



Psyllaephagus malloticolae sp. nov. (Hymenoptera, Encyrtidae) from India, a parasitoid of leaf gall former, *Trioza mallotica* (Crawford) (Hemiptera, Triozidae) on *Mallotus philippensis*

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ABSTRACT. *Psyllaephagus malloticolae* Rawat & Kumar sp. nov. a parasitoid of *Trioza mallotica* (Crawford) (Hemiptera, Psylloidea, Triozidae) causing galls on leaves of the Kamala tree, *Mallotus philippensis* Muell, 1865 is described from India. An updated key to all the known allied species of *Psyllaephagus* Ashmead from India is also provided. The new species comes close to *P. garuga* Sudhir & Singh, 2011 but differs from it in having Funicular V the longest segment, mid-tibial spur longer than basitarsus, and the exerted ovipositor sheath.

Key words: Chalcidoidea, parasitoid wasp, psyllid, Taxonomy, Uttarakhand, biocontrol

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INTRODUCTION

The genus *Psyllaephagus* Ashmead, 1900 is a cosmopolitan taxon including 246 described species, of which 19 are recorded in India (Noyes, 2019). The genus includes primary parasitoids of Psyllids, some of them caused severe damage to various plants (Noyes & Fallahzadeh, 2005). *Mallotus philippensis* Muell (Family: Euphorbiaceae) is an economically important tree, commonly called Kamala, Kapila, and locally known as Shendri. It grows as a perennial shrub or small tree, found in the tropical and subtropical regions in the outer Himalayas regions below 1000 m. It is also found in Southeast Asia, Afghanistan and Australia. *Mallotus philippensis* has shown high medicinal properties and has been used as traditional medicine in several countries including India. Every part of this plant possesses specific medicinal properties. Hence, it is used in Ayurveda for the treatment of antifilarial, anti-bacterial, anti-inflammatory and immune-regulatory activity (Sharma & Verma 2011, Gangwar et al., 2014). Its fruits have a reddish brown powder which is used as a red dye for dyeing silk and wool and also used in cosmetics (Orwa et al. 2009). In this context, a new species, *P. malloticolae* sp. nov. (Hymenoptera, Encyrtidae) is recently discovered from Almora, Uttarakhand which is found parasitic on *Trioza mallotica* (Crawford) (Hemiptera, Psylloidea, Triozidae) causing galls on leaves of *Mallotus philippensis*. The newly described parasitic wasp *P. malloticolae* could be used in future for controlling the leaf gall causing psyllid i.e. *T. mallotica* on *M. philippensis*.

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MATERIAL AND METHODS

Galled leaves of *M. philippensis* were collected from Dhokaney waterfall, Suyalbari, Nainital, Uttarakhand in October–November, 2021. Collected materials were reared and kept under regular observation for the emergence of associated insects, particularly the chalcidoids. Specimens were collected in 75% ethanol. A standard procedure given by Noyes (1982) was followed for preparing permanent slides of the emerged specimens to examine diminutive and abstruse characters under microscope. An Olympus® Magnus Stereozoom Trinocular MSZ-TR (Olympus Optical Co Ltd; Tokyo, Japan) was used to capture an assortment of photographs and an Olympus® CX-31-TR Microscope was used for the detailed taxonomic study of the encyrtid specimens that emerged from the rearing material. The terminology used in the descriptions follows Noyes and Hayat (1994), and Singh and Agarwal (1993). The following abbreviations were used in the text: CC: Costal Cell; F1–F6 segments: Funiculars 1–6; Gonostylus: 3rd valvula; ITD: Distance between the toruli; MTS: Mid Tibial spur; MV: Marginal Vein; PMV: Postmarginal Vein; SMV: Submarginal Vein; SV: Stigmal Vein; TED: Shortest distance between torulus and eye margin; TMD: Distance between torulus and mouth margin; TS1: Tarsal Segment I. All measurements in millimetre (mm) are used. Type specimens are deposited in the National Pusa Collection, NPC, and ICAR-Indian Agricultural Research Institute (ICAR-IARI), India.

RESULTS

Taxonomic hierarchy

Class Insecta Linnaeus, 1758

Order Hymenoptera Linnaeus, 1758

Superfamily Chalcidoidea Latreille, 1817

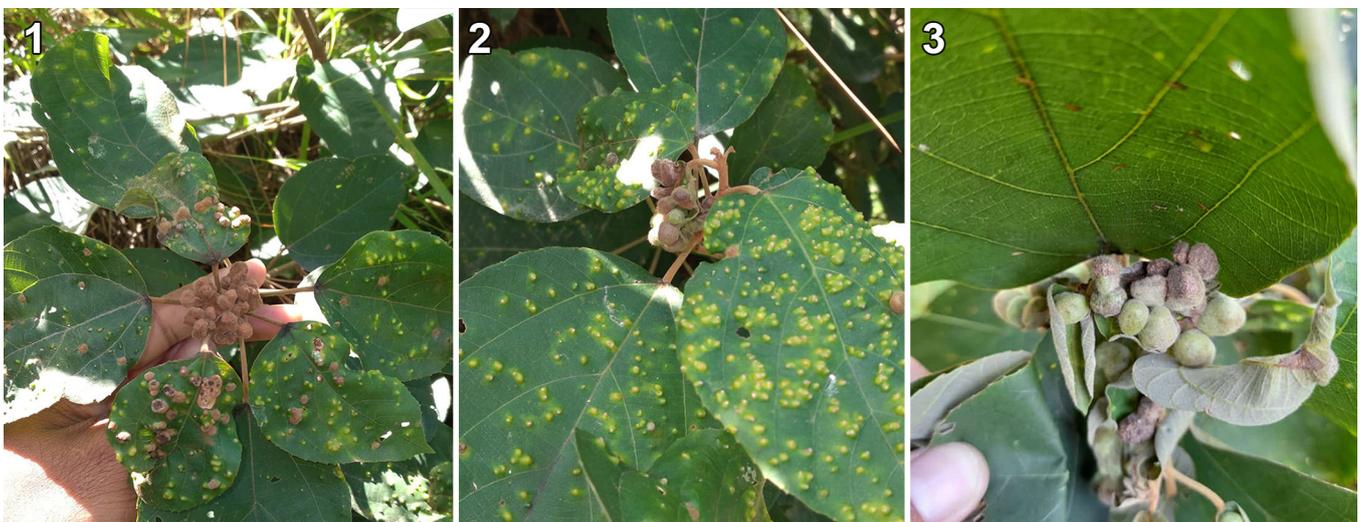
Family Encyrtidae Walker, 1837

Genus *Psyllaephagus* Ashmead, 1900

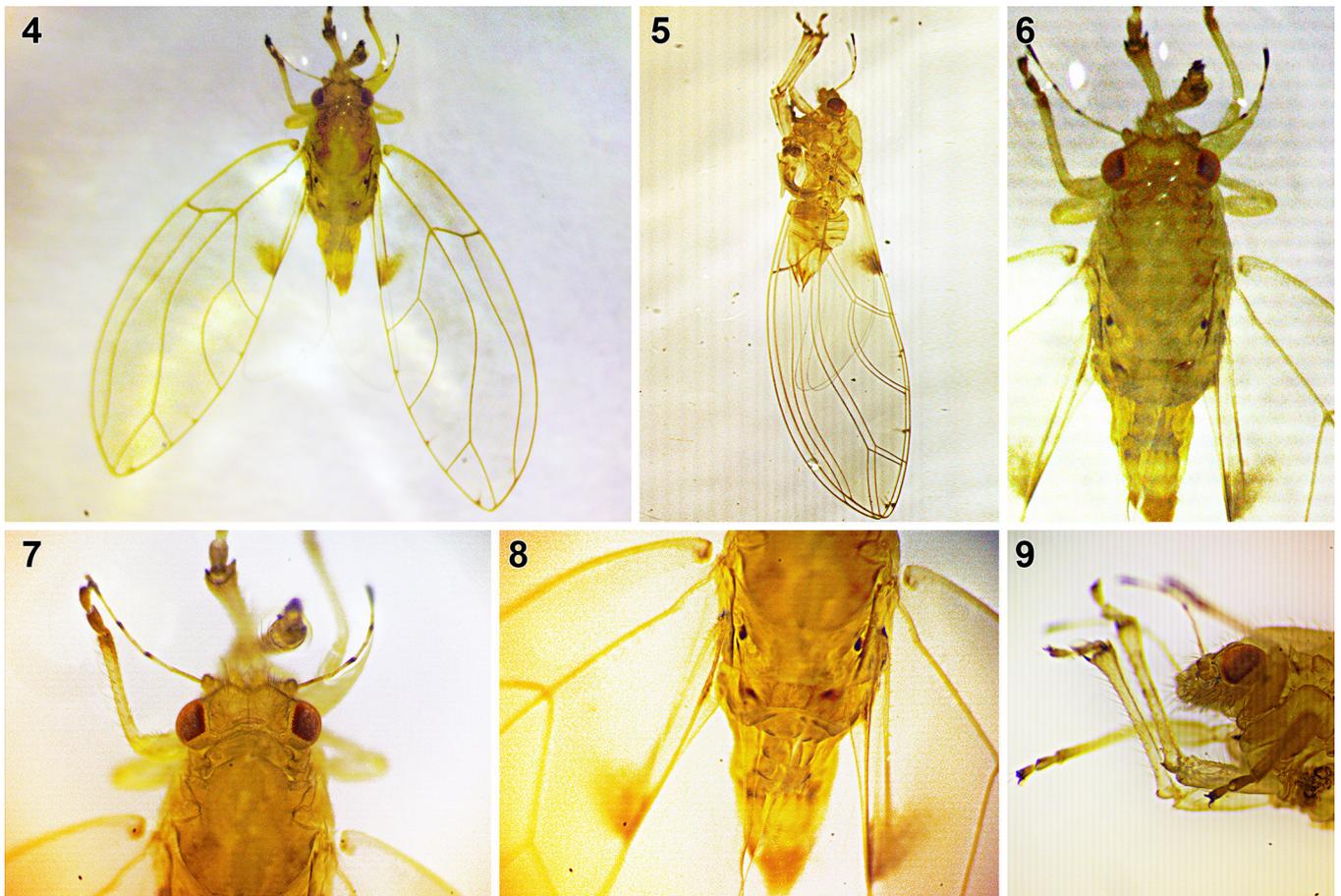
***Psyllaephagus malloticolae* Rawat & Kumar sp.nov.** (Figs 10–23)

<https://zoobank.org/NomenclaturalActs/2d8e1f56-4c04-47e9-aa5a-138544bca3a6>

Type material. **Holotype:** ♀ (on a slide), INDIA: Uttarakhand, Nainital, Suyalbari, Dhokaney waterfall, 4.xi.2021; ex *Trioza malloticola* (Hemiptera, Triozidae) forming leaf galls on *M. philippensis*. **Paratypes:** 7♀♀ 6♂♂, same data holotype, S. Rawat & S. Kumar, legs.



Figures 1–3. Leaves of *Mallotus philippensis* turned into galls, due to infestation of *Trioza malloticola* (Crawford) (Hemiptera, Psylloidea, Triozidae).



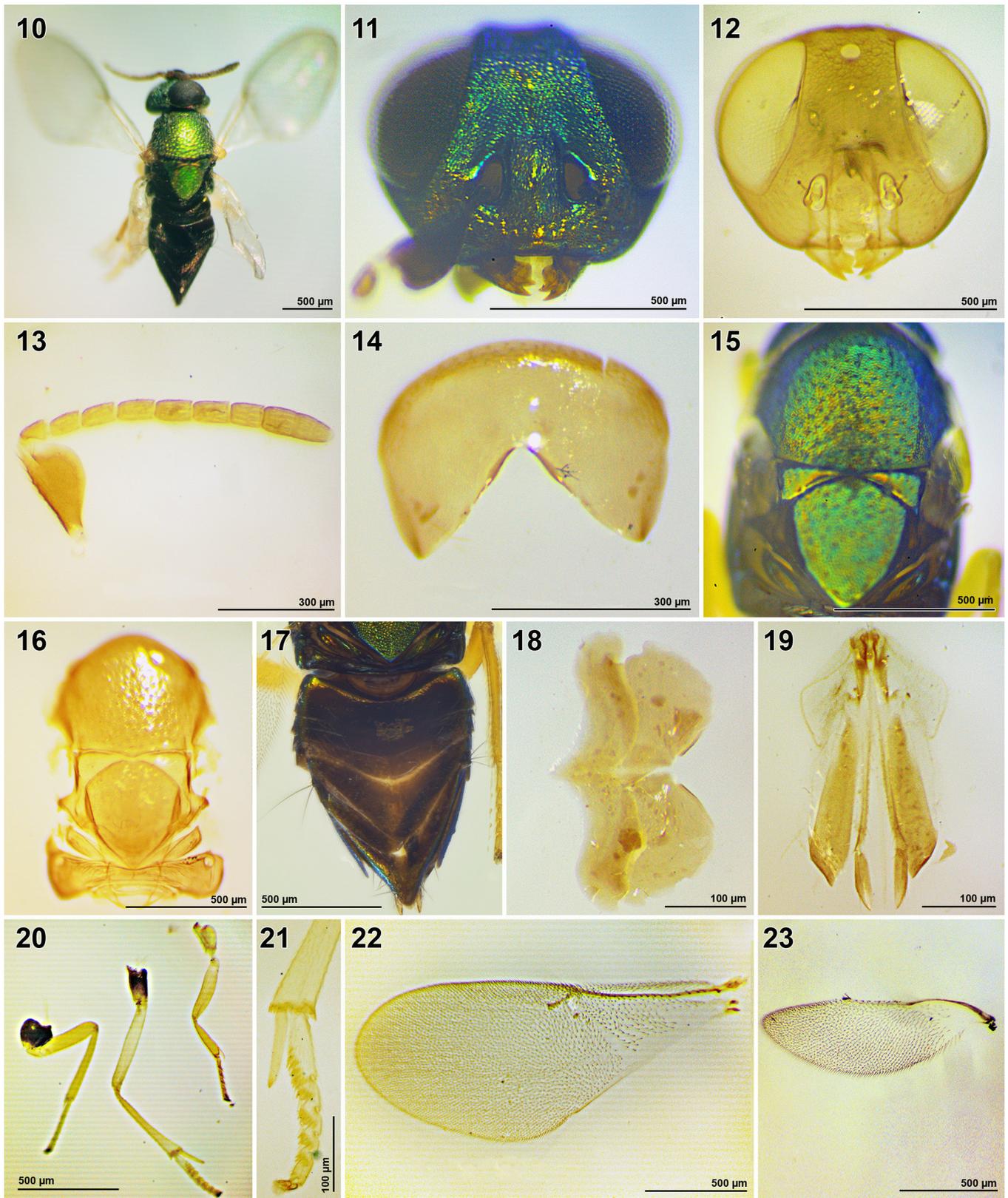
Figures 4–9. Adult *Trioza mallotocola* (Crawford) (Hemiptera, Psylloidea, Triozidae), host of *Psyllaephagus mallotocolae* Rawat & Kumar *sp. nov.*

Description – Female. Body length 2.34 mm (Holotype), Average body length 2.30 mm (n = 08)

Head. 1.2× wider than long in frontal aspect (Fig. 12); ocelli arranged in an acute-angle 44.88°, posterior ocelli close to eye margins; eyes 1.5× as long as wide; toruli inserted at the lower margins of eyes; ITD 1.5× more than TED; TVD 1.9× more than TMD; scrobes deep, clearly defined, well separated from eye margin; scape (Fig. 13) conspicuously broadened and flattened about 2× as long as its greatest width, pedicel 1.4× long as wide, pedicel is smaller than F1, all funiculars longer than wide, F1 the shortest