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Morphological description and predatory potential of two *Chelisoches* species of earwigs on arecanut inflorescence caterpillar, *Thirathaba* sp. from South India

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ABSTRACT: Earwigs (Dermaptera) are omnivorous insects distributed worldwide. Their ecological role in agricultural cropping ecosystem is not fully understood. The present study explores the ecological role of two black earwig species in arecanut ecosystem. In the present study, two species of earwigs were collected and found predating on arecanut inflorescence caterpillar, *Thirathaba* sp. (Lepidoptera: Pyralidae) for the first time from India. Further, survey was conducted in the major arecanut growing regions of Karnataka from 2021-23 to explore the diversity of earwigs. Results revealed the occurrence of two black earwig species *viz*., *Chelisoches brevipennis* and *C. morio* (Chelisochidae). Among them *C. brevipennis* is a new record from south India. The species were morphologically identified and an illustrated identification key to both the species was provided. Further study confirmed the predatory role of earwigs on arecanut inflorescence caterpillar implying a significant potential for use in biocontrol. The current study reported two species of earwigs *C. brevipennis* and *C. morio* from arecanut ecosystems which were observed as efficient predators on arecanut inflorescence caterpillar.

Keywords: Biocontrol, dermaptera, diversity, India, palms

INTRODUCTION

Earwigs are a moderately diversified group of insects which comprise approximately 1,900 species distributed mainly in tropical and subtropical parts of the world (Hopkins *et al*., 2018). The previous taxonomic study by Srivastava (2013) reported 284 species from India. Earwigs are omnivorous insects that may be considered as helpful organisms within agro ecosystems (Van Huis, 1981; Jones *et al.,* 1988; Gravena and Da Cunha, 1991; Mariani *et al*., 1996). The beneficial actions of earwigs in many crops of economical relevance have been described previously by Buxton (1974) and Canellas *et al*. (2005). *Chelisoches* is an important genus of the family Chelisochidae belongs to the order Dermaptera. *Chelisoches* includes only two species in India *viz*., *C. brevipennis* and *C. morio*. Owing to their ecological and behavioural observations in agricultural ecosystem they are considered as the important predators of insect pests (Zhong *et al*., 2016; Li *et al*., 2011). The adults of these two species have been reported to predate on different stages of coconut leaf beetle, *Brontispa longissima* in Thailand and Philippines (Chomphukhieo *et al*., 2008). The extensive work of Srivastava (2013) mainly concentrated on taxonomy of Dermaptera and there was no publishised information about the ecological role of earwigs in different crops. Karthik *et al*. (2022) recently reported one new species from sugarcane crop which shows the importance of taxonomy of Dermaptera in India. There is a need to study earwig species distribution, status, and role in agricultural and horticultural cropping systems (Karthik and Kalleshwaraswamy, 2023; Kamimura *et al.,* 2022). The present study emphasizes the species composition and ecological role of earwigs as predators in arecanut cropping ecosystem.

MATERIALS AND METHODS

Survey was done in the major arecanut growing regions of Karnataka covering Chitradurga, Shivamogga, Mysore, Chikkamangalore and Davanagere from 2021 to 2023. From all the surveyed regions, the earwig samples were collected in 70% ethanol and brought to laboratory. For the morphological identification, the specimen was examined under a Stemi 508 stereozoom microscope (Carl Zeiss Microscopy GmbH, Jena, Germany). Photographs of the habitus and external body parts were taken under an M205C stereozoom microscope attached with a DFC450 camera (Leica, Wetzlar, Germany). The male genitalia were removed by gently lifting the penultimate abdominal sternite, pulling out from the genital chamber with forceps, and cutting at the site of attachment to the ejaculatory ducts. The genitalia were processed by submersion in 5% KOH for two days for clearing tissues and mounted on a glass slide with glycerol. Photographs of dissected genitalia were taken an M205C stereozoom microscope attached with a DFC450 camera. The terminology of Kamimura (2014) was adopted to describe male genital structures

of the species collected. The species were identified by using keys developed by Srivastava (2013) and a revised key with illustrations and additional morphometric measurements were provided for easy identification. The additional taxonomic characters with digital images were provided for quick and reliable identification of earwigs.

Arecanut inflorescence infested with inflorescence caterpillar stages such as larvae, pupae including earwigs were brought to laboratory and separated manually. 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 were placed individually in glass tubes (15 cm x 1.5 cm) covered with a cotton plug till the emergence of adult moth. Once the moths are emerged, they are morphologically identified up to the genus level. The voucher specimens were deposited at Insect Systematics Laboratory, Department of Entomology, College of Agriculture, Shivamogga.

In order to assess the predatory potential, early instar larvae of *Thirthaba* sp. were kept in insect breeding dish (Himedia, TCP030- 90 × 40 mm dia) and the active adults of *Chelisoches* species were released into insect breeding dish to test their predatory efficiency of earwigs. Initially the earwigs were collected from the field were pre-starved for 3 to 4 days. After four days, one adult earwig (n=10) was released into insect breeding dish (Himedia, TCP030- 90 × 40 mm dia) containing five early instar larvae of inflorescence caterpillar. Then, after 48 hours of release predation of earwigs on *Thirthaba* sp. was confirmed by counting the number of larvae remained in insect breeding dish (Himedia, TCP030- 90 × 40 mm dia).

RESULTS AND DISