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Short Article

Discovery and host association of *Brachymeria apicicornis* Cameron (Hym.: Chalcididae) parasitizing *Cassida obtusata* Boheman (Col.: Chrysomelidae) on *Amaranthus palmeri* in the Thar Desert, India

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ABSTRACT. The Thar Desert of northwestern India harbours underdocumented parasitoid–host interactions and unique ecological interactions often overlooked due to its arid landscapes. Here, we report the first confirmed host association of *Brachymeria apicicornis* (Cameron, 1911) (Chalcididae: Brachymeriinae) as a pupal parasitoid of *Cassida obtusata* Boheman, 1854 (Chrysomelidae: Cassidinae) feeding on *Amaranthus palmeri* S. Wats (Amaranthaceae) in Rajasthan, India. Solitarily emerged adult parasitoids from five individually isolated pupae establish a pupal idiobiontic parasitoidism on the cassidine host. Species identity is corroborated through a diagnostic redescription. The present study also provides a structured evidence framework encompassing rearing isolation, emergence chronology, exit-hole morphology and position, and host pupal phenotype. Broader implications on ecological dynamics in arid landscapes are also discussed.

KEYWORDS: Brachymeriinae, Biocontrol, Host association, Parasitoid, Palmer amaranth

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INTRODUCTION

The Thar Desert, also referred to as the Great Indian Desert, is the tenth largest desert ecosystem globally, extending over approximately 2.34 million km² across north-western India, Pakistan, and adjacent regions (Roy & Roy 2019; Gaurav Sharma 2013). In India, it encompasses large areas of Rajasthan and extends into parts of Gujarat, Punjab, and Haryana. Despite its arid climate, pronounced thermal extremes, and low and erratic rainfall, the Thar Desert supports a distinctive assemblage of flora and fauna adapted to severe environmental constraints. Recent assessments indicate that the desert biogeographic zone harbours more than 3,300 faunal species representing over 600 families; nevertheless, invertebrate diversity, particularly insects, remains considerably under-documented when compared to vertebrate groups (Chandra et al. 2021). Insect communities play a central role in desert ecosystems, with Hymenoptera constituting a key functional component owing to their importance as pollinators and parasitoids. Within Hymenoptera, the family Chalcididae Latreille, 1817 consists predominantly of pupal parasitoids attacking a broad spectrum of holometabolous insect orders, including Lepidoptera, Coleoptera, Diptera, Neuroptera, Orthoptera, Strepsiptera, and Hymenoptera (Herting 1976; Narendran 1989). Chalcidids are ecologically significant because of their regulatory effects on host populations and their recognised role in natural biological control processes.

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The genus *Brachymeria* Westwood, 1829 is among the most speciose and widely distributed genera within Chalcididae, with more than 300 species described worldwide and a particularly strong representation in the Oriental region (Joseph et al. 1973; Narendran 1989; Binoy et al. 2021; UCD Community 2023; Binoy 2025a, 2025b). Species of *Brachymeria* are typically solitary endoparasitoids, most frequently associated with the pupal stages of Lepidoptera and Coleoptera, although the genus exhibits considerable breadth in host utilisation (Binoy 2025a; Binoy & Sureshan 2025). Despite its global distribution and ecological importance, *Brachymeria* remains poorly documented in arid and semi-arid landscapes such as the Thar Desert (Binoy et al. 2021). To date, only two chalcidid species have been formally recorded from this region, highlighting the limited extent of systematic parasitoid surveys in this biome (Chandra et al. 2021).

Brachymeria apicicornis (Cameron, 1911), originally described under the genus *Oncochalcis*, is a widely distributed Oriental species with confirmed records from India, Malaysia, and Indonesia (Cameron 1911; Narendran 1989; UCD Community 2023; Basak & Saroj 2024). Published host records indicate its association with both Lepidoptera and Coleoptera, including cassidine beetles, suggesting a degree of ecological plasticity in host exploitation (Herting 1976; Sabu et al. 2023). Nevertheless, host associations supported by direct rearing evidence remain relatively few, particularly from arid regions of the Indian subcontinent.

