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DESCRIPTION OF A NEW SPECIES OF *ALLOTROPA* FÖRSTER 1856 (HYMENOPTERA: PLATYGASTRIDAE), AN ENDOPARASITOID OF THE CASSAVA MEALYBUG

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ABSTRACT

The genus *Allotropa* Förster 1856 (Hymenoptera: Platygastridae: Sceliotrachelinae) comprises a group of primary endoparasitoids known for their critical role in controlling mealybug populations. In this study, authors reported the discovery and description of a new species within this genus, reared from *Phaenacoccus manihoti* (Matile-Ferrero) collected in a cassava (*Manihot esculenta* Crantz) field in Kanchanaburi Province, Thailand. The collected mealybugs were reared in a laboratory setting, where the emergence of the parasitoid led to the identification of a previously undocumented species. This new species, *Allotropa suasaardi* Sarkar sp. nov. was distinguished by several unique morphological characteristics. The holotype female and allotype male exhibit unusual yellow body coloration, in contrast to the typically blackish appearance of other described *Allotropa* species. Additionally, the male is characterized by exceptionally long bristles on the antennomeres. Other defining features include reduced wing venation and distinct sculpturing of the mesosoma. This discovery not only expands to the known diversity within the genus *Allotropa* but also highlights the potential of this new species as a biological control agent for managing mealybug infestations in cassava crops, thereby enhancing our understanding of parasitoid biodiversity in Southeast Asia.

***Keywords*:** *Allotropa suasaardi*, new record, parasitoid, *Phaenacoccus manihoti*, unusual yellow body

INTRODUCTION

The genus *Allotropa* Förster 1856 (Hymenoptera: Platygastridae: Sceliotrachelinae) is globally distributed and primarily known as a group of primary endoparasitoids

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of mealybugs (Hemiptera: Pseudococcidae) (Masner and Huggert 1989, Vlug 1995). Taxonomic reviews by Masner and Huggert (1989), Vlug (1995), and subsequent revisions (Buhl 2002, 2019) have emphasized the diversity and ecological importance of this genus. However, knowledge remains fragmentary, especially in the Oriental region (van Noort 2021). Ecologically, *Allotropa* species play a vital role in the natural suppression of mealybug populations across a wide range of agroecosystems. For example, *Allotropa* sp., a gregarious endoparasitoid of the cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero, was found in Paraguay and Mato Grosso do Sul State of Brazil (Lohr *et al*. 1990). In East Asia, it is one of the most important native parasitoids of *Pseudococcus cryptus* Hempel in Japan as it can parasitize all the nymphal stages of the mealybug (Arai and Mishiro 2004). Such interactions underscore their potential in augmentative biological control programs. However, as emphasized by Ricciardi *et al*. (2021), taxonomic accuracy and host-specificity studies are crucial before parasitoids can be safely and effectively applied in pest management. *Allotropa* Förster in the subfamily Sceliotrachelinae of Platygastridae is distributed worldwide. The genus *Allotropa* Förster currently includes approximately 33 recognized species as of 2020, though taxonomic revisions are ongoing with new species periodically described from various regions (Masner and Huggert 1989, Vlug 1995, Buhl 2002, Veenakumari *et al*. 2013, Johnson 2020), including five species reported from the Nearctic region (Muesebeck 1979). Diversity is highest in North America, where at least 5 species have been recorded as of 2004, while Europe hosts a smaller number of species, such as 2 in the British Isles as of 2016 (Buhl *et al*. 2016). Most of these are primary endoparasitoids of various mealybugs However, many of these early descriptions were brief and lacked diagnostic illustrations or comparative morphology. As a result, most of the species have not been fully described or re-described in sufficient detail following modern taxonomic standards (Table 1), including revisions by Muesebeck (1954, 1970), Annecke and Prinsloo (1977), Masner *et al*. (2004), Asadi-Farfar *et al*. (2020), and van Noort (2021). This discrepancy highlights the need for further revisionary work and demonstrates that the genus remains incompletely characterized despite its global distribution.

Table 1. Thirty-three species of *Allotropa* Förster and their body color with references

Sl. No.	Name of the species	Body color	Reference
01.	*Allotropa*	Dark brown to black	Förster 1856
02.	*Allotropa mecrida*	Black	Walker 1835
03.	*Allotropa ashmeadi*	Blackish	Muesbeck 1939
04.	*Allotropa utilis*	Dark brown to shiny black	Gilliatt 1939
05.	*Allotropa convexifrons*	Yellowish brown to piceous	Muesebeck 1942
06.	*Allotropa burreli*	Black	Muesebeck 1942
07.	*Allotropa scutellata*	Black	Muesebeck 1954
08.	*Allotropa merrilli*	Black	Muesebeck 1954
09.	*Allotropa citri*	Black	Muesebeck 1954
10.	*Allotropa subclavata*	Black	Muesebeck 1970
11.	*Allotropa magnini*	Black	Risbec 1955a
12.	*Allotropa pauliani*	Black	Risbec 1955b
13	*Allotropa canopyana*	Black	Buhl 1995
14.	*Allotropa fusca*	Medium brown	Buhl 1995
15.	*Allotropa antennalis*	Blackish	Buhl 2001
16.	*Allotropa muesebecki*	Blackish	Bhul 2002
17.	*Allotropa pallidicornis*	Brown	Bhul 2002
18.	*Allotropa transversiceps*	Blackish	Bhul 2002
19.	*Allotropa musae*	Black	Buhl 2005
20.	*Allotropa fusca*	Dark brown	Bhul 2011
21.	*Allotropa delottococci*	Black	Bhul 2019
22.	*Allotropa japonica*	Black	Ashmead 1904, Mukerjee 1978
23.	*Allotropa loundsburyi*	Polished black	Ashmead 1901
24.	*Allotropa meridionalis*	Blackish	Brethes 1913
25.	*Allotropa kamburovi*	Black to dark	Annecke and Prinsloo 1977
26.	*Allotropa oracellae*	Black	Masner *et. al.* 2004
27.	*Allotropa phenacocca*	Black	Chen *et al.* 2011
28.	*Allotropa gundlupetensis*	Black	Veenakumari *et al*. 2013
29.	*Allotropa vanajae*	Black	Veenakumari *et al*. 2013
30.	*Allotropa nigra*	Black	Veenakumari *et al*. 2013
31.	*Allotropa conventus*	Dark / standard integument	Asadi-Farfar *et al*. 2020
32.	*Allotropa* sp.	Dark blackish	van Noort *et al*. 2021
33.	*Allotropa* sp.	Black	Kiran *et al.* 2024

However, the taxonomy and species identification within *Allotropa* remain challenging for females, as their antennal structures are often very similar across species. Females are difficult to distinguish due to conserved antennal structures and subtle morphological variation, whereas males are generally more diagnostic because of their diverse antennal modifications (Muesebeck 1954, Ricciardi *et al*. 2021). The subtle differences in the morphology, sculpture, and coloration of females require detailed study to develop reliable identification keys (Muesebeck 1954). The very small body size of these wasps (<1mm) and their morphological conservatism complicate species delimitation and hinder the development of reliable identification keys.

Recent advances in Platygastridae systematics have revealed substantial hidden diversity within Sceliotrachelinae. Awad *et al*. (2023) reviewed the Förster genera of Platygastridae through re-examination of type specimens and detailed comparative morphology, while Asadi-Farfar *et al*. (2020) documented new records of *Allotropa* and related sceliotracheline taxa from Iran, thereby exposing significant taxonomic gaps. Although molecular approaches are increasingly applied in Platygastridae to resolve cryptic taxa, morphology continues to serve as the foundation for species description, particularly in cases where molecular-grade material is unavailable. This reliance on detailed morphological analysis follows established precedents in sceliotracheline taxonomy (Kamalanathan *et al*. 2019).

Given the ecological and applied importance of *Allotropa* in regulating mealybug populations, there is a pressing need for regional surveys and species-level revisions. In Southeast Asia, particularly in cassava-based systems where *P. manihoti* has emerged as a major invasive pest, the diversity of *Allotropa* remains poorly documented. Here, authors describe a new species of *Allotropa* from Thailand, reared from *P. manihoti* infesting cassava (*Manihot esculenta* Crantz). This species exhibits distinctive morphological character states, including unique coloration and antennal structures, which justify its recognition as a novel taxon. The discovery contributes not only to the taxonomy of the genus but also to the potential deployment of native parasitoids in sustainable mealybug management programs.

MATERIAL AND METHODS

Field Collection: Specimens of the parasitoid *Allotropa* sp. were obtained from a cassava (*Manihot esculenta* Crantz) field naturally infested with cassava mealybug (*Phenacoccus manihoti* Matile-Ferrero) in Kanchanaburi Province, Western Thailand (14°00′15″ N, 99°32′57″ E). Kanchanaburi, the third-largest province of Thailand, is located ~130 km northwest of Bangkok and is characterized by tropical evergreen and mixed deciduous forest vegetation, which provides favorable habitats for cassava cultivation and associated pest–natural enemy complexes.

Sample handling and rearing: Cassava shoots and leaves heavily infested with *P. manihoti* were carefully excised from the field and placed into ventilated plastic containers to prevent condensation and fungal growth during transport. Samples were immediately transferred to the National Biological Control Research Center (NBCRC), Kasetsart University, Kamphaeng Saen Campus, Thailand. In the laboratory, infested plant material was maintained under controlled ambient conditions (25 ± 2 °C, 70 ± 10% RH, and natural photoperiod). The material was inspected daily under a stereomicroscope to record parasitoid emergence.

Parasitoid recovery and preservation: Emerging *Allotropa* specimens were aspirated daily and transferred into labeled glass vials. Specimens for morphological examination were preserved in 95% ethanol, while a subset was processed for slide mounting following standard entomological techniques (i.e., critical-point drying, mounting in Canada balsam or Hoyer's medium), and later examined using a stereomicroscope and compound microscope equipped with an ocular micrometer. Voucher specimens were deposited in the insect collection of NBCRC, Kasetsart University, for future reference.

Morphological identification: The emerged parasitoid was identified based on external morphology, following the diagnostic keys of Masner and Huggert (1989) and Buhl (2019). Diagnostic characters examined included antennal segmentation, mesoscutal sculpture, scutellar structure, wing venation, and body coloration. High-resolution images were taken using a digital imaging system attached to the Olympus SZ61 stereo zoom and compound microscope. Scanning electron microscope photographs were taken with a, JEOL (JSM-6490LA) Analytical SEM and Morphological terminology followed Talamas *et al*. (2017). The following abbreviations are used: A1, A2 , . . . , A9: antennomeres 1, 2 , . . . , 9; T1, T2 , . . . , T7: metasomal tergites 1, 2 , . . . , 7.

Allotropa suasaardi Sarkar sp. nov. (Fig. 1a-r)

The parasitoid obtained from *P. manihoti* infesting cassava in Kanchanaburi Province, Thailand, was identified to represent a new species of *Allotropa* (Hymenoptera: Platygastridae: Sceliotrachelinae). Detailed morphological analysis revealed several unique character states distinguishing it from all congeners. Most notably, the new species exhibits bright yellow body coloration in both sexes, in contrast to the predominantly black to dark brown body color typical of described *Allotropa* species worldwide (Table 1, Vlug 1995, Buhl 2002, Masner *et al*. 2004). Such coloration is taxonomically significant as body color in *Allotropa* has proven to be stable within species and diagnostic across lineages.

A second diagnostic feature is the presence of exceptionally long bristles on the male antennomeres. These bristles, extending up to four times the length of the antennal segments in A3–A4, and twice as long on A5-A6, are unprecedented among described species (Fig. 1q-r). In most congeners, male antennae possess short, decumbent setae that are never longer than the segment itself (Muesebeck 1954, Buhl 2001, 2005). Together, the unique yellow body coloration and the extreme antennal bristle length in males establish robust diagnostic characters justifying the recognition of this taxon as a new species.