and F5 the longest, F1 1.4× long as wide, F2 1.6× as long as wide, F3 1.8× as long as wide, F4 1.8× as long as wide, F5 2× as long as wide, F6 1.33× as long as wide, club segmented 2.6× as long as wide, sub equal in length to 2 preceding funiculars (F5 and F6).

Mesosoma. Pronotum (Fig. 14) 3.25× median width to its median length, single line of setae present on anterior region; Mesoscutum (Figs 15–16) 1.22× as wide as long, Scutellum (Figs 15–16) 0.73× shorter than mesoscutum; Scutellum 0.11× as long as wide; metanotum narrow; Propodeum (Fig. 16) smooth with median carina and lateral carinae, propodeal spiracles oval, large, exposed and slightly separated from the anterior margin of propodeum.

Legs. *Fore legs* (Fig. 20), coxa 1.46× as long as wide, 2× longer than trochanter; femur 3.4× as long as wide, 1.12× longer than the length of the tibia, TS1 sub equal to the length of the tibial spur. *Mid legs* (Fig. 20), coxa 1.5× as long as wide, 1.5× longer than mid trochanter; femur 8× as long as wide, 0.86× less than the length of the tibia; tibial spur 1.2× longer than TS1 (Fig. 21). *Hind legs* (Fig. 20), coxa 1.4× as wide as long, 1.42× longer than hind trochanter; femur 6.7× as long as wide, 0.73× shorter than to the length of tibia in length; TS1 longer 1.9× than tibial spur length.



Figures 10–23. *Psyllaephagus malloticolae* Rawat & Kumar **sp.nov.** Holotype, female. **10.** Habitus; **11.** Head; **12.** Head (after KOH treatment); **13.** Antenna; **14.** Pronotum; **15.** Thorax; **16.** Thorax (after KOH treatment); **17.** Propodeum, Metasoma; **18.** Hypopygium; **19.** Ovipositor; **20.** Legs, hind, mid, and fore legs; **21.** Mid spur, basitarsus; **22.** Fore wing; **23.** Hind wing.

Wings. Fore wing (Fig. 22) 2.25× as long as wide, 1.56× longer than the length of hind wing; CC 10.8× as long as wide, narrow, densely setose all over the surface; basal cell open, linea calva closed by one line of setae posteriorly; SMV setose with 18 setae across its length, PMV subequal to SV in length. Hind wing (Fig. 23) 3.2× as long as wide, the length of the wing 1.5× than the length of the vein.

Metasoma. Metasoma (Fig. 10) slightly longer than the mesosoma (1.06×); ovipositor (Fig. 19) 1.6× as long as mid-tibia; gonostylus about as long as mid-tibial spur; outer plate 1.2× shorter than the second valvifer; Width of hypopygium at most 2.5× of its own lateral length (Fig. 18).

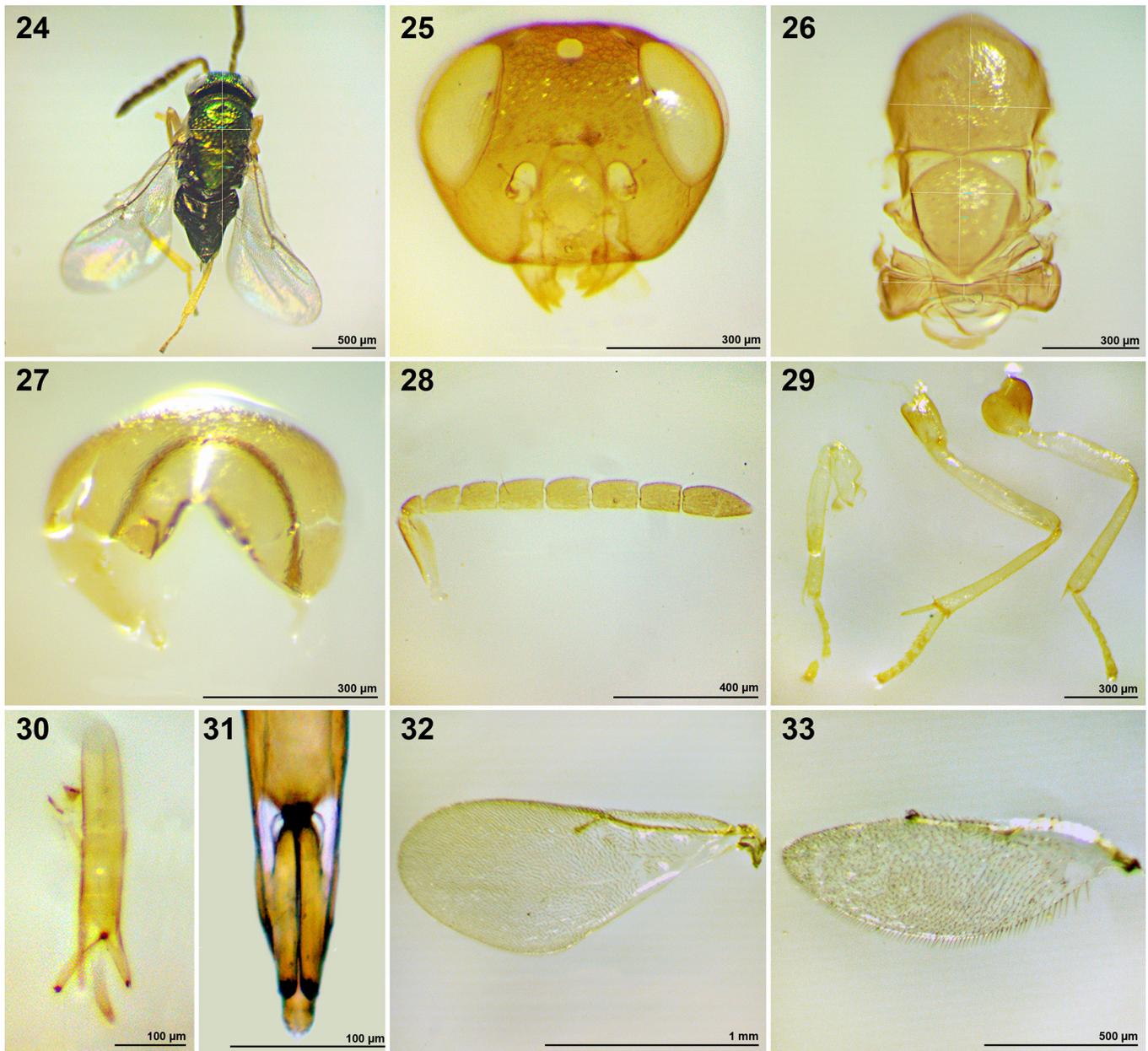
Colouration and Sculpture. Head (Figs 10–11) metallic green, clypeal and genal region metallic green with a golden tinge, lower half of the head reticulately-punctate, punctures large and shallow, thickly setose with silvery white setae (Fig. 11); eyes black; ocelli black; mandible brown with 2 teeth and an upper truncation, maxillary and labial palpi yellow. *Antenna:* scape blackish brown except the basal and distal end translucent, pedicel and funiclers pale brown; club black. *Mesosoma:* pronotum, mesoscutum and scutellum metallic green with golden tinge (Fig. 15); before KOH treatment, no sculpture seen on head and on mesoscutum except silvery setae on both; after KOH treatment head having small flower like sculptures, whereas mesoscutum and scutellum with polygonal reticulation; dorsellum, metanotum and propodeum metallic green with no such tinge (Fig. 17). *Legs* (Fig. 20): all parts of legs yellow except hind and mid coxa brownish black (Fig. 20), upper 1/3 part of mid coxa brownish black and remaining part yellow. *Wings* (Fig. 22): forewing venation brown, tegula yellow. *Metasoma* (Fig. 17): gaster black brown; ovipositor sheath yellow; hypopygium reaching more than half of the gaster, tergites with polygonal sculpture.