During field observations and controlled rearing experiments conducted in the Thar Desert of Rajasthan, adults of *B. apicicornis* were obtained from pupae of the tortoise beetle *Cassida obtusata* Boheman, 1854 (Coleoptera: Chrysomelidae: Cassidinae) feeding on *Amaranthus palmeri* S. Wats (Amaranthaceae). This constitutes the first confirmed host association of *B. apicicornis* with *C. obtusata* and represents the first documented record of this parasitoid–host interaction from the Thar Desert ecosystem. In the present study, we substantiate this association through individual host rearing, emergence chronology, and pupal exit-hole characteristics. In addition, a diagnostic redescription of *B. apicicornis* is provided, accompanied by notes on its morphology, ecology, and biogeographic significance within arid environments.

MATERIAL AND METHODS

Field collections were undertaken at the Desert Regional Centre, Zoological Survey of India, Jodhpur, Rajasthan (located in the Thar Desert biogeographic zone). Larvae and pupae of *C. obtusata* were hand-picked from infested *Amaranthus palmeri* plants (during routine field surveys) (Figs 2, 3). Each pupa was placed individually in sterile, aerated vials to ensure isolation. Samples were reared under ambient laboratory conditions. Strict aseptic protocols were employed, and each sample was coded with date and time. Emergence was monitored daily, ensuring precise host–parasitoid association linkage. Parasitoids, adult hosts, and parasitoid-emerged host remains were examined using a Leica S9i stereomicroscope and imaged using an attached camera setup. Focus-stacked images were processed in LAS v.3.6. General terminology follows Hymenoptera Anatomy Consortium (2022) and Burks et al. (2025). The nomenclature for integumental sculpture follows Harris (1979). Abbreviations of terms used are as follows: Gtx = gastral tergum number; OOL = oculo-ocellar distance, the minimum distance between a posterior ocellus and eye; pmv = postmarginal vein; POL = postocellar distance, the distance between the two posterior ocelli; stv = stigmal vein. Measurements were taken with calibrated ocular micrometry. The collection details were georeferenced using the open-source QGIS software version 3.22 (Fig. 1).

Specimens were identified as *B. apicicornis* using diagnostic characters, by cross-checking with keys and literature (Joseph et al. 1973; Narendran 1989; Narendran & van Achterberg 2016). All parasitoids and host pupal exuviae are deposited in the National Zoological Collections (NZC). Accession numbers are assigned: ZSI/DRC/Hymenoptera/*Brachymeria*/16024/A (parasitoid) and ZSI/DRC/Coleoptera/*Cassida*/16157/A (host).

Museum abbreviation. NHMUK: Natural History Museum, London, U.K.; ZSI DRC: Zoological Survey of India, Desert Regional Centre, Rajasthan, India.

RESULTS

Class Insecta Linnaeus, 1785

Order Hymenoptera Linnaeus, 1758

Superfamily Chalcidoidea Latreille, 1817

Family Chalcididae Latreille, 1817

Genus *Brachymeria* Westwood, 1829

Brachymeria apicicornis (Cameron, 1911)

Oncochalcis apicicornis Cameron, 1911:3, Holotype ♀, Malaysia: Sarawak [combined with *Brachymeria* (Joseph et al. 1973:174)] (NHMUK)

Figs 8–13

Material examined. 5 ♀♀ INDIA: Rajasthan, Jodhpur, ZSI-DRC campus, ex. pupae of *Cassida obtusata* on *Amaranthus palmeri* S. Wats (Amaranthaceae), 05.viii.2025, coll. V. Sushama (ZSI DRC).

Diagnostic characters. **Female** (Indian specimens). Body length 9.0–11.8 mm; length of fore wing 8.1–8.4 mm. *Head.* Head transverse; POL 2.8× OOL. Preorbital carina strong and sharply developed; postorbital carina weak, dorsally effaced. Frons, vertex, and face densely punctate, punctures coarse; interspaces narrow and matte. *Mesosoma.* Pronotum, mesoscutum, and scutellum coarsely and closely punctate. Scutellum apex broadly rounded, with shallow median emargination, not produced. Mesoscutellum–metanotum junction smooth, without carinate ridge. Metanotum and propodeum irregularly rugulose; lateral plicae weakly indicated, corresponding to the irregular reticulation noted in the original description. *Legs.* Fore- and midlegs brownish to testaceous with yellow patches. Hind femur brown, apically yellowish; ventral margin with 11–12 teeth, stout, basal teeth largest, remaining teeth stout, widely spaced. Hind tibia dark brown to blackish, with base and apex yellow. *Fore wing*. Fore wing hyaline; venation brown to blackish; mv 2.3× pmv; stv moderately long; basal cell partially bare. *Metasoma.* Metasoma strongly convex, ovate. Gt_1 smooth, shiny. Gt_2–Gt_5 finely microsculptured, matte laterally. Gt_6 with five transverse rows of pits forming a distinct apical sculptural band. Hypopygium moderately produced; ovipositor sheath slightly visible dorsally.