Additional characters that reinforce the distinctiveness of this species include; Reduced forewing venation, with only a sub-marginal vein present and bearing crenulae along its posterior margin. A finely sculptured meso-scutum with posteromedial smoothening, combined with a rugulose scutellum. A slender and elongated metasoma with distinct furrows on T1 and striated basal foveae on T2 (Fig. 1f-h). These features conform to the generic concept of *Allotropa* (Masner and Huggert 1989, Vlug 1995), yet differ markedly in their specific expression relative to other species described from the Oriental and Afrotropical regions (Annecke and Prinsloo 1977, van Noort 2021)

In the present paper one species is described; that can be separated from the other species by use of the key below. The key is based on the descriptions in Ashmed (1901, 1904), Brethes (1913), Kleffer (1926), Muesebeck (1939, 1942, 1954), Bhul (2002, 2005), Masner (2004), Chen (2011), Veenakumari (2013), van Noort (2021) and Kiran (2024).

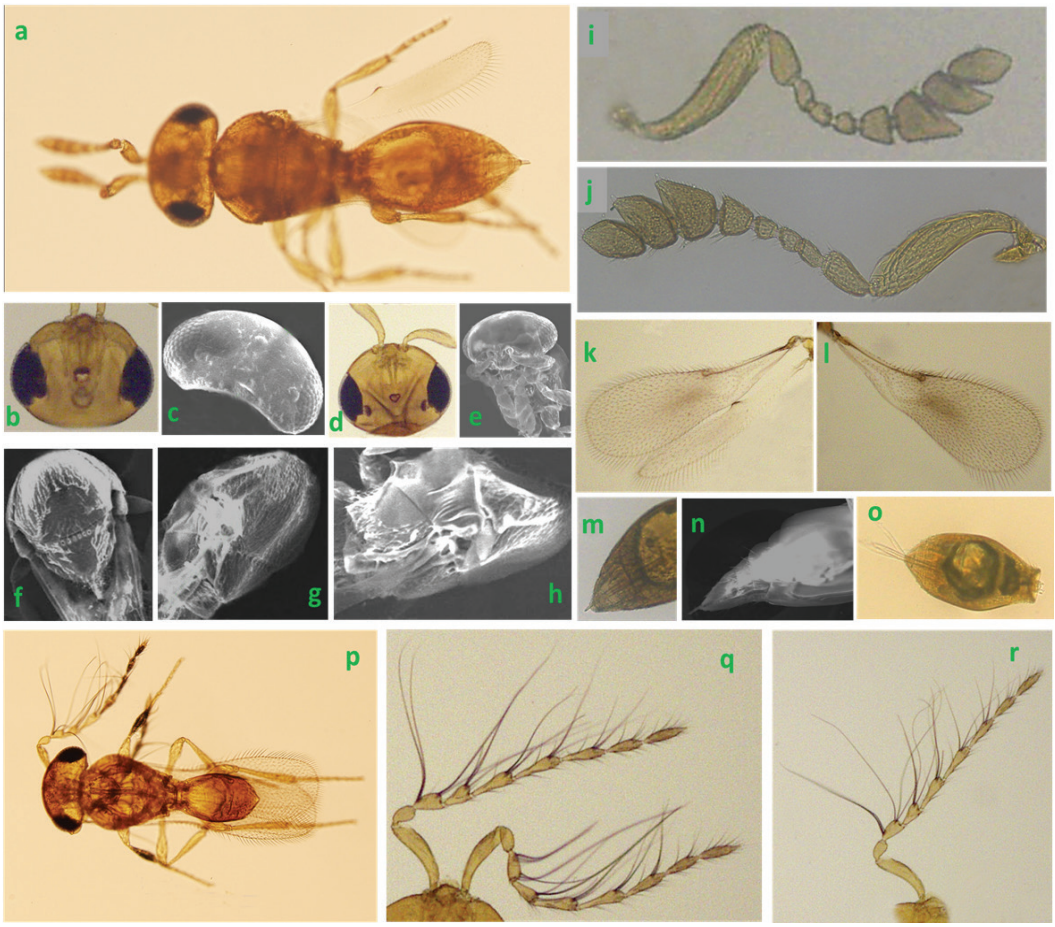

Fig. 1. Morphological features of *Allotropa suasaardi* Sarkar **sp. nov.** a) Adult female; b) Head, dorsal view (female, stereo zoom microscope); c) Head, dorsal view (female, scanning electron micrograph, SEM); d) Head, frontal view (female, compound microscope); e) Head, frontal view (female, SEM); f) Mesosoma, dorsal view (female, SEM); g) Mesosoma, lateral view (female, SEM); h) Mesosoma, ventral view (female, SEM); i) Antenna (female); j) Antennomeres showing hair (female); k) Fore and hind wings; l) Fore wing; m) Ovipositor (stereo zoom microscope); n) Ovipositor (SEM); o) Ovipositor sheaths; p) Adult male; q) Antennae, both (male); r) Ditto, single (male).

Key to World species *of Allotropa*

1. Body yellow; frons is highly polished (Fig. 1a) ..... *A. suasaardi* **sp. nov.**
- Body black; frons is not polished 2
2. Antenna short, with 3-segmented club, with only short hairs (females) 3
- Antenna long, filiform, with long hairs (males) 12
3. Scutellum smooth and shiny 4
- Scutellum at least sculptured lateraliy 7
4. Scutellum strongly convex (USA) ..... *A. burrelli* Muesebeck 1942
- Scutellum rather flat 5
5. Frons smooth (USA) ..... *A. convexifrons* Muesebeck 1942
- Frons at least partly sculptured 6
6. A3 about 1.75 x as long as wide (China, introduced to USA) ..... *A. citri* Muesebeck 1954
- A3 about 1.33 x as long as wide (Panama) ..... *A. muesebecki* Bhul 2002
7. A3 fully twice as long as wide 8
- A3 hardly twice as long as wide 11
8. Scutellum medially smooth (Canada) ..... *A. utilis* Muesebeck 1939
- Scutellum sculptured all over 9
9. Frons mostly smooth (Brazil) ..... *A. scutellata* Muesebeck 1954
- Frons coriaceous except a small median area 10
10. Mesoscutum somewhat shiny; scutellum rather flat (USA) ..... *A. ashmeadi* Muesebeck 1939
- Mesoscutum dull; scutellum convex (USA) ..... *A. merrilli* Muesebeck 1954
11. Basal flagellar Segments relatively slender; legs pale yellow (Panama) ..... *A. pallidicornis* Bhul 2002
- Basal flagellar Segments relatively short; legs partly brownish (Panama) ..... *A. transversiceps* Bhul 2002
12. Preapical antennal Segments hardly longer than wide ..... *A. burrelli* Muesebeck 1942
- Preapical antennal Segments distinctly longer than wide 13
13. Scutellum entirely or partly smooth 14
- Scutellum sculptured all over 17
14. Hairs of basal flagellar Segments about 5 x as long as length of Segments ..... *A. convexifrons* Muesebeck 1942
- Hairs of basal flagellar Segments at most about 2 x as long as length of Segments 15