Relative measurement (Length:Width). Head (0.59:0.68), TED (0.1), ITD (1.5), TMD (0.2), TVD (0.38), *Antenna* (L:W): scape (0.26:0.13), pedicel (0.06:0.05), F1 (0.07:0.05), F2 (0.08:0.05), F3 (0.09:0.05), F4 (0.09:0.05), F5 (0.1:0.05), F6 (0.057:0.05), club (0.18:0.07), *Mesosoma* (L) (0.98 mm): pronotum (0.2:0.65), mesoscutum (0.49:0.6), scutellum (0.44:0.4), *fore wing* (1.98:0.85), SMV(L) (0.76 mm), MV (0.03 mm), SV (0.14 mm), PV (0.13 mm), *Hind wings* (1.23:0.38), venation (L) (0.8 mm), *Fore legs:* coxa (0.22:0.15), trochanter (L) (0.11 mm); femur (0.44:0.13), tibia (L) (0.39 mm), TS1 (L) (0.13 mm), spur (L) (0.12 mm). *Mid legs:* coxa (0.25:0.17), trochanter (L) (0.15 mm); femur (0.64:0.08), tibia (L) (0.74 mm); mid-tibial spur (L) (0.21 mm), mid-basitarsus (L) (0.17 mm). *Hind legs:* coxa (0.28:2), trochanter (L) (0.14 mm), femur (0.47:0.07), tibia (L) (0.64 mm), TS1 (L) (0.17 mm), spur length (L) (0.09 mm). *Metasoma* (L) (1.04 mm): ovipositor (1.2 mm), gonostylus (0.2 mm), second valvifer (0.93 mm), outer plate (0.78 mm), Hypopygium (L:W) (0.31:0.79).

Male (Figs 24–33). Body length 1.53 mm (Fig. 24); male generally very similar to female in appearance except for scape (Fig. 28) conspicuously broadened and flattened about twice as long as its greatest width in female and sub-cylindrical in male. Head (Fig. 25) 1.28× wider than long in frontal aspect; mesoscutum (Fig. 26) 1.15× as wide as long; scutellum (Fig. 26) markedly shorter than mesoscutum, scutellum 1.08× as long as wide; propodeum (Fig. 26) 14.25× as wide as long; forewing (Fig. 32) 2.25× as wide as long; hindwing (Fig. 33) 2.7× as wide as long; male genitalia (Fig. 30, 31) phallobase closed, digital sclerites with 2 hooks in it; parameral lobe with 1 seta each side; aedeagus broad at base and narrow at apical region.

Relative measurement (Length: Width). head (0.49:0.63), scutellum (0.37:0.34), propodeum (0.57:0.04), fore wing (1.53:0.68), hind wing (0.95:0.34).

Etymology. Name given after the specific epithet of the host, *T. mallotica*, a gall making psyllid, associated with Kamala tree, *Mallotus philippensis*.



Figures 24–33. *Psyllaephagus malloticolae* Rawat & Kumar **sp. nov.** Paratype, male. **24.** Habitus, **25.** Head **26.** Thorax (mesoscutum, scutellum & Propodeum); **27.** Pronotum; **28.** Antenna; **29.** Legs; **30.** Male genitalia; **31.** Lower part of the male genitalia; **32.** Fore wing; **33.** Hind wing

Key to the females of some most allied Indian species of *Psyllaephagus* Ashmead (Modified from Hayat, 2006, and Sudhir & Singh, 2011).

- 1 Metasoma elongate-triangular, apically pointed (Fig. 17), with last tergite long, V-shaped; ovipositor usually longer than dorsal length of metasoma, and then in ventral view base of metasoma protruding anteriorly between metacoxae; body generally large, 1.5–3.9 mm. (Males with funiculars flattened and covered with short setae not more than half width of respective funicular).2
- Metasoma not as described above, apically rounded, with last tergite broader than long, wide U-shaped, and in ventral view base of metasoma not protruding anteriorly between metacoxae; ovipositor usually shorter than three-quarters dorsal length of metasoma; body generally smaller,

	1.2–2.5 mm. (Males with cylindrical funicluars and bearing whorls of long, curly setae longer than width of respective funicular). <i>Psyllaephagus</i> species with U-shape last metasomal tergite [as mentioned in the key provided by Hayat, 2006]	
2	At least one pair of coxae dark brown to black.	3
–	All coxae pale yellow to white.	6
3	Hind coxa dark brown, fore and mid coxae pale yellow..... <i>P. macrohomotoma</i> Singh & Agarwal, 1993	
–	Hind and middle coxae brown, fore coxa pale yellow.	4
4	Scape slightly expanded mesally but elongate, 4× as long as wide.	
 <i>P. phacopteron</i> Sudhir & Singh, 2011	
–	Scape distinctly expanded mesally, only about 2× as long as wide, funicluars longer than wide.	5
5	Club as long as two preceding segments. <i>P. malloticolae</i> sp. nov.	
–	Club distinctly longer than two preceding segments. <i>P. garuga</i> Sudhir & Singh, 2011	
6	F1 clearly shorter than pedicel and F2 both, F1–F2 longer than broad, F6 broader than long; F1 in dorsal half and F2–6 at least in basal half, brownish, remaining parts of pedicel, funicluars whitish [male antenna].	<i>P. mycopsyllus</i> Singh, 1996
–	F1 subequal in length to pedicel and slightly longer than F2; F1–F6 longer than width, brownish yellow.	<i>P. phylloplectae</i> Sushil & Khan, 1995

DISCUSSION

After running with the keys to the genera of Encyrtidae given by Riek (1962 - Australia), Prinsloo (1981 - South Africa), Noyes & Hayat (1984 - Indo-Pacific), Trjapitzin (1989 - Palaearctic), Singh and Agarwal (1993 - India), Singh (1996 - India), Hayat (2006 - India), Sudhir & Singh (2011 - India), Tang et al. (2016 - China), Wu et al. (2021 - China), *P. malloticolae* sp. nov. comes most close to *P. garuga* in having (1) 1.2× wider than long in frontal aspect; (2) scape 2× as long as wide; (3) mid-coxa brown; (4) all funiculars longer than wide; (5) ovipositor sheaths dark brown; (6) toruli inserted at the lower margins of eyes. However, *P. malloticolae* sp. nov. can easily be distinguished with *P. garuga* and other allied species, by following characters given below in the comparative table (Table 1).