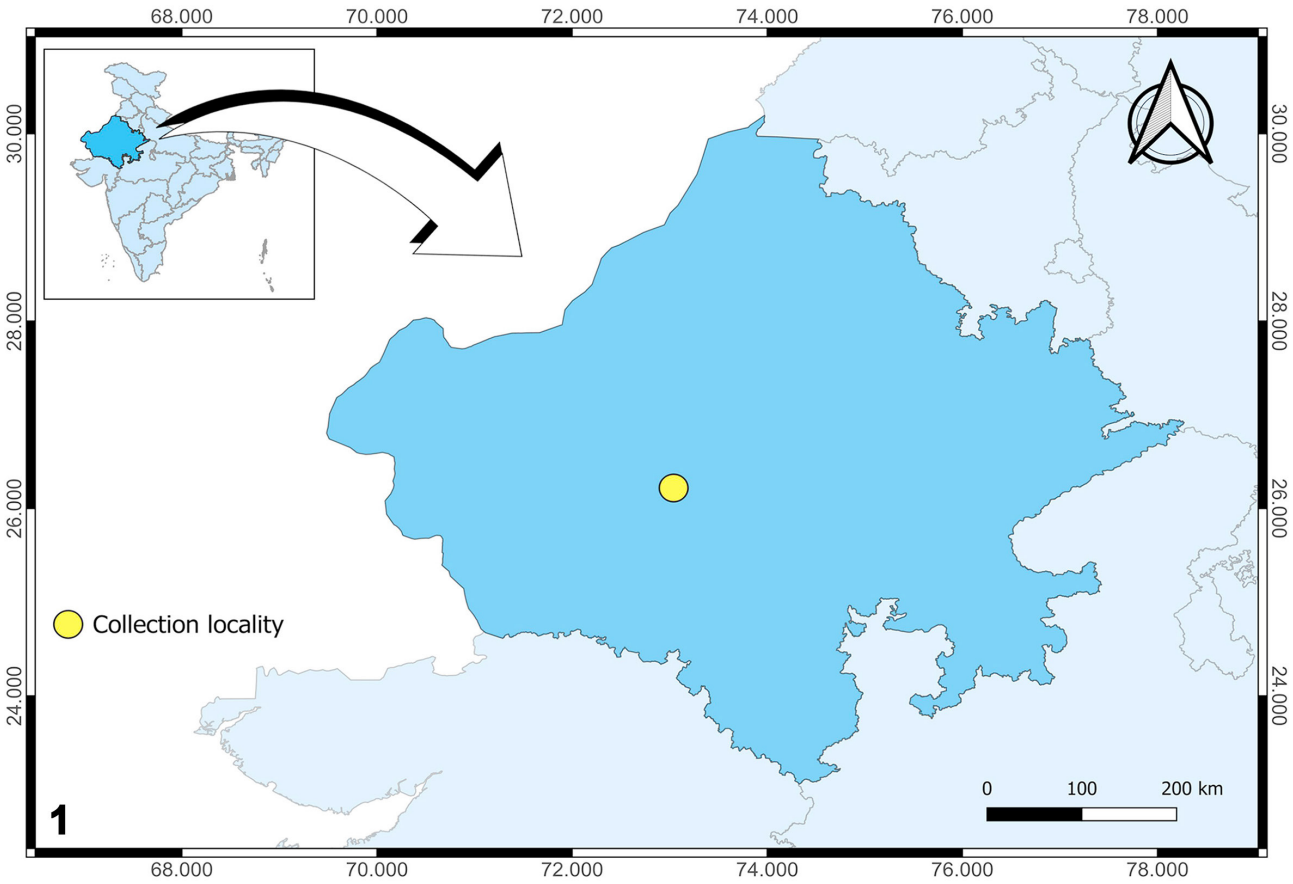
Colour. Body black; tegulae yellowish brown. Antenna brown to dark brown; apical antennal segments pale. Pro and mesofemur black with apex yellowish brown; Pro and mesotibia yellowish brown with median brown patch; Metafemur black with a small apical yellow patch; metatibia brown with a basal and apical yellow patch.

Variations. Fresh specimens conform closely to the original description of *Brachymeria apicicornis* (Cameron 1911) and subsequent interpretations. Minor intraspecific variation is observed in body length (9.0–11.8 mm compared to 4.0–4.3 mm in the original description), intensity of mesosomatic sculpture, and number of metafemoral teeth (11–12). No structural characters were observed that deviate from the type concept.

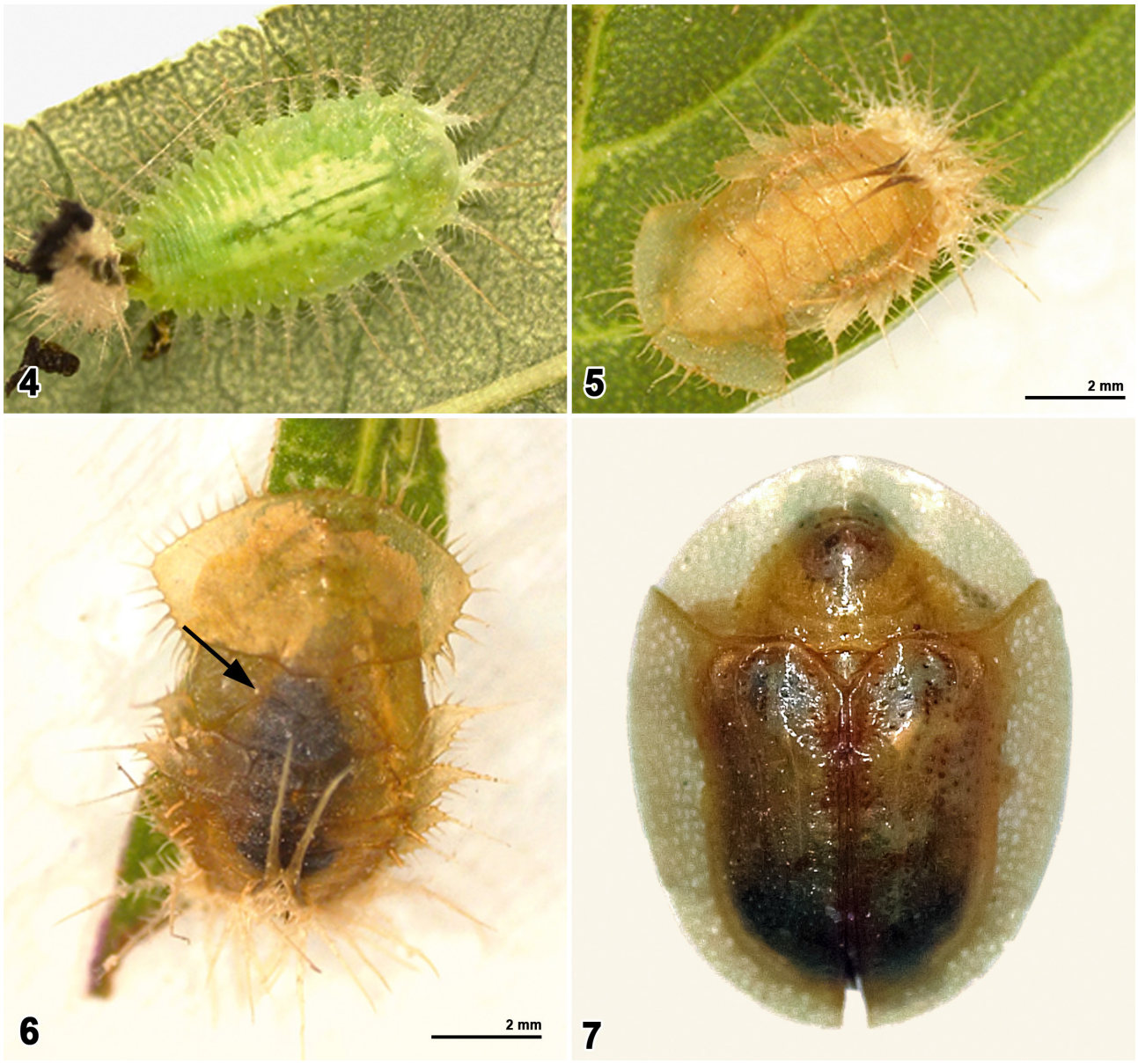
Distribution. India (including Rajasthan), Southeast Asia (Indonesia, Malaysia) (Narendran 1989; UCD Community 2023).

Host records. Coleoptera: Cassidinae: *Cassida obtusata* (present study (Figs 4–7), *Silana farinosa* (Sabu et al. 2023); Lepidoptera (*Artona catoxantha*) (reported but unconfirmed, Herting 1976).

Host–parasitoid association evidence. Larvae and pupae of *Cassida obtusata* were collected alive and isolated individually immediately after field collection, ensuring that each rearing unit contained a single host individual. Rearing was conducted without disturbance under ambient laboratory conditions, allowing uninterrupted development and emergence. Adult parasitoids identified as *Brachymeria apicicornis* emerged within 3–9 days after collection, indicating that parasitism had occurred prior to sampling in the field. In all confirmed cases, a single adult parasitoid emerged from each host pupa, indicating solitary parasitism. No instances of multiple adult emergence from a single pupa were recorded. Parasitoid emergence occurred through a circular to subcircular exit hole positioned consistently on the dorsoposterior region of the pupal cuticle.

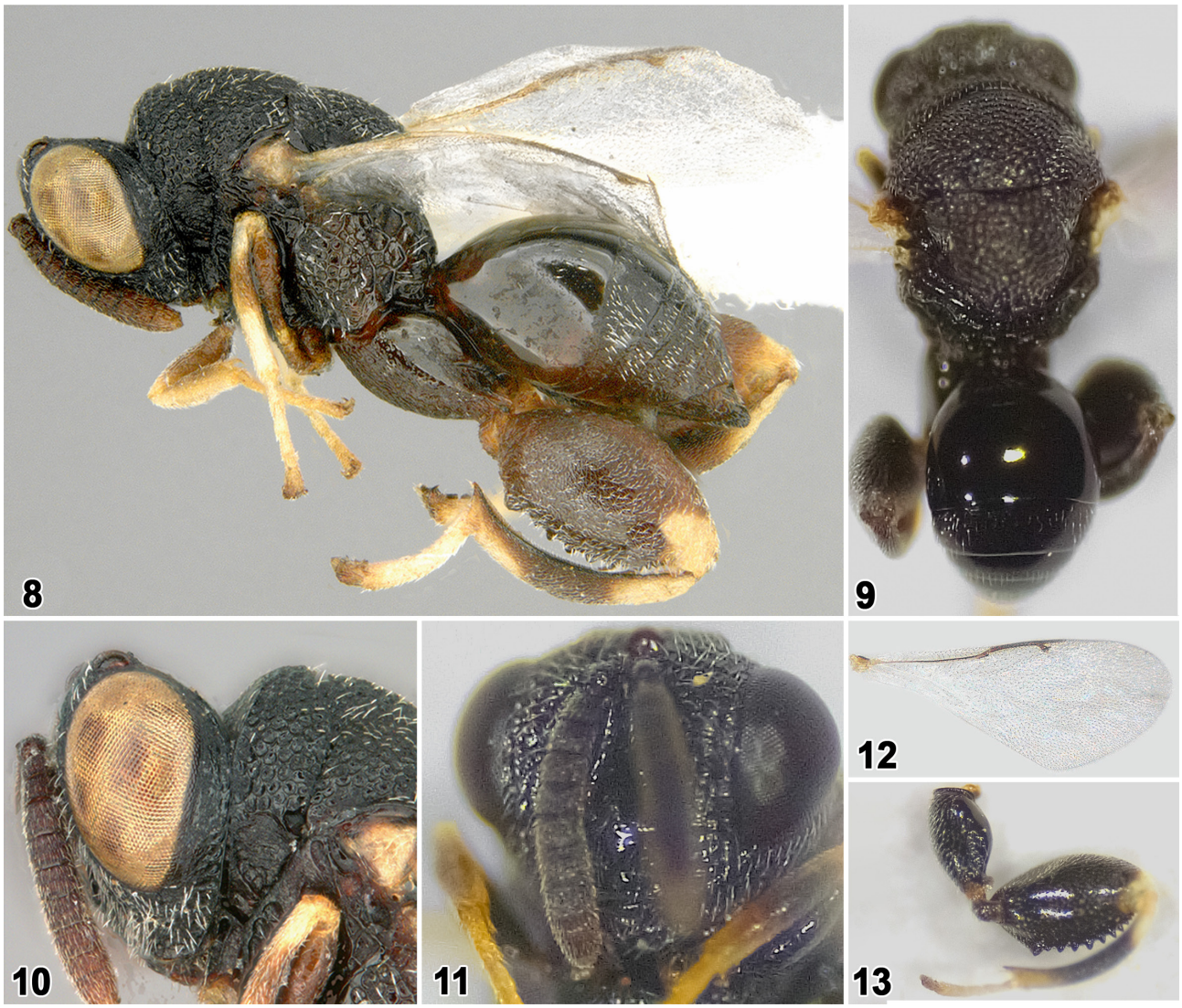


Figures 1–3. Map and collecting localities. **1.** Collection locality of *Brachymeria apicicornis* attacking *Cassida obtusata* on *Amaranthus palmeri* S. Wats (Amaranthaceae); **2.** host plant *A. palmeri* with *C. obtusata* infested leaves; **3.** Adult beetle (arrow indicated) on *Amaranthus* leaf.



Figures 4–7. Host *Cassida obtusata* Boheman. **4.** Larva (green, dorsal view); **5.** Healthy pupa (pale yellow, transparent); **6.** Parasitized pupa (brownish, internal darkening visible); **7.** Adult beetle.

Exit holes measured 0.9–1.8 mm in diameter and exhibited smooth, sharply defined margins, suggesting controlled exit behaviour rather than mechanical rupture or decomposition-related damage. Parasitized pupae showed progressive internal darkening prior to adult emergence, visible through the pupal cuticle. This darkening was absent in non-parasitized pupae, which remained pale to light brown throughout development. Healthy pupae yielded adult beetles through the normal posterior pupal opening, with no additional perforations or cuticular damage. No partially emerged beetles or malformed adults were observed, indicating normal host development in non-parasitized individuals. No hyperparasitoids, secondary parasitoids, or inquilines emerged from any reared pupa. Rearing containers remained free of fungal growth, scavengers, or external contamination, ruling out post-collection mortality or opportunistic colonization as explanations for observed emergence patterns. The host–parasitoid association is confirmed through a combination of controlled individual rearing, direct observation of adult parasitoid emergence from identified host pupae, consistent and diagnostic emergence marks, and preservation of emerged parasitoids together with their corresponding host pupal exuviae.



Figures 8–13. *Brachymeria apicicornis* (Cameron, 1911), female. **8.** Habitus, lateral view; **9.** Habitus, dorsal view; **10.** Head, lateral view; **11.** Head, frontal view; **12.** Fore wing; **13.** Hind leg, inner view.

DISCUSSION

Parasitoid Emergence and Ecological Resilience. The emergence of *Brachymeria apicicornis* from pupae of *Cassida obtusata* under severe Thar Desert conditions underscores notable ecological resilience and developmental plasticity in this chalcidid parasitoid. While direct thermal tolerance assays were not conducted here, the rapid emergence following collection implies tight temporal synchrony with host pupation under highly variable and extreme temperatures. Shifts in temperature regimes are known to affect parasitoid phenology and survival, with increased temperature variation often disrupting host–parasitoid synchrony and reducing parasitoid success when host availability becomes temporally mismatched (Ramos Aguila et al. 2023). Such precise timing likely enhances persistence in harsh desert-margin environments, where opportunities for host exploitation are fleeting.

For parasitoids, synchronizing emergence with the availability of susceptible host stages is a key mechanism for maintaining population stability, particularly where abiotic extremes impose narrow windows for successful development and oviposition. Parasitoids in other systems have demonstrated similar dependencies on phenological alignment to maximize reproductive output and persistence under climatic stressors (Ramos Aguila et al. 2023). Close ecological tracking of host populations indicates a significant potential for *B. apicicornis* to regulate *C. obtusata* densities on ruderal *Amaranthus* hosts. Parasitoid pressure has been shown to regulate herbivore populations in diverse systems, and where

temporal synchrony is maintained, trophic interactions can buffer against episodic herbivore outbreaks (Sabu et al. 2023). Comparative studies across congeneric and allied taxa could clarify whether such morphological features in *B. apicicornis* represent derived specializations within generalist lineages or convergent traits shaped by parallel ecological pressures in xeric habitats. Morphological diversity in parasitoid functional traits, including ovipositor form and associated musculature, has been linked to distinct host exploitation strategies across Hymenoptera (Fei et al. 2023).

Biogeography and Ecological Plasticity. The present from Rajasthan expands the documented ecological range of *B. apicicornis* within India, complementing previous host–parasitoid associations reported on Cassidinae beetles such as *Silana farinosa*. *B. apicicornis* has been recorded on *S. farinosa* in Kerala, representing one of the few confirmed natural host associations within Cassidinae for this species (Sabu et al. 2023). Such biogeographic extension reflects notable ecological plasticity, likely underpinned by broad host use and tolerance of varied abiotic regimes. Members of the genus *Brachymeria* are known to parasitize an array of holometabolous hosts, particularly in pupal stages across several insect orders, demonstrating adaptability in host exploitation that may facilitate persistence in heterogeneous environments (Narendran & van Achterberg 2016).

Arid landscapes, such as the Thar Desert, act as ecological filters that test the limits of parasitoid adaptability. In such environments, effective dispersal, thermal tolerance, and host-tracking capacities are critical determinants of parasitoid success. Host–parasitoid interactions in these contexts can illuminate how extreme abiotic stress shapes species' range limits and may forecast responses to ongoing climatic changes that increasingly expose biota to extreme thermal variation (Ramos Aguila et al. 2023).

AUTHOR'S CONTRIBUTION

The authors confirm their contribution to the paper as follows: V. Sushama: Conceived and designed the study, collected and assembled specimens; analysed and interpreted the data, identified species, reviewed and commented on the manuscript; C. Binoy: Conceived and designed the study, analysed and interpreted the data, drafted the manuscript; carried out species identification, reviewed and commented on the manuscript; S. Yadav: Collected and assembled specimens, carried out species identification; reviewed and commented on the manuscript; I. Sharma: Reviewed and commented on the manuscript. All the authors read and approved the final version of the manuscript.

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This research received no specific grant from any funding agencies.

AVAILABILITY OF DATA AND MATERIAL

The specimens listed in this study are deposited in the collections of the National Zoological Collections, Desert Regional Centre, Jodhpur, Rajasthan, and are available from the curator upon request.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study only included arthropod material, and all required ethical guidelines for the treatment and use of animals were strictly adhered to in accordance with international, national, and institutional regulations. No human participants were involved in any studies conducted by the authors for this article.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTERESTS

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

GENERATIVE AI STATEMENT

Artificial intelligence–based language models (OpenAI) were used in a limited manner to assist with language refinement, sentence restructuring, and improvement of clarity during manuscript preparation. The AI tool was not used for data generation, analysis, interpretation of results, taxonomic decisions, or drawing scientific conclusions. All scientific content, interpretations, references, and final editorial decisions were made entirely by the authors, who take full responsibility for the accuracy and integrity of the work.

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کشف و ارتباط میزبانی زنبور *Brachymeria apicicornis* Cameron (Hym.: Chalcididae) پارازیتویید *Cassida obtusata* Boheman (Col.: Chrysomelidae) روی تاج‌خروس (*Amaranthus palmeri*) در منطقهٔ بیابانی تار، هند

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ویراستار علمی
حسین لطفعلی‌زاده

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چکیـده: علی‌رغم شرایط و تعاملات اکولوژیک منحصر به فرد، صحرای تار در شمال غربی هند، به دلیل منظره خشک و بیابانی، به لحاظ روابط حشرات پارازیتویید و میزبان‌هایشان، به خوبی بررسی نشده است. در این تحقیق، اولین ارتباط تأیید شده میزبانی *Brachymeria apicicornis* (Cameron, 1911) (Chalcididae: Brachymeriinae) را به عنوان انگل شفیرهٔ *Cassida obtusata* Boheman, 1854 روی گیاه تاج‌خروس *Amaranthus palmeri* S. Wats (Amaranthaceae) در راجستان، هند ثبت شد. زنبورهای انگل پس از فعالیت ایدیوبیونت روی شفیره سوسک میزبان به طور مجزا از آن خارج شدند. هویت گونه از طریق یک توصیف افتراقی تأیید می‌شود. مطالعه حاضر چارچوب شواهد ساختاری شامل شرایط جداسازی پرورش، زمان‌بندی ظهور، ریخت‌شناسی و موقعیت منفذ خروج و فنوتیپ شفیرهٔ میزبان را ارایه می‌دهد. پیامدهای وابسته و موثر بر پویایی زیست‌بوم مناظر خشک نیز مورد بحث قرار گرفته است.

واژگـان کلیدی: Brachymeriinae، مهار زیستی، روابط میزبانی، انگل‌واره، تاج‌خروس