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Hymenopteran parasitoids of black-headed caterpillar *Opisina arenosella* Walker (Lepidoptera: Xyloryctidae) in South India

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Abstract

The coconut Black Headed Caterpillar (BHC), *Opisina arenosella* Walker (Lepidoptera: Xyloryctidae), poses a significant threat to coconut plantations in South India. The present study investigates the diversity and prevalence of hymenopteran parasitoids associated with *O. arenosella*. BHC larvae and pupae were collected from 15 locations spread across 9 districts of Tamil Nadu. Life stages of BHC were reared to observe the emergence of parasitoids. A total of six parasitoids viz., *Antrocephalus hakonensis* (Ashmead), *Brachymeria nephantidis* Gahan, *Kriechbaumerella* sp. (Family: Chalcididae), *Apanteles* sp. (Family: Braconidae), *Goniozus nephantidis* Muesebeck (Family: Bethylidae) and *Xanthopimpla punctata* Fabricius (Family: Ichneumonidae) were found to be associated with larvae and pupae of BHC. This study provides the first documented evidence of *Kriechbaumerella* sp. parasitizing BHC pupae. The level of natural parasitisation by various parasitoid species varied across different sampling locations. Highest natural parasitisation (31.64 %) of BHC was noticed in Tiruppur district. Field surveys and laboratory rearing of collected specimens highlight the potential of these parasitoids for biological control, contributing valuable data towards integrated pest management strategies. Further research into the life cycles, host specificity and ecological interactions of these parasitoids is recommended to enhance their utilization in sustainable agriculture practices.

Keywords

biological control; black headed caterpillar; coconut; natural parasitisation

Introduction

The coconut palm (*Cocos nucifera* L.) (Arecales: Arecaceae) is a versatile multipurpose palm referred to as "Kalpavriksha" or "Tree of Heaven" or "Tree of Life", since each part of the tree is useful to the mankind. Globally, India ranks third position in coconut production. In India, coconut is grown in more than 17 states and Kerala ranks first in coconut production followed by Karnataka and Tamil Nadu (1). In Tamil Nadu, coconut is being cultivated in 4.44 lakh hectares with the productivity of 11,526 nuts / ha (1). More than 100 species of insect pests are reported to be associated with coconut palm (2). However, only a few insect species cause economic damage. Coconut black headed caterpillar (BHC) *Opisina arenosella* Walker (Lepidoptera: Xyloryctidae) is one of the serious pests recorded in coconut plantations (3). Its infestation was officially documented during the mid-19th century in Sri Lanka (4). In India, this pest was first recorded in 1907, specifically on palmyrah palms in the Coimbatore district of Tamil Nadu (5). Since then, BHC has been reported in several Indian states, including Andhra Pradesh, Karnataka, Kerala, Gujarat, Orissa, West Bengal, Bihar and Maharashtra (6).

The black-headed caterpillar targets all stages of coconut palm (7, 8) and causes yield loss up to 45% (9). The larvae feed by scraping chlorophyll content from the leaflets, causing the entire fronds to have a scorched appearance. Severe infestation reduces spike formation and results in premature nuts dropping. When the infestation exceeds the threshold, caterpillars scrape chlorophyll even on the developing nuts (10). In cases of heavy infestation, the entire field shows signs of wilting (7, 8). BHC infestations are managed by cutting and burning of the infested fronds and by using light traps. During heavy infestation, applications of chemical pesticides are recommended. However, insecticide application in coconut ecosystem is difficult due to the tall nature of the palms. Further, indiscriminate insecticide application may affect the natural enemies (parasitoids and predator) population, pollinators (bees and wasps) population, development of resistance in pest population and residues in coconut products (11). Considering the health hazards and other issues associated with chemical use, releasing natural enemies, parasitoids in general, is an effective method for controlling the BHC population (6, 10, 12, 13). Over 50 species of parasitoids have been found to be associated with various life stages of *O. arenosella* (3, 7).

