Short Scientific Report

doi: 10.25081/jpc.2019.v47.i2.5784
Journal of Plantation Crops, 2019, 47(2): 124-127

First report of two chalcidoids parasitizing arecanut inflorescence caterpillar, *Tirathaba mundella* Walker (Lepidoptera: Pyralidae) from Karnataka, India

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(Manuscript Received: 11-02-2019, Revised: 29-04-2019 Accepted: 31-05-2019)

Keywords: Arecanut, *Brachymeria nephantidis, Elasmus punctulatus,* parasitoids, *Tirathaba mundella*

Arecanut, *Areca catechu* Linn. (Family: Arecaceae) is an important commercial crop which contributes to the economy of 16 million peasants in India; for a majority among them, the income from arecanut based industries is the sole means of livelihood. Considering the global scenario, India ranks first in the area (473.33 thousand hectares) and production (705.60 thousand tonnes) of arecanut (Chowdappa and Cherian, 2016). In India, the cultivation of arecanut is primarily restricted to the foot hills of Western Ghats (Karnataka and Kerala) and North East states like Assam, West Bengal Meghalaya and Mizoram.

The arecanut palm is prone to infestations by an array of insects and non-insect pests, which attack almost all plant parts *viz.*, root, stem, leaf, inflorescence and nut. Around 102 species of pests are reported to be injurious to arecanut (Nair and Daniel, 1982). Inflorescence caterpillar, *Tirathaba mundella* Walker (Lepidoptera: Pyralidae) causes considerable economic loss to the crop by directly damaging economic parts of the palms *i.e.,* inflorescence and developing buttons. *T. mudella* is widely distributed in India and South East Asian countries like Thailand, Indonesia and Solomon Island (Lever, 1969). The attack is severe in certain pockets of Karnataka and Kerala (Nair and Rawther, 1969). The infestation is manifested as bore holes on the inflorescence with webbed or damaged rachillae and female flowers (Fig. 1 A & B). Infestation by slug, *Mariaella dussumieri* Gray (Gastropoda: Ariophantidae) predisposes the palm to the attack of inflorescence caterpillar, as the adult moths oviposit through bore holes on the spathe made by slugs. The emerging larvae gregariously feed on the male flowers and rachillae. Moreover, larvae bore into the buttons or developing nuts during severe infestation and thereby delay the opening of the infested inflorescence.

Natural enemies are potential biological control agents, which suppress the pest population in the ecosystem and aid in balancing pest - parasitoid population equilibrium. Chalcididae and Eulophidae are agriculturally significant parasitoid families of Hymenopteran superfamily Chalcidoidea. Usually, chalcidids are endoparasitic on Lepidoptera and Diptera with around 1530 species of chalcidids in 90 genera reported so far from around the world (Noyes, 2015). Eulophidae are small parasitoid wasps of which 5000 species under 443 genera are identified and described worldwide (Noyes, 2015).

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The knowledge on the parasitic associations with *T. mundella* in arecanut ecosystem is meagre. Hence, the present study was aimed to document and characterize the indigenous parasitoid complex associated with *T. mundella* in Dakshina Kannada region of Karnataka state.

Arecanut inflorescences infested with *T. mundella* were collected from a 15 years old garden (N 12^0 46.436'; E $075^0$06.586') comprising of Konkan collections located in the Research Farm, ICAR-CPCRI Regional Station, Vittal, Karnataka, India. Sampling was done from December, 2016 to April, 2017 at fortnightly intervals. The larvae and pupae from the inflorescence were manually separated. Larvae were reared in plastic containers (15 cm x 8 cm) covered with muslin cloth and provided with fresh inflorescence pieces for feeding. The pupae, on the other hand, were placed individually in glass tubes (15 cm x 1.5 cm) covered with a cotton plug till the emergence of either adult moth or parasitoid. Both cultures were maintained at 30±5 ^{0}C and 75±5 per cent relative humidity. Parasitoids emerging from the pupae were collected with a mouth aspirator into small vials and identified to species level by the third author. The voucher specimens were deposited at ICAR-Central Plantation Crops Research Institute, Regional Station, Vittal and also at Systematic Entomology Laboratory, Malabar Christian College, Calicut. The per cent parasitism was calculated with the following ratio:

Parasitization of pupae (%) = Pp/Tp x100

where; Pp is the number of parasitized pupae and Tp is the total number of collected pupae.

Out of the 140 pupae collected, 20 pupae were parasitized. Two species of parasitic wasps, which emerged from the pupae of *T. mundella*, were identified as *Brachymeria nephantidis* Gahan (Hymenoptera: Chalcididae) and *Elasmus puctulatus* Verma and Hayat (Hymenoptera: Eulophidae) (Fig.1 C, D, E & F). The above species are reported for the first time as parasitoids of *T. mundella*. Varying degree of parasitisation was recorded during this study. Parasitization attained its peak during second week of February to the fourth week of March. The percentage of parasitism by *B. nephantidis* was slightly higher (8.5%) than that of *E. punctulatus* (5.7%). A total 12 adults of *B. nephantidis* emerged out of 140 collected pupae whereas, 41 adults of *E. punctulatus* emerged from eight parasitized pupae. While *B. nephantidis* is solitary, *E. punctulatus* is a gregarious parasitoid. From a single pupa, 4 to 7 numbers of *E. punctulatus* emerged in the laboratory from field collected pupae. In Kerala, Joy and Joseph (1973) reported 6.5 per cent field parasitism by *B. nephantidis* from *Opisina arenosella* Walker. Gan *et al.* (2011) reported 20-30 per cent field level parasitism by *E. puctulatus* on *Tirathaba rufivena* Walker in China.

The Genus *Brachymeria* Westwood is predominant with 200 species worldwide, which includes 42 species from Neotropics and 71 species from the Oriental region (Joseph *et al*., 1973). The genus *Elasmus* Westwood is cosmopolitan in distribution with dominance in all the zoogeographical regions. Globally, this genus comprises 258 species, of which 35 species are reported from India (Verma *et al.,* 2002). A brief note on the taxonomic characteristics of both species is given below.

Brachymeria nephantidis (Gahan, 1930): 77(8) (2831): 5. Type: F. India: Tamil Nadu

Diagnosis: "Length 5 mm. Antennal flagellum cylindrical, slightly narrower at base; antennal depression smooth; preorbital carina distict and well developed, face with small median area between clypeus and antennal depression smooth; other parts of head coarsely punctate, punctations of vertex coarser than between antennal depression and inner eye margins; carina separating face and cheek with a well-developed postorbital branch that extends to occipital margin. Pronotum, mesoscutum and scutellum with coarse umbilicate punctures; scutellum rounded at the apex, not emarginate; propodeum coarsely rugoso-reticulate without projections. Forewing behind submarginal vein devoid of cilia; post marginal vein twice as long as the stigmal vein. Hind coxa polished above and punctuate beneath without tubercle on inner side; hind femur punctate on outer side and with 10 teeth on lower margin. Abdomen as long as head and thorax, pointed and ovate. Tegula, anterior and middle femora at extreme apices, their tibia at base and apices, and all tarsi yellow, hind femur with a small yellow spot at extreme apex; hind tibia with a yellow spot; wings hyaline, rest of the insect black".

Some biological attributes like long life span, adaptability to hot climate and a short development duration makes *Brachymeria* spp, an ideal biocontrol agents (Joy, 1975). *B. nephantidis* was first described from the host, coconut black headed caterpillar, *O. arenosella* from India and is widely distributed in peninsular India. This species also occurs in Sri Lanka and Philippines. *B. nephantidis* is predominantly associated with coconut black headed caterpillar in Kerala, but it can parasitize a few other lepidopterans including *Corcyra cephalonica* (Stainton), *Sylepta derogata* Fabricius, *Pyrausta machaeralis* Walker, *Deudorix isocrates* (Fabricius) and *Anadevidia peponis* (Fabricius). It is hyperparasitic on *Apanteles taragame* Viereck, *Stomatomyia bezziana* Baranoff and *Eriborus trochanteratus* (Morley) (Ghosh and Abdurahiman, 1985; Dharmaraju, 1962; Cock and Perera, 1987; Joy *et al.,* 1978). Total developmental duration varies from 10 to17 days when the host is *O. arenosella*. (Joy *et al.,* 1978).

Elasmus punctulatus (Verma and Hayat, 2002): 267-268, F. Type F: India: Tamil Nadu.

Diagnosis: "Length 1.75 - 2 mm. Body black with bluish shine on frontovertex, thoracic dorsum, more intense on propodeum; brownish tegulae with yellowish base; Mesosomal dorsum dark brown to black, mesoscutum with yellow spot on each side near tegulae; metanotum dark brownish at base with hyaline posterior extension; gaster dark brown or black dorsally, with bluish shine on sides of T1 (first gastral tergum), yellowish brown laterally and ventrally, brownish stripes at apex of T1, T3, T4 and T5, faintly on T2; basal half of fore coxa and mid coxa brown.; hind coxa yellow at least in apical third. Antennal clava as long as combined length of F1 and F2; pedicel shorter than F1".

Elasmus spp. are generally ectoparasitic on larval or pupal stages of Lepidoptera and some are hyperparasitic on Hymenoptera particularly, braconids and ichneumonids (Narendran, 2011). The occurrence of *E. punctulatus* has been reported from southern India and China (Verma *et al*. 2002; Gan *et al*., 2011).

The management of *T. mundella* by insecticide spray is often cumbersome because larvae, the damage causing stage, occur in the concealed and inaccessible parts of the plant, within unopened inflorescence protected by spathe. Hence, it is imperative to look for alternative pest management strategies. These natural enemies are potential candidates to successfully check the pest population. In future, these two potential biocontrol agents *viz., B. nephantidis* and *E. punctulatus* could efficiently be utilized for suppressing *T. mundella* and shall further strengthen the biocontrol research in arecanut pest management.

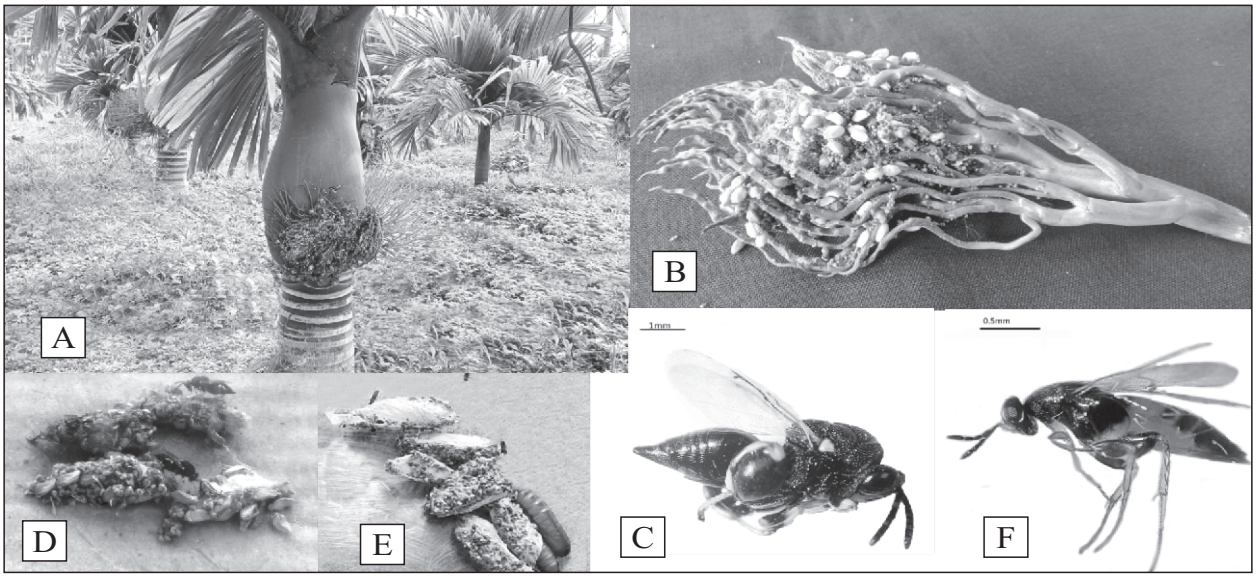

Fig. 1. Symptoms damage by *Tirathaba mundella* in arecanut and its parasitoids

A & B: Symptoms of damage by *T. mundella;* C: Adult of *B. nephantidis*; D: *B. nephantidis* parasitizing *T. mundella* cocoon; E: Emergence of *E. punctulatus* from *T. mundella* cocoon and F: Adult of *E. punctulatus*

Acknowledgments

The authors are thankful to Director, ICAR-Central Plantation Crops Research Institute (ICAR-CPCRI), Kasaragod; Head of ICAR-CPCRI, Regional Station, Vittal and authorities of Malabar Christian College, Calicut for the laboratory facilities extended to conduct this work.

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