15. Hairs of basal flagellar Segments about 2 x as long as length of Segments; A8 about 4x as long as wide ..... *A. muesebecki* Bhul 2002
- Hairs of basal flagellar Segments less than twice as long as length of Segments; A8 at most about 3 x as long as wide 16
16. Scutellum entirely smooth ..... *A. citri* Muesebeck 1954
- Scutellum reticulate laterally ..... *A. utilis* Muesebeck 1939
17. Hairs of basal flagellar Segments less than twice as long as length of Segments 18
- Hairs of basal flagellar Segments at least twice as long as length of Segments 19
18. Body length 0.6 mm ..... *A. ashmeadi* Muesebeck 1939
- Body length 0.95 mm (Brazil) ..... *A. meridionalis* Brethes 1913
19. Legs pale yellow; scutellum hardly convex ..... *A. pallidicornis* Bhul 2002
- Legs brown; scutellum slightly convex ..... *A. musae* Bhul 2005
- Legs darker; scutellum convex 20
20. Frons mostly smooth; legs brownish yellow ..... *A. scutellata* Muesebeck 1954
- Frons coriaceous except a small median area; legs piceous ..... *A. merrilli* Muesebeck 1954
21. Legs brown or brown-black; abdomen conically pointed; thorax united ..... *A. loundsburyi* Ashmed 1901
- Legs yellowish; abdomen smooth; thorax longitudinally striate ..... *A. japonica* Ashmed 1904
22. Body length 0.935mm; metasoma shining brown to black except orangish T1; mesosoma slightly convex anteriorly ..... *A. gundlupetensis* Veenakumari 2013
- Body length 0.819 mm; metasoma brownish black except brownish T1..... 23
23. Mesosoma flattened..... *A. vanajae* Veenakumari 2013
- Mesosoma anteriorly convex; body length 0.901 mm; metasoma black except T1 ..... *A. nigra* Veenakumari 2013
24. Body length 0.96 mm; wings membranous; fore wing 2.37 x as long as wide ..... *A. phenacocca* Chen 2011
- Body length 0.8 mm; wings hyaline; fore wing 2.3 x as long as wide ..... *A. phenacocca* Kiran 2024
25. Subellipsoidal transverse; metasoma distinctly elongate ..... *A. oracellae* Masner 2004
- Subellipsoidal lens-like; metasoma lateral edge indistinct ..... *Allotropa* species van Noort 2021

Description

Holotype (Female): The body length ranges from 0.65-0.70mm. The entire body, including the head, antennae, and legs, is yellow (Fig. 1a). The head, when viewed dorsally, is slightly wider than the thorax with a concave posterior margin and a harshly convex anterior margin. The head is wider than high in anterior view, with a distinct but somewhat effaced hyperoccipital carina. The lateral ocelli are widely separated and nearly touch the inner orbit of the eye. The frons is highly polished with a narrow transverse strip above the antennae insertion and finely reticulate areas adjacent to the eyes. The antennal sockets are close to the mouth margin, separated by a narrow interscrobal prominence (Fig. 1b-e). The antennomeres (A1-A9) are dissimilar in proportion, with A1 being the longest, followed by A2 and A3. A7 and A8 are distinctly elongated and pointed, with tiny setae on both sides (Fig. 1i-j).

Mesosoma: In dorsal view, it is slightly narrower than the head. The pronotum is barely visible and overlaps the mesoscutum laterally. The mesoscutum exhibits dense coriaceous microsculpture that smoothens posteromedially. The scutellum is finely rugulose, slightly convex, and separated from the mesoscutum by a foveolate furrow. The pronotum sides are covered with coriaceous sculpture, while the mesopleuron is smooth and hairless, with some wrinkles. The mesopleural depression is distinct, and the metapleuron shows irregular coriaceous sculpture with a distinct hairy propodeum (Fig. 1f-h).

Wings: The forewing exhibits reduced venation, is slightly curved, and faintly infuscated. The submarginal vein is strong, with a single long seta beyond the middle, and the hind edge of the submarginal vein has distinct crenulae from near the base to near the apex. The apex of the venation is clavate, with setation present in the wing disc, and a strong marginal fringe. The hind wing is narrow with a rounded apex, sparsely setose in the apical two-thirds, and devoid of setae in the basal part (Fig. 1k-l).

Metasoma: The metasoma is distinctly elongated. T1 has longitudinal furrows, T2 has two slightly striated basal foveae, and T3-T5 are short with sparse hairs. T6 is largely triangular, wider than long, sharply pointed apically, and slightly longer

than the mesosoma. The ovipositor assembly is extended and protected by a pair of ovipositor sheaths (Fig. 1m-o).