Among them, hymenopteran larval parasitoids like *Goniozus nephantidis* Muesebeck (Bethylidae), *Bracon hebetor* Say (Braconidae) and pupal parasitoid, *Brachymeria nosatoi* Gahan (Chalcididae) are mass reared and released to combat the initial stages of BHC infestation because of their higher host searching ability and parasitisation rates when compared to other parasitoids (14). Many predators have also been recorded against BHC. The dominant predators in the coconut ecosystem that regulate BHC populations are *Parena nigrolineata* (Chaudoir), *Calleida splendidula* (Fabricius) (Coleoptera: Carabidae) and *Cardiastethus exiguus* Poppius (Hemiptera: Anthocoridae) (7, 11).

Understanding the species richness of parasitoids associated with this pest is vital for implementing an effective integrated pest management programme (16). However, studies on the parasitoid fauna associated with BHC in Tamil Nadu are lacking. In view of the above, the present work aims to investigate the natural parasitoid repertoire associated with BHC in coconut ecosystem of Tamil Nadu.

Materials and Methods

Geographically, the survey covered the North-Eastern, North-Western and Western zones of Tamil Nadu, comprising nine districts showing considerable BHC infestation. Information about coconut gardens infested with black headed caterpillars was collected by contacting extension officials from the Department of Agriculture and Horticulture, Government of Tamil Nadu. A planned survey was conducted over the period from November 2023 to August 2024 in 15 locations, with intervals of two months between each survey (Table 1, Fig. 1.). In each location, 10 palms were selected randomly and from each palm, 10 leaflets were collected from lower or middle whorl of the crown. Live larvae and pupae were collected from the infested leaflets and stored in the small containers to monitor parasitoid emergence. Emerging parasitoids were collected and preserved in glass vials containing 70 % ethanol (Fig. 2.). The parasitoids were card mounted, morphological characters were observed