Species of *Psyllaephagus* are cosmopolitan and 19 species were also reported from India which were enlisted here excluding new described species – *P. aligarhensis* Shafee, Alam & Agarwal, 1975; *P. macrohomotoma* Singh & Agarwal, 1993; *P. mesohomotomae* Singh & Agarwal, 1993; *P. tekeddyensis* Singh & Agarwal, 1993; *P. phylloplectae* Sushil & Khan, 1995; *P. solanensis* Sushil & Khan, 1995; *P. mycopsyllus* Singh, 1996; *P. aizawlensis* Singh, 1996; *P. bengalensis* Hayat, 2003; *P. phacopteron* S. Singh, 2011, *P. garuge* Sudhir & Singh, 2011, *P. ramamurthy* Hayat, 2013; *P. kundapurensis* Singh, 2014; *P. azafa* Hayat, 2015; *P. eponus* Hayat, 2015; *P. punesis* Hayat & Khan, 2015; *P. hebbalensis* Hayat, 2015; *P. pauropsylla* Hayat, 2015, and *P. arjuna* Sudhir & Singh, 2016. Psyllids present on every continent, with the exception of Antarctica, however the tropics and south temperate zones have the greatest diversity of species and many of them are known as pest (Burckhardt et al., 2018). *Psyllaephagus* species are primary parasitoids of Psyllidae and several species has been already used in biological control programs (Berry, 2007). *Psyllaephagus pilosus* Noyes, 1988 and *P. bliteus* Riek, 1962 both Australian species, were successfully introduced into California against blue gum psyllids, *Ctenarytaina eucalypti* (Maskell) (Dahlsten et al., 1998) and *Glycaspis brimblecombei* Moore (Daane et al., 2005), respectively. Similarly if *T. malloticola* becomes a serious pest of *M. philippensis* then *P. malloticolae* and *Aprostocetus malloticolae* Singh, 2017 can be considered as biological control agents for inhibiting the development in the population of the mentioned pest.

Table 1. Comparison of *P. mallotocola* sp. nov. with the closely related species based on the morphological and morphometrical characters.

<i>Psyllaephagus</i> species	Characters							
	Club/F ₅ +F ₆	Longest funicular	Colour of mid-coxa	MTS/basitarsus	SV/PMV	Metasoma/mesosoma	Ovipositor sheath	Host
<i>P. mallotocolae</i>	Subequal	F ₅	Brownish black	Longer	Equal	Longer	Exserted	<i>Trioza mallotocola</i> (Trioziidae)
<i>P. garuga</i>	Longer	F ₃	Dark brown	Shorter	Longer	Equal	Not exserted	<i>Phacopteron lentiginosum</i> (Phacopteronidae)
<i>P. macrohomotoma</i>	Longer	F ₂ *	Pale	Shorter	Equal	Longer	Exserted	<i>Macrohomotoma</i> sp. (Homotomidae)
<i>P. guangxiensis</i>	Longer	All subequal, F ₁ is smallest	Pale Yellow	Shorter	Equal	Longer	Exserted	<i>Macrohomotoma sinica</i> (Homotomidae)
<i>P. phacopteron</i>	Longer	F ₁	Brown	Shorter	Equal	Equal	Exserted	<i>Phacopteron lentiginosum</i> (Phacopteronidae)

* According to the Fig. 20 in Singh & Agarwal (1993)

AUTHOR'S CONTRIBUTION

The authors confirm their contribution in the paper as follows: S.R.: Collecting the specimens, preparation of slides and making images; S.K.: Identification of the specimens and preparation of the manuscript. Both authors read and approved the final version of the manuscript.

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AVAILABILITY OF DATA AND MATERIAL

Datasets and specimens used to support the findings of this study are available from the corresponding author upon request.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this paper.

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گونه جدید، *Psyllaephagus malloticolae* (Hymenoptera, Encyrtidae) از هند، پارازیتوئید پسیل
 گالزای *Triozza malloticola* (Hemiptera, Triozidae) روی درختچه قنبليله، *Mallotus philippensis*

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چکیده: گونه جدید *Psyllaephagus malloticolae* Rawat & Kumar **sp. nov.** پارازیتوئید پسیل (*Triozza malloticola* (Crawford) (Hemiptera, Psylloidea, Triozidae)) عامل ایجاد گال رو برگ‌های درختچه قنبليله از هند شناسایی و توصیف شد. کلید به‌روزرسانی شده گونه‌های نزدیک از جنس *Psyllaephagus* Ashmead در هند ارایه شد. گونه جدید شبیه به گونه *P. garuga* Sudhir & Singh, 2011 است اما بر اساس دارا بودن صفاتی شامل، بند پنجم فلاژلوم به عنوان بلندترین بند، خار ساق میانی بلندتر از بند اول پنجه، غلاف تخم‌ریز بیرون زده، از آن متمایز می‌شود.

واژگان کلیدی: کالسیدها، زنبور انگل، پسیل، رده‌بندی، اوتاراکنند، مهار زیستی