Allotype (Male): The body length ranges from 0.59-0.64 mm, distinctly shorter than the female (Fig. 1p). The male resembles the female closely but differs primarily in the structure of the antenna. The antennomeres (A1-A9) are dissimilar, with A1 being the longest, followed by A5-A9. The funicle segments are plainly longer than wide and subequal in size. A3-A9 have long upright bristles, with the hairs on A3-A4 being about four times as long as the segment, while A5-A6 have hairs about twice as long as the antennomeres. In A7, the hair is shorter than in A3-A6, and A8-A9 have distinctly shorter bristles than the other antennomeres (Fig. 1q-r).

Etymology: The new species is named *Allotropa suasaardi* Sarkar **sp. nov.** in honor of the collectors (Wiwat Suasa-ard & Md. Akhataruzzaman Sarkar) of the material, recognizing their contribution to parasitoid biodiversity research in Thailand.

Host, Biology, and Distribution: *Allotropa suasaardi* Sarkar **sp. nov.** was obtained from *P. manihoti* infesting cassava in Kanchanaburi. The mealybugs were pinkish in coloration. Based on rearing, *A. suasaardi* Sarkar sp. nov. appears to be a primary, possibly gregarious, endoparasitoid (multiple individuals sometimes emerge from a single host). No hyperparasitoids were detected in this system during the rearing period. Geographic distribution is currently known only from the type locality in western Thailand.

Comparison with Closely Related Species: The yellow coloration and the long bristles on the male antennae, traits, distinguish *A. suasaardi* Sarkar **sp. nov.** as new species from previously described species such as *A. burrelli, A. delottococci*, and *A. phenacocca*. For example, *A. phenacocca* described from China parasitizing *Phenacoccus solenopsis* has darker integumentation and more conventional antennal setation (Chen *et al*. 2011). *A. delottococci* from South Africa also carries a darker body and differing meso-scutal sculpture (Buhl 2019). Further, molecular data (DNA barcoding) should be sought to confirm phylogenetic placement and divergence from known species (as in recent *Allotropa* studies from India) (Kiran *et al*. 2023).

Significance of the Newly Identified Parasitoid: The discovery of *A. suasaardi*

Sarkar **sp. nov.** expands the known diversity of *Allotropa* in Southeast Asia and provides a candidate for further evaluation as a biocontrol agent against *P. manihoti* on cassava. The remarkable yellow coloration is unusual in the genus and merits reconsideration of coloration as a diagnostic character in *Allotropa*. It is essential to complement morphological taxonomy with molecular data. Recent integrative studies of *Allotropa* lineages from India have applied both morphological diagnosis and molecular markers to refine species delimitation (Kiran *et al*. 2023). Such an approach could help verify whether *A. suasaardi* Sarkar sp. nov. is indeed distinct and to elucidate its phylogenetic affinities. From a biological control perspective, pre-release host range testing under no-choice and choice assays should be conducted (akin to those done for *A. burrelli*) to evaluate non-target risk (Quaglietti *et al*. 2017). Additionally, life-history parameters (development time, fecundity, host-stage preference) must be determined in controlled experiments to assess its suitability. Furthermore, interactions with existing parasitoids, possible hyperparasitoids, and environmental compatibility need evaluation.

Given the prevalence of mealybugs in cassava cropping systems and the limitations of chemical control, novel native parasitoids such as *A. suasaardi* Sarkar **sp. nov.**, could contribute to integrated pest management (IPM) in Southeast Asia. Finally, further field surveys in Thailand and neighboring countries may reveal a broader distribution or additional species of *Allotropa* in cassava ecosystems.

CONCLUSION

Authors formally describe *Allotropa suasaardi* Sarkar **sp. nov.**, (Platygastridae) as a new endoparasitoid species associated with *P. manihoti* in Thailand. Key distinguishing features include yellow body pigmentation and extremely elongate antennal setae in males. This addition to *Allotropa* enhances regional taxonomic knowledge and suggests potential for exploitation in the biological control of cassava mealybugs. Additional molecular, ecological, and parasitism-performance studies were recommended to validate its utility in IPM frameworks.

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