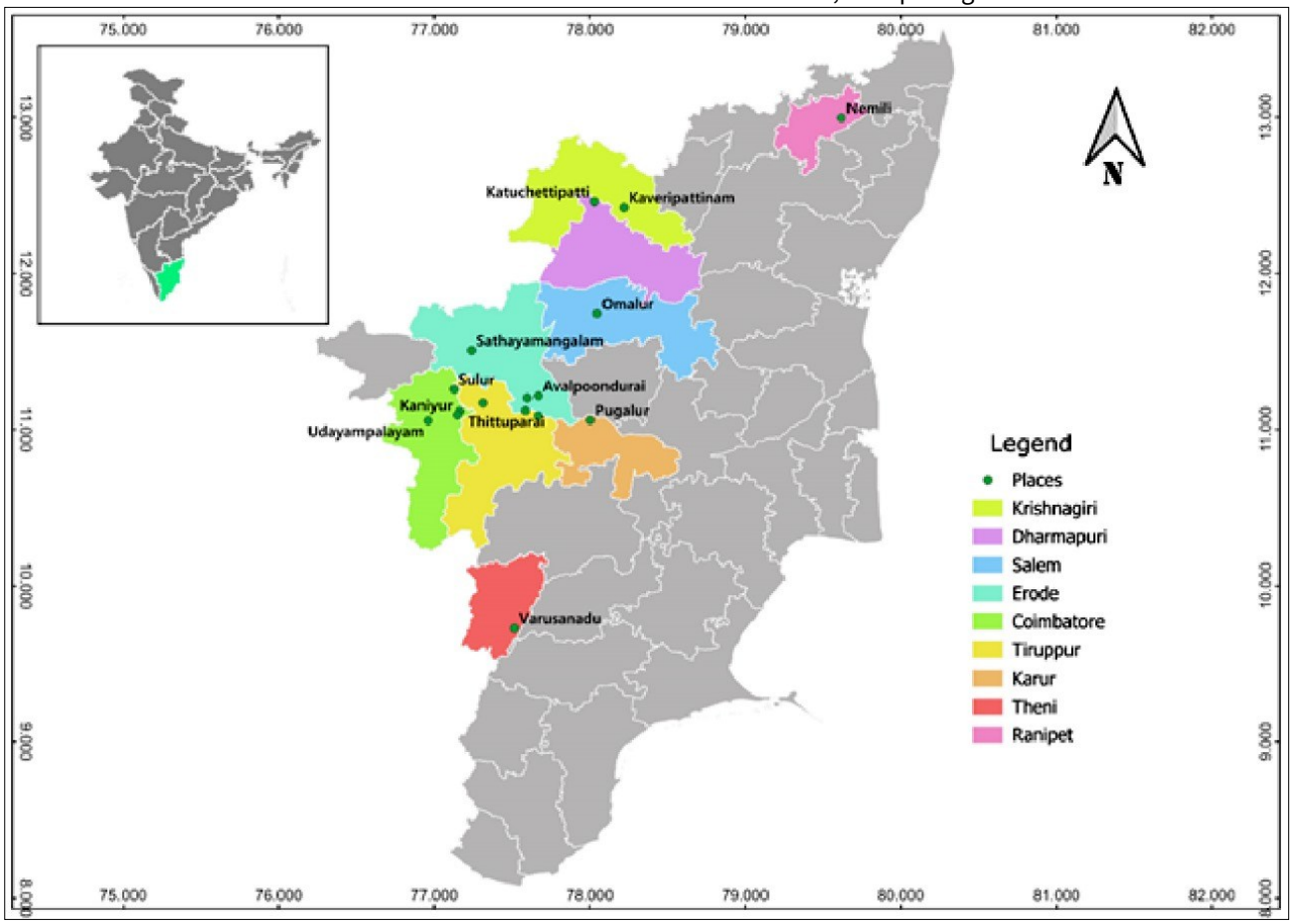

Fig. 1. Map showing the sampling locations of the black-headed caterpillar (*Opisina arenosella*) in Tamil Nadu.

Table 1. Sampling locations of the black-headed caterpillar (*Opisina arenosella*) in Tamil Nadu

Agro climatic zones	Districts	Sampling locations	Latitude (°N)	Longitude (°E)	Elevation (amsl) in m	Age of the pam (in years)	Variety
North - Eastern zone	Ranipet	Nemili	12.98°	79.61°	172	2 - 3	East Coast Tall (ECT)
		Vellode	11.23°	77.65°		45 - 50	ECT, Dwarf
	Erode	Kothampalayam	11.18°	77.45°	204	25 - 30	Tall
		Sathyamangalam	11.50°	77.24°		40 - 45	D x T Hybrid
		Kaniyur	11.09°	77.14°		13 -15	ECT
	Coimbatore	Udayampalayam	11.00°	77.00°	502	23 - 25	ECT
Western zone		Karumathampatti	11.10°	77.17°		4 - 5	Tall
	Karur	Pugalur	11.05°	77.99°	129	33 - 35	ECT
		Thirumurugan poondi	11.14°	77.30°		10 - 11	
	Tiruppur	Thittuparai	11.10°	77.58°	334	2 - 3	ECT
		Nathakadayur	11.08°	77.66°		9 - 10	
	Theni	Varsanadu	9.72°	77.51°	408	45	ECT, Dwarf
	Dharmapuri	Kaduchettipatti	12.44°	78.01°	503	30	ECT
North-Western zone	Salem	Omalur	11.74°	78.04°	400	30	ECT
	Krishnagiri	Kaveripattinam	12.35°	78.43°	533	20	ECT

