera: Heteroptera: Anthocoridae), a predator of gall-forming thrips on black pepper in southern India

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Abstract. A new flower bug, *Montandoniola indica* Yamada, sp. nov., is described on the basis of specimens collected in Kerala State, southern India. It is an efficient predator of gall-forming thrips, *Liothrips karnyi* Bagnall, 1924 (Thysanoptera: Phlaeothripidae), infesting black-pepper leaves. *Montandoniola indica* Yamada, sp. nov. is distinguished from its related species, *M. thripodes* Bergroth, 1916, by slightly sinuate flagellum approximately twice as long as cone and by the copulatory tube apex exceeding the anterior margin of sternum VII. Biology of this new species and identity of Indian species of *Montandoniola* Poppius, 1909 are discussed.

Key words. Heteroptera, Anthocoridae, Oriini, *Montandoniola*, new species, biology, predator, *Liothrips karnyi*, *Piper nigrum*, India

Introduction

Montandoniola Poppius, 1909 is well known as a genus containing efficient predators of economically important thrips. *Montandoniola moraguesi* (Puton, 1896) has hitherto been reported as biological control agent for a variety of thrips (Lattin 2000, Pluot-Sigwalt et al. 2009). This species was intentionally introduced for controlling the Cuban laurel thrips into Bermuda, Hawaii and USA (e.g. Funasaki 1966, Davis & Krauss 1966, Bennett 1995). Pluot-Sigwalt et al. (2009) reviewed the specimens of *Montandoniola* from various parts of the world and indicated that several species had been confused under the name *M. moraguesi*. Their examination revealed that the true *M. moraguesi* seems to be restricted to the Mediterranean region and Africa. In addition, they described *M. confusa* Streito & Matocq,

2009 from Guadeloupe. *Montandoniola confusa* was subsequently recorded from Mexico (Cambero-Campos et al. 2010), apparently more or less confused with *M. moraguesi* in the past. More recently, two species, *M. carayoni* Streito & Matocq, 2010 from Nigeria and *M. kerzhneri* Yamada, Yasunaga & Miyamoto, 2010 from the Iriomote island of the Ryukyus, Japan, were added to the genus (Streito & Matocq 2010, Yamada et al. 2010c). The genus is now represented by 10 species in the world. In India, *M. moraguesi* is known to occur in agro-ecosystems and have been studied extensively as regards their biology (Muraleedharan & Ananthakrishnan 1971, 1978); however, Indian species studied by them (Muraleedharan & Ananthakrishnan 1971) may not be true *M. moraguesi*, as indicated by Pluot-Sigwalt et al. (2009).

Recently, Yamada had an opportunity to examine the Indian specimens of *Montandoniola*, which were associated with gall-forming thrips, *Liothrips karnyi* Bagnall, 1924 (Thysanoptera: Phlaeothripidae), collected from the black-pepper, *Piper nigrum* Linnaeus (Piperaceae), in Kerala State, southern India. Through careful examinations, we came to the conclusion that it represents an undescribed species, related to *M. thripodes* Bergroth, 1916 and *M. moraguesi*. In this paper, we describe the new species, provide its biology, and discuss identity of Indian species of *Montandoniola*.

This paper is a continuation of our recent studies of taxonomy, biology and biocontrol potential of Indian Anthocoridae (see Yamada et al. 2008, 2010a,b).

Materials and methods

All specimens were killed and preserved in 70–80% ethanol just after collecting. They were then dried and mounted for observation of their various structures. Examination and illustration of genitalia and other detailed external structures such as ostiolar peritreme and evaporatorium were done on specimens macerated in 5% hot KOH solution until the organs became transparent. They were dissected with micro-pins and forceps in glycerin on a glass slide under a binocular microscope (Nikon Stereoscopic Zoom Microscope SMZ1500). Illustrations were done using this microscope, with the aid of an eyepiece grid. Photographs (Figs. 20–23) were taken using a Zeiss, while the other photographs (Figs. 10–19) were taken using a Hirox digital microscope KH-7700. All measurements are given in millimeters. Terminology for genitalia mainly follows Carayon (1961) and Yasunaga (1997).

Depositories of the types are abbreviated as follows:

MNHN Muséum National d'Histoire Naturelle, Paris, France;
TKPM Tokushima Prefectural Museum, Tokushima, Japan;
USNM U. S. National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA.

Taxonomy

Montandoniola indica Yamada sp. nov.

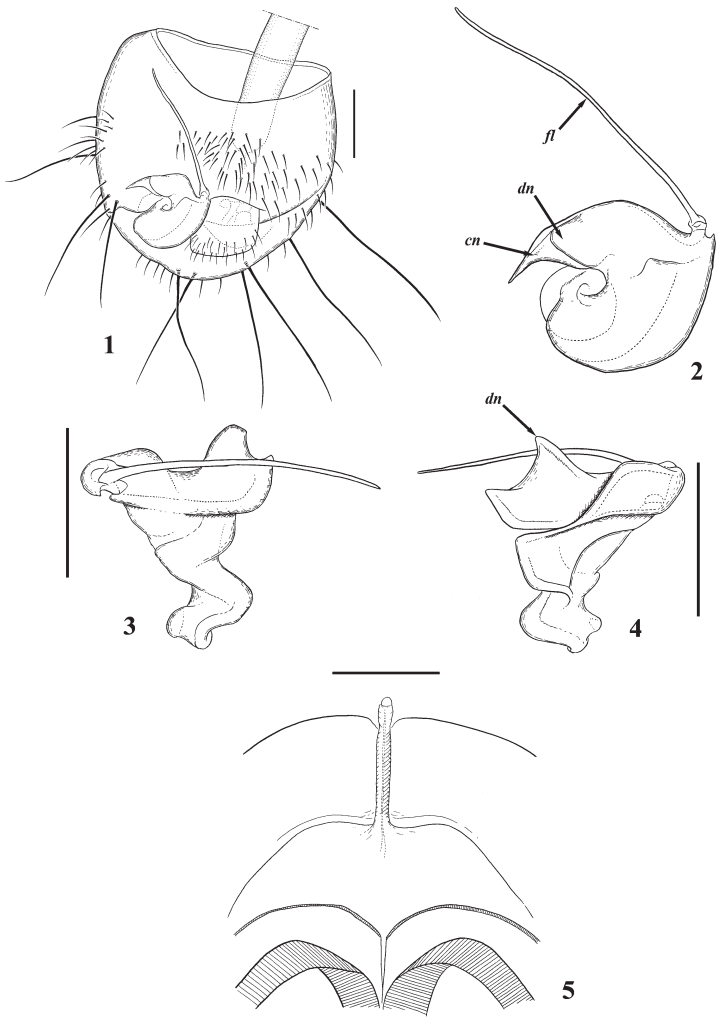
(Figs. 1–19, 21–23)

Type locality. Southern India, Kerala State, Palakkad, Kuzhalmannam.

Type material. Holotype: ♂ (TKPM-IN-13042, with glass slide for genitalia; Figs. 1–4, 10, 15, 17–18), 'INDIA: Kerala / Palakkad / Kuzhalmannam / 13. i. 2008 / K. Bindu leg.' [white square] // 'Host Insect: / *Liothrips karnyi* /

Host Plant: / *Piper nigrum*' [white square] (TKPM). Paratypes: **INDIA: Kerala:** 52 ♂♂ (one shown in Figs. 6–7, 11, 19; other in Figs. 12, 14; other in Fig. 9), 48 ♀♀ (one shown in Figs. 8, 13, 16; other in Fig. 5), same data as holotype (all in TKPM except for 2 ♂♂ 2 ♀♀ in MNHN, 2 ♂♂ 2 ♀♀ in USNM); 4 ♂♂ 2 ♀♀, Calicut University Campus, 27. ii. 2008, A. Nasreem (TKPM).

Description. Measurements [♂♂ (n = 10) / ♀♀ (n = 10), holotype in parentheses]. Body length 2.25–2.58 (2.38) / 2.38–2.80; head length (incl. neck) 0.38–0.39 (0.38) / 0.36–0.44; head width across eyes 0.35–0.38 (0.36) / 0.33–0.36; vertex width 0.16–0.18 (0.16) / 0.16–0.19; width between ocelli 0.11–0.13 (0.13) / 0.13–0.15; length of antennal segments I–IV: I – 0.10–0.13



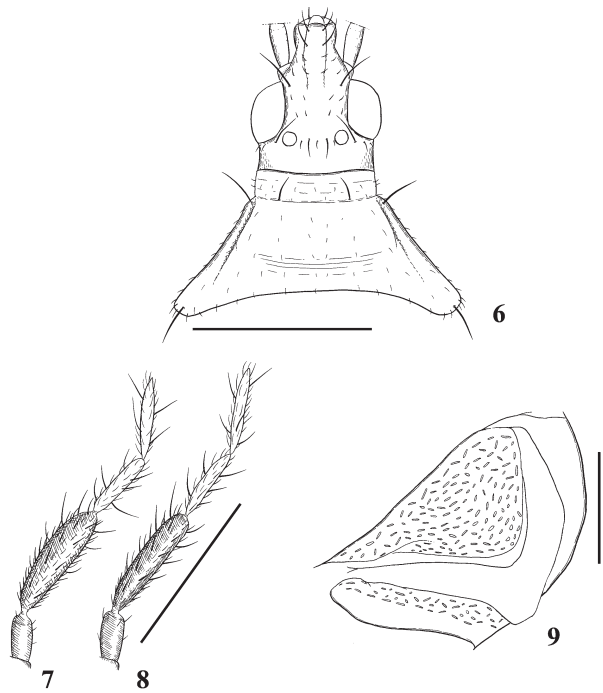
Figs. 1–5. *Montandoniola indica* Yamada sp. nov., male (1–4, holotype) and female (5, paratype) genitalia. 1 – pygophore with paramere, dorsal view; 2 – paramere, dorsal view; 3–4, ditto, two different orientations; 5, copulatory tube, dorsal view. Scale bars = 0.1 mm. Abbreviations: cn = cone; dn = denticule; fl = flagellum.

(0.12) / 0.10–0.13, II – 0.31–0.35 (0.34) / 0.30–0.36, III – 0.20–0.22 (0.21) / 0.21–0.23, and IV – 0.21–0.24 (0.23) / 0.22–0.25; length of labial segments II–IV: II – 0.08–0.09 (0.09) / 0.10–0.11, III – 0.28–0.31 (0.29) / 0.30–0.33, and IV – 0.20–0.22 (0.21) / 0.21–0.23; anterior pronotal width 0.30–0.33 (0.30) / 0.31–0.34; mesal pronotal length 0.29–0.31 (0.29) / 0.30–0.34; basal pronotal width 0.74–0.81 (0.79) / 0.74–0.88; length of embolial margin 0.58–0.66 (0.63) / 0.61–0.71; length of cuneal margin 0.40–0.44 (0.42) / 0.43–0.48; maximum width across hemelytra 0.71–0.78 (0.77) / 0.72–0.85.

Coloration. Head and pronotum (Figs. 10, 12–13) uniformly black, sometimes brown; eyes reddish black; margin of ocellus red to reddish brown. Antennal segments I and II (Figs. 7–8, 12–13) dark brown to black; segment II somewhat reddish at tip; segments III and IV (Figs. 7–8, 12–13) pale yellow. Labium (Figs. 11, 14) dark brown to black except for pale yellow apical one-third of segment III and basal two-thirds of segment IV. Scutellum (Fig. 10) overall blackish. Clavus (Fig. 10) dark brown to black along inner margin and claval commisure; endocorium (Fig. 10) narrowly dark brown to black along corium-membrane boundary; embolium and cuneus (Fig. 10) wholly dark brown to black; membrane (Fig. 10) centrally with clear blackish stripe except for basal semi-transparent area; remainder area of hemelytra off-white or semi-transparent. Fore- and mid femora (Figs. 15–17) entirely black; fore- and mid tibiae (Figs. 15–17) pale yellow except for somewhat darkened base of tibiae; hind femora and tibiae (Fig. 18) black; each tarsus (Figs. 15–18) pale yellow tinged with fuscous apex. Venter of thorax (Fig. 11) uniformly black. Abdomen (Fig. 11) black tinged with reddish brown.

Structure. Body (Fig. 10) elongate, shiny on dorsal and ventral surfaces, sparsely covered with short, silky setae. Head (Figs. 6, 12–13) cylindrical, impunctuated, slightly longer than width across eyes, sparsely covered with long, erect setae intermixed with short, reclining setae; pairs of long, erect setae on side of tylus, near anterior inner margin of eyes, between eye and ocellus, and between ocelli; anteocular region about 0.75 times as long as length of eye in dorsal view; vertex about 1.6 times as wide as eye in dorsal view; postocular region distinctly long, not constricted; eye oblong, not exceeding level of ventral surface and dorsal surface of head in lateral view. Antennal segment I (Figs. 12–13) just reaching apex of head, sparsely with short setae; segment II (Figs. 7–8, 12–13) greatly swollen, male thicker than female, about 0.9 times as long as head width across eyes, densely covered with short reclining setae interspersed with long suberect setae, of which the longest are slightly shorter than width of the segment; segments III and IV (Figs. 7–8) shorter and somewhat slender than segment II, covered with long, suberect setae intermixed with short, reclining setae; longest seta as long as or longer than width of respective segments; segment III about 0.6 times as long as segment II; segment IV flattened, slightly longer than segment III. Labium (Figs. 11, 14) exceeding anterior margin of prosternum, not reaching fore coxae; segments I, II, and III respectively with long, suberect setae near apex; segment III about three times as long as segment II; segment IV about 0.7 times as long as segment III.

Pronotum (Figs. 6, 12–13) with long, stout, erect setae on anterolateral and posterolateral corners and a pair of similar setae behind the collar; surface smooth, with scattered short, reclining setae and short, suberect setae along lateral margin; anterior margin nearly straight,



Figs. 6–9. *Montandoniola indica* Yamada sp. nov., male (6–7, 9) and female (8). 6 – head and pronotum, dorsal view; 7–8 – antennae, dorsal view; 9 – ostiolar peritreme and evaporatorium, left lateroventral view. Scale bars = 0.5 mm for 6–8; 0.1 mm for 9.

slightly longer than mesal length; lateral margin shallowly concave inwardly; lateral carina well developed anteriorly, gradually more obscure posteriad; posterior margin concave, about 2.3 times as wide as anterior margin; collar about one-fourth of mesal pronotal length, with scattered short setae, weakly rugose; callus demarcated by a shallow transverse impression; posteromedian region of pronotum widely depressed. Scutellum (Fig. 10) smooth, anteriorly swollen and gradually more depressed posteriad, with a pair of long, erect setae near base of both sides. Hemelytra (Fig. 10) subparallel-sided, impunctuated, sparsely covered with short, suberect setae; endocorium about twice as wide as maximum width of embolium; cuneal margin 0.6–0.7 times as long as embolial margin; membrane with two weak veins, inner vein arising from base of membrane and extending along outer margin, outer vein a little remote from outer margin. Ostiolar peritreme (Figs. 9, 19) broad, elbowed at middle, posteriorly angular, gradually narrowed anteriad, slightly bent interiorly, not touching anterior margin of metapleuron; outer margin of ostriolar peritreme strongly raised above level of surrounding evaporatorium. Legs densely covered with short, reclining setae; fore tibia (Figs. 15–16) slightly thickened apicad, in male (Fig. 15) furnished with a ventral row of 16–20 fuscous, small teeth; hind tibia weakly flattened; mid- and hind coxae far from each other. Abdomen ventrally covered with short, suberect setae at posterior portion of respective segments; a pair

of long, stout setae on lateral margin of seventh and eighth sternum in male; eighth sternum in male covered with low number of long, stout setae at right posterolateral area; scissure on abdominal tergite reaching posterior margin of third segment.

Male genitalia (Figs. 1–4): Pygophore (Fig. 1) with 8–10 long, stout setae intermixed with short, suberect setae along outer margin and on posteroventral surface, of which the longest are longer than length of pygophore; midventral surface very hirsute with short, suberect setae; cone (Figs. 2–4) very thin, acute apically in dorsal view, with a strongly elevated denticule; flagellum (Figs. 1–2) long, slightly sinuate, slender and tapering, basally not adjacent to the paramere body, approximately twice as long as maximum width of cone.

Female genitalia (Fig. 5): Genital segments (seventh to ninth segments) laterally covered with long, stout setae; ninth sternum very hirsute with short, suberect setae; copulatory tube (Fig. 5) mesally located at sternum VII, distinctly separated from base of ovipositor, consisting of much longer, straight, sclerotized cylinder-shaped tube leading into minute and membranous apex; apex of copulatory tube exceeding anterior margin of sternum VII.

Differential diagnosis. Judging from Pluot-Sigwalt et al. (2009) and Yamada et al. (2010c), *Montandoniola indica* Yamada sp. nov. is closely allied to *M. thripodes* Bergroth, 1916 described from Hong-Kong in the coloration of labium, hemelytra and legs. The structure of male and female genitalia is the only key character clearly separating the species. *Montandoniola indica* Yamada sp. nov. can be distinguished from *M. thripodes* by slightly sinuate flagellum approximately twice as long as cone (Fig. 2) (in *M. thripodes*, straight, shorter than twice width of cone) and much longer copulatory tube distinctly separated from the base of ovipositor and exceeding the anterior margin of sternum VII (Fig. 5) (vs. very close to the base of ovipositor, shortened, not reaching the anterior margin of sternum VII). From *M. moraguesi*, *M. indica* Yamada sp. nov. differs by dark brown to black labium except for pale yellow apical one-third of segment III and basal two-thirds of segment IV (in *M. moraguesi*, entirely dark brown), posteriorly angular ostiolar peritreme (Fig. 9) (vs. rounded), pale yellow fore tibia except for somewhat darkened base (vs. black, apical part whitish), slightly sinuate flagellum (Figs. 1–2) (vs. strongly curved), and copulatory tube distinctly separated from the base of ovipositor, exceeding the anterior margin of sternum VII (Fig. 5) (vs. close to the base of ovipositor, reaching the anterior margin of sternite VII).

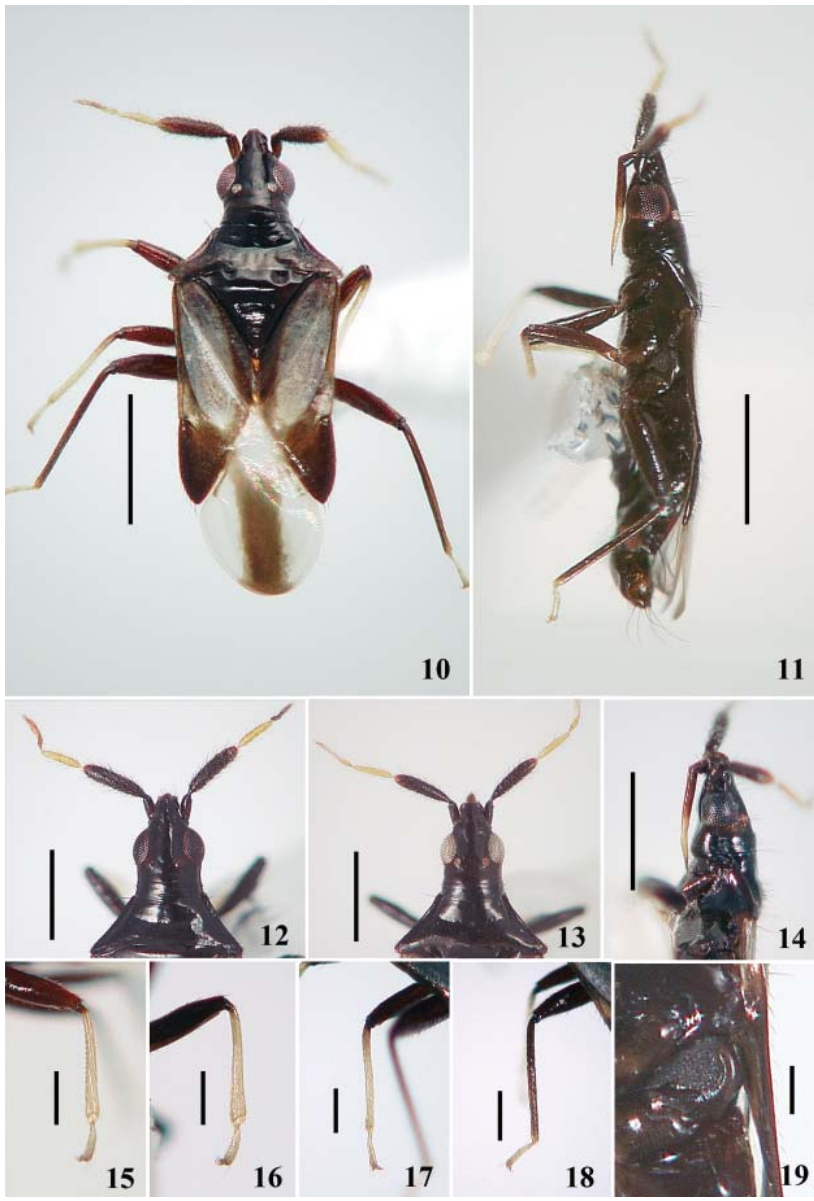
Etymology. Named after the type area, India; an adjective.

Distribution. Southern India (Kerala State).

Biology

Habitat. Eggs, all nymphal instars and adults of *Montandoniola indica* Yamada sp. nov. were found within the leaf curl galls induced by the thrips, *Liothrips karnyi* (Fig. 20), on the black pepper leaves, *Piper nigrum* (Piperaceae).

Oviposition. Eggs are inserted, singly or in pairs, at an angle into the leaf tissue, with only the operculum exposed (Fig. 21). Egg insertion has been reported in a number of anthocorid species.

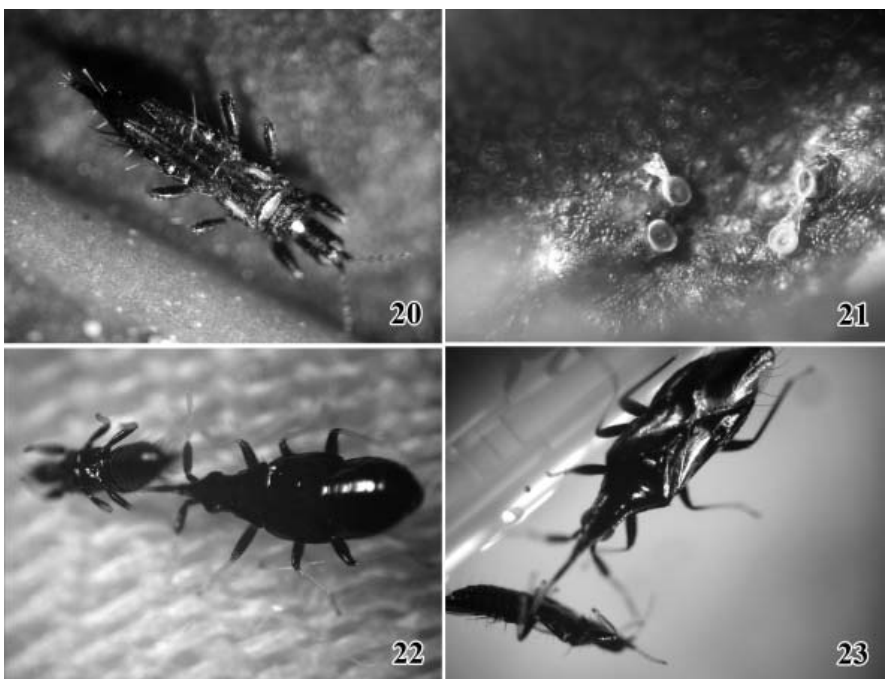


Figs. 10–19. *Montandoniola indica* Yamada sp. nov., male (10–12, 14–15, 17–19) and female (13, 16). 10–11 – habitus, dorsal and lateral views; 12–14 – head and pronotum, dorsal (12–13) and lateral (14) views; 15–16 – left fore legs, inner views; 17 – left mid leg, outer view; 18 – left hind leg, outer view; 19 – ostiolar peritreme and evaporatorium, left lateroventral view. 10, 15, 17–18 – holotype; 11–14, 16, 19 – paratypes. Scale bars = 0.5 mm for 10–14; 0.2 mm for 15–18; 0.1 mm for 19.

Prey and predatory behavior. Field and laboratory observations on *M. indica* Yamada sp. nov. indicate that 1st and 2nd instar nymphs feed on larval thrips, with the 1st instar feeding on eggs of thrips as well; whereas 3rd, 4th and 5th (Fig. 22) instars, adult males and females of *M. indica* Yamada sp. nov. feed mainly on adult thrips (Fig. 23).

To study the prey capturing behavior, the rate of feeding and duration of feeding of the predator, field collected adult males (n = 5) and females (n = 5) were confined in 5 cm × 2 cm glass vials individually and were starved for 6 hours. One adult thrips at a time was then added as prey to each of the vials. When the first prey was consumed another thrips was added and this was continued for 24 hours. The average number of thrips consumed in a 24 hours period by adult females was 4.2 (range = 3–6), while for adult males during the same interval it was 2.8 (range = 1–5). Mean duration of feeding by adult bugs on the first thrips after starving was 31 minutes (range = 16–60 minutes), and it was not significantly different from the mean feeding time on the second thrips, which was 30 minutes (range = 12–74 minutes). After feeding on the first prey, the second prey was captured either immediately or after a few minutes or it may take several hours, which may depend on the physiological state of the predator.

Observations on the prey capturing behavior suggest that *M. indica* Yamada sp. nov. does not pursue the prey, but waits for the prey to come nearby. This strategy may be successful



Figs. 20–23. 20 – Prey, *Liothrips karnyi* Bagnall, 1924; 21 – eggs of *Montandoniola indica* Yamada sp. nov., with only the operculum exposed; 22 – habitus of a nymph sucking adult thrips; 23 – habitus of an adult sucking adult thrips.

as the prey does not have much space to avoid the predator within the narrow leaf curl gall. While stopping and moving, adults and nymphs of *M. indica* Yamada sp. nov. bend the abdomen upward in a manner similar to their prey, the thrips, which again could be part of their prey capturing strategy.

Once the prey is sufficiently near, the predator rapidly inserts its labium into the prey. Some attempts at prey capture were not successful as the prey was found to engage in escape tactics. The predator used its forelegs to hold and manipulate the prey, once feeding was initiated. During the process of feeding adult bugs inserted their labium into different parts of host's body, thus ensuring that the whole body fluid is sucked leaving only the exoskeleton behind. While feeding, if disturbed by other thrips, the predator was found to walk away with the prey impaled upon its labium.

Development of *M. indica* Yamada, sp. nov. from egg to adult includes five nymphal instars. Further studies on the biology and behavior of *M. indica* Yamada sp. nov. need to be carried out both in the field and laboratory to achieve a better understanding of the efficacy of *M. indica* Yamada sp. nov. as a bio-control agent of *L. karnyi*.

Discussion

The Indian species of *Montandoniola* have hitherto been recorded as *M. moraguesi*. As indicated by Pluot-Sigwalt et al. (2009), however, the description of adult in Muraleedharan & Ananthakrishnan (1971) may not be that of *M. moraguesi*. Most morphological characters such as the coloration of labium, hemelytra and legs given by them agree with those of *M. indica* Yamada sp. nov. In addition, the illustration of copulatory tube (Muraleedharan & Ananthakrishnan 1971, fig. 3, p. 8) is very similar to *M. indica* Yamada sp. nov. in having much longer, straight copulatory tube and its apex exceeding the anterior margin of sternum VII. Unfortunately, because we could not examine directly the species studied by Muraleedharan & Ananthakrishnan (1971, 1978) in the course of this study, these specimens are not precisely determined as *M. indica* Yamada sp. nov. However, now we can suppose that some records of the so-called *M. moraguesi* in India are doubtful. These two species may be regarded as conspecific in India for a long time, because they superficially resemble each other not only in the external characters but also in the general shape of female copulatory tube.

Most biological data in our study are different from those of Muraleedharan & Ananthakrishnan (1971, 1978). Our observation focused on the prey capturing behavior and the rate and duration of feeding of the predator, while Muraleedharan & Ananthakrishnan (1971, 1978) studied mainly the life cycle including mating behavior and the morphological characters of all nymphal stages. Our data as regards habitat and oviposition are in accordance with their data. In addition, Muraleedharan & Ananthakrishnan (1978) recorded 20 species of host thrips and gall plants in many localities of India including Kerala State, the type locality of *M. indica* Yamada, sp. nov. If *M. indica* Yamada sp. nov. is assigned to the species studied by Muraleedharan & Ananthakrishnan (1971, 1978), *Liothrips karnyi* and *Piper nigrum* are reported for the first time as the host thrips and gall plant of the species respectively.

Correct identification of the Indian species of *Montandoniola* is very important to be able to apply them as biological control agent. Therefore, sufficient investigations especially in agro-ecosystems of India are required to clarify the fauna of *Montandoniola*.

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