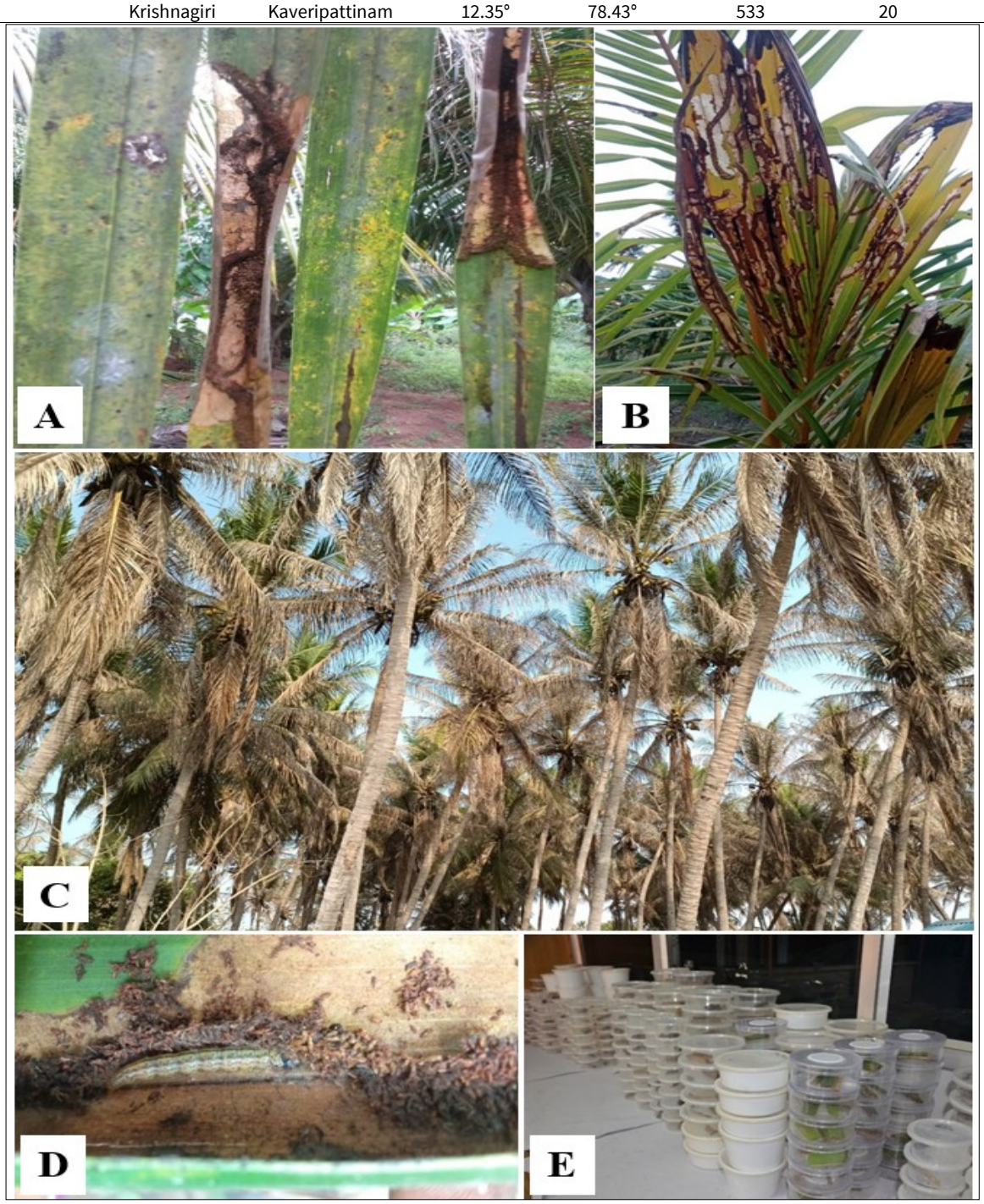

Fig. 2. (A-E) Damage symptoms caused by *Opisina arenosella* Walker: **(A)** Initial chlorophyll scraping, **(B)** Severe leaf scorching, **(C)** Reduced spike formation, **(D)** Grown up larva with larval frass on leaflet; **(E)** Larvae and pupae of *O. arenosella* stored in containers for parasitoid emergence monitoring.

using Leica S8APO and photographed with Leica M205A stereo microscopes. Parasitoid species identification was done by following the diagnostic keys (17). Parasitisation rates were determined by applying the following formula (10).

$$\text{Per cent parasitisation} = \frac{\text{Number of parasitoids emerged}}{\text{Total number of samples collected}} \times 100$$

Results

The study on parasitoids associated with BHC in the coconut ecosystem of Tamil Nadu revealed the presence of several species, including *Antrocephalus hakonensis* (Ashmead), *Brachymeria nephantidis* Gahan, *Kriechbaumerella* sp. (Family: Chalcididae), *Apanteles* sp. (Family: Braconidae), *Goniozus nephantidis* Muesebeck (Family: Bethylidae) and *Xanthopimpla punctata* Fabricius (Family: Ichneumonidae). Baring the genus *Kriechbaumerella*, all other parasitoid species recorded in this study are reported in the coconut growing tracts of India including Tamil Nadu (18, 19). This report forms the first record of the genus *Kriechbaumerella* Dalla Torre parasitizing the pupae of BHC. This represents the first documented report of this genus *Kriechbaumerella* sp (Fig. 3) both from India and globally. Among those parasitoid species recorded in this study, *G. nephantidis* and *Apanteles* sp. were found to attack the larvae of BHC, while *Kriechbaumerella* sp., *A. hakonensis*, *B. nephantidis* and *X. punctata* were found to parasitise pupae of BHC.

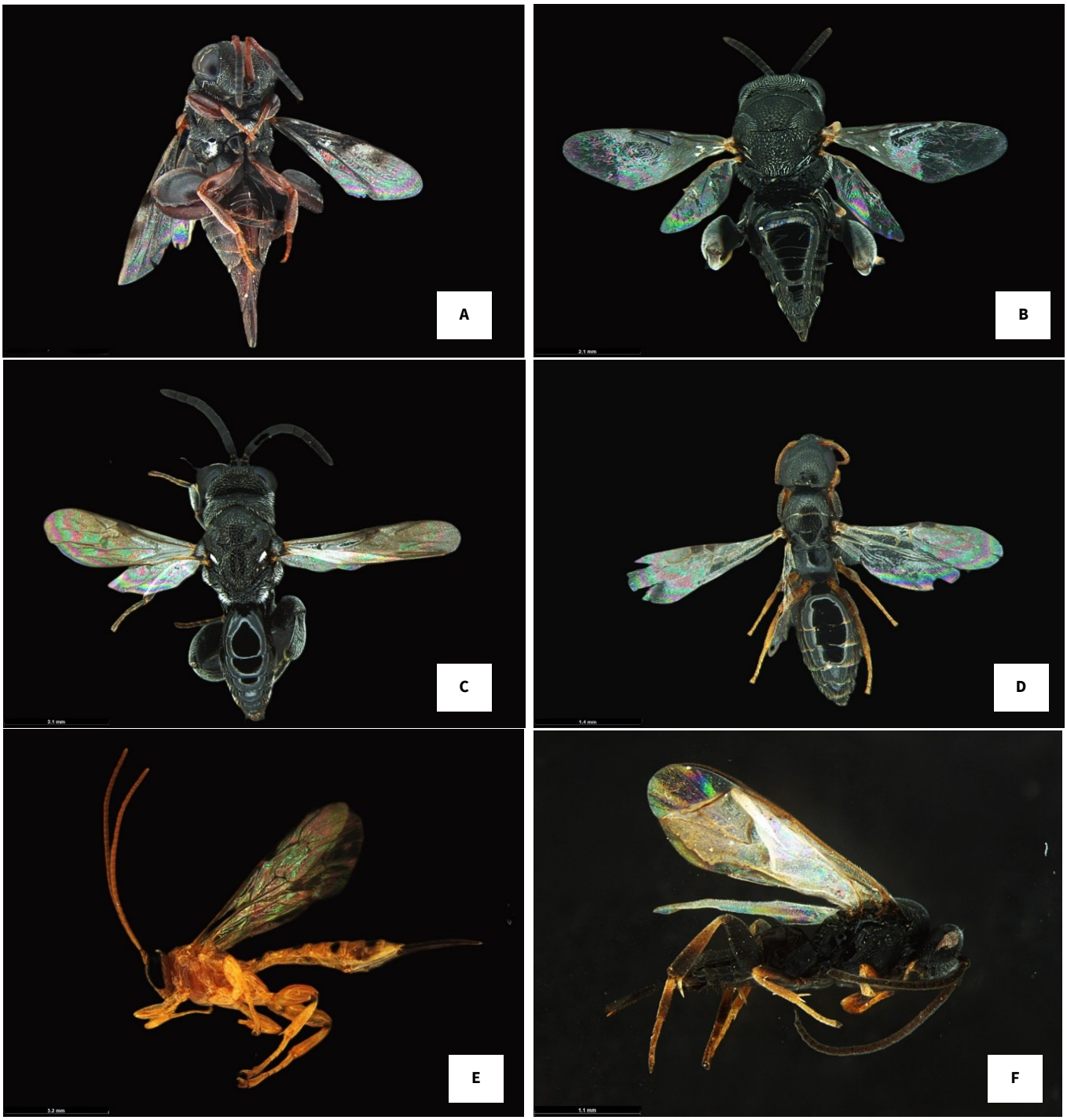

Fig. 3. (A-F) Images of parasitoids identified in this study: **(A)** *Kriechbaumerella* sp., **(B)** *Brachymeria nephantidis* Gahan, **(C)** *Antrocephalus hakonensis* Ashmead, **(D)** *Goniozous nephantidis* Muesebeck, **(E)** *Xanthopimpla punctata* Fabricius, **(F)** *Apanteles* sp.

The levels of natural parasitisation by various parasitoid species varied across different sampling locations (Fig. 4.). Notably, the percentage natural parasitisation was highest (31.64 %) in the Tiruppur district (Fig. 5.). In Erode district, natural parasitisation observed was 29.44 %. In both districts, pupal parasitoids (*B. nephantidis* and *A. hakonensis*) were abundant (Fig. 6). The Coimbatore region showed a parasitisation rate of 15.76 % with a significant presence of *B. nephantidis*, *G. nephantidis* and *Apanteles* sp. The natural parasitism percentages for Dharmapuri and Karur were 17 % and 21.91 %, respectively. Conversely, no parasitisation was observed in Krishnagiri, Ranipet, Salem and Theni regions.

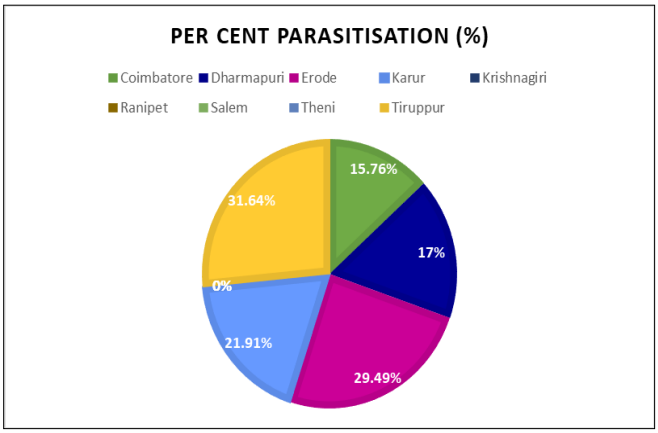

Fig. 5. Percentage of natural parasitisation on *Opisina arenosella* across different districts of Tamil Nadu.

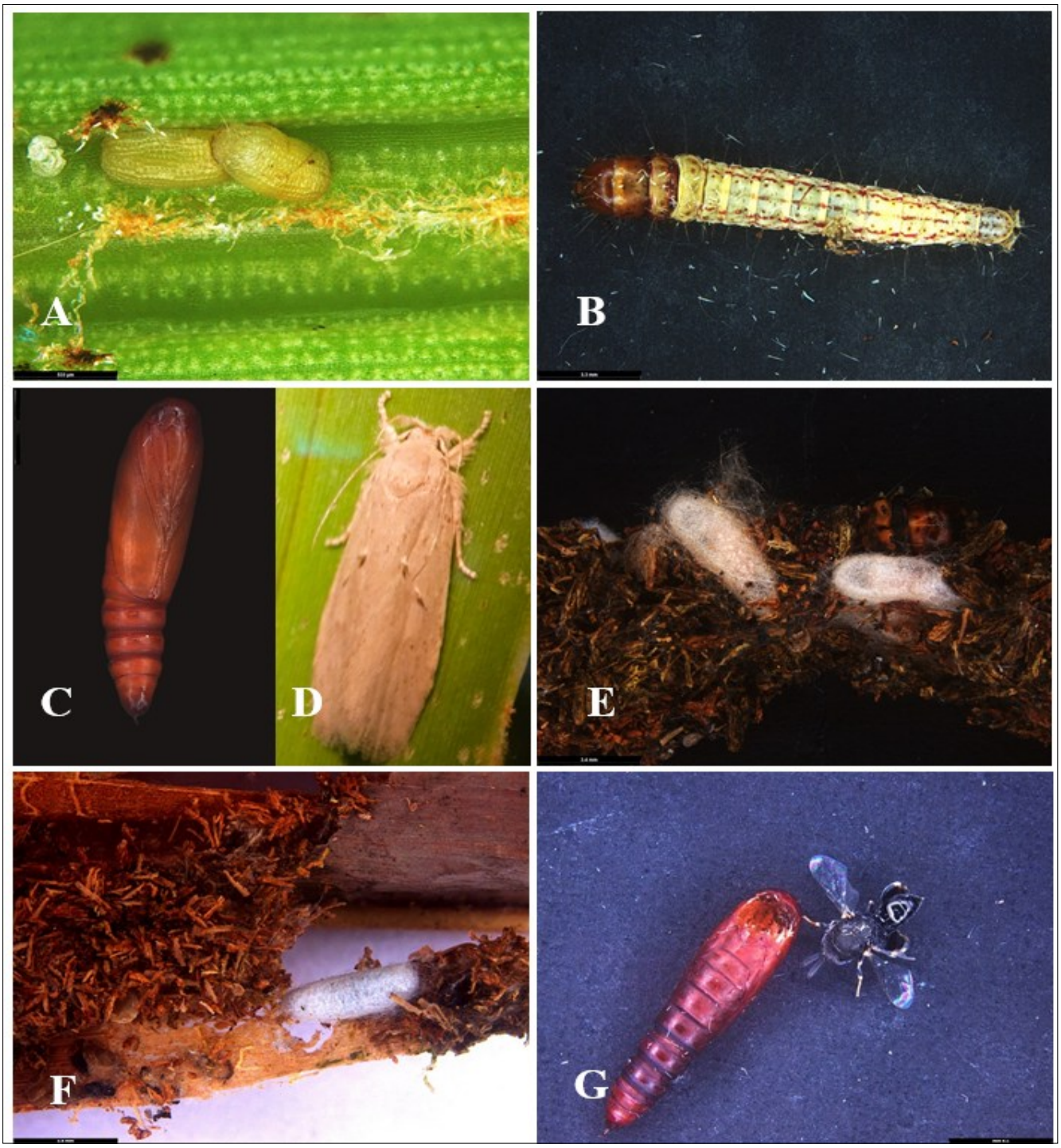

Fig. 4. (A-G) Life stages and parasitisation of *Opisina arenosella*: **(A)** Egg, **(B)** Larva, **(C)** Pupa, **(D)** Adult (♀), **(E)** Larva parasitised by *Goniozous nephantidis* Muesebeck, **(F)** Cocoon of *Apanteles* sp., **(G)** *Brachymeria nephantidis* Gahan (Pupal parasitoid).

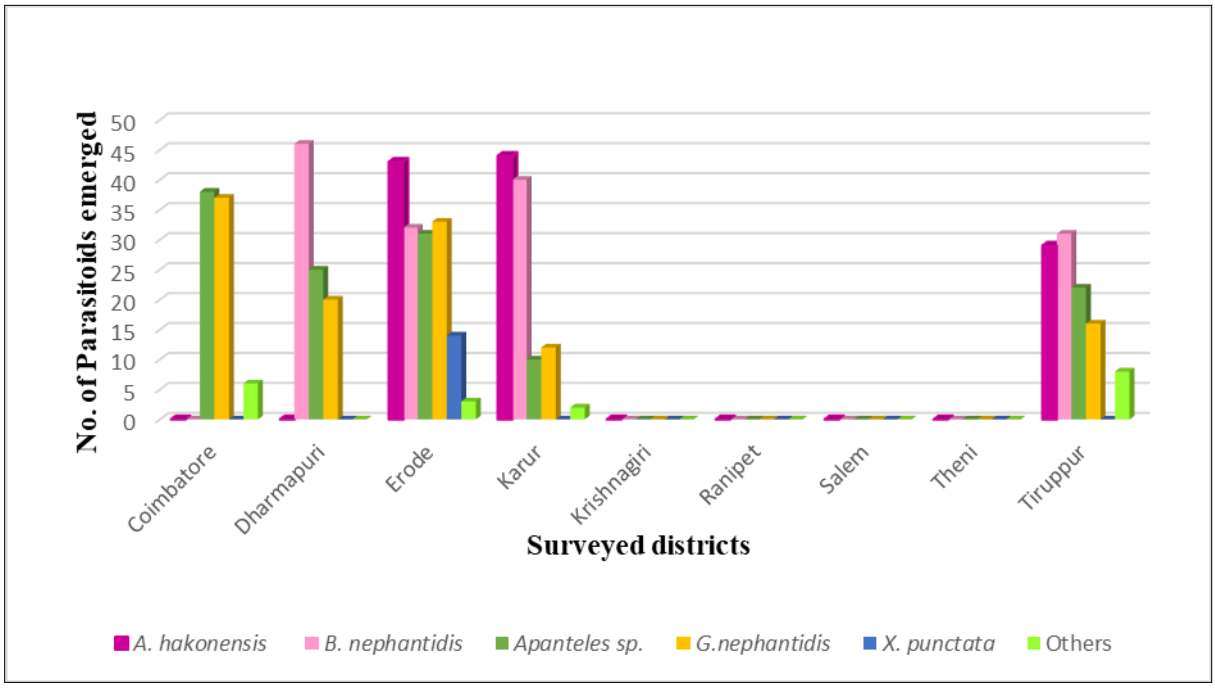

Fig. 6. Parasitoids diversity in different locations of Tamil Nadu.

Discussion

The present survey of hymenopteran parasitoids associated with the coconut BHC in Tamil Nadu revealed intriguing contrasts and similarities in comparison with previous studies conducted across different regions of India and Sri Lanka. One of the notable findings from our study was the predominant occurrence of *B. nephantidis* as the most effective parasitoid across surveyed localities in Tamil Nadu. This contrasts with findings that highlighted *G. nephantidis* as the prevalent parasitoid of BHC (10). Similarly, it was documented that *G. nephantidis* was highly effective in Andhra Pradesh, with a parasitisation rate of 28.0 % in BHC infested fields, along with the discovery of *Apanteles taragamae* Viereck (20). Other studies emphasized the longstanding presence of *B. nephantidis* as a significant natural enemy of *O. arenosella* from South India (18, 19). Dominance of *B. nephantidis* could be attributed to the elevated temperature observed across the sampling locations in Tamil Nadu between December 2023 to June 2024. Earlier reports have also indicated the dominance of *Brachymeria nephantidis* during summer months (18). These studies, alongside our findings, contribute to a comprehensive understanding of the complex of hymenopteran parasitoids associated with *O. arenosella* across different regions. The present study also revealed the presence of *B. nephantidis* in the interior districts of Tamil Nadu. For instance, in the Thrissur district of Kerala, *Brachymeria nosatoi* Habu emerged as the predominant parasitoid species (21, 22), whereas in South Karnataka, the higher prevalence of *B. nephantidis* in interior regions was recorded which is like the present study (23). The absence of natural parasitisation in regions like Krishnagiri, Ranipet, Salem and Theni may be attributed to the application of chemical pesticides particularly organophosphorus insecticide, monocrotophos to manage black headed caterpillar infestation by the farmers in coconut ecosystem.

The findings of the study suggest localized variations in parasitoid efficacy, influenced by environmental conditions and host availability which are crucial for understanding and implementing targeted pest management strategies in coconut ecosystems affected by BHC infestation. Out of 38 districts in Tamil Nadu, present study was conducted only in nine districts. Expanding the study in other coconut growing districts in future could reveal the occurrence of more numbers of parasitoid species associated with black headed caterpillar. Further, research on parasitoid-host and parasitoid-parasitoid interactions in coconut ecosystem can be planned. This could aid in identifying effective parasitoid species for managing black headed caterpillar and developing / refining Integrated Pest Management programmes for black headed caterpillar. The study also showed non-recovery of *Bracon brevicornis* Wesmael and *B. hebetor* Say from fields in which they were released for the management of BHC, necessitating serious monitoring and parasitoid recovery studies.

Conclusion

In conclusion, this study provides the first documented evidence of the pupal parasitoid, *Kriechbaumerella* sp. on *O. arenosella* in Tamil Nadu, India. The findings contribute to the understanding of parasitoid complex in coconut ecosystem and emphasize the potential chalcidid parasitoids such as *B. nephantidis*, *A. hakonensis* and *Kriechbaumerella* sp., for the biological control of *O. arenosella*. Future research should explore the parasitoid species complex associated with the black-headed caterpillar across all coconut-growing districts of Tamil Nadu, with a focus on parasitoid-host and parasitoid-parasitoid interactions. Additionally, assessing environmental factors that enhance parasitoid efficiency will be crucial for optimizing biological control strategies.

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Authors' contributions

RA and NC conceived the study and performed design, analysis and interpretation of results. SN collected the specimens and assembled them for the study. SN and CB performed species identification. SN, RA, CB and NC drafted the manuscript.

Compliance with ethical standards

Conflict of interest: No potential conflict of interest was reported by the authors

Ethical issues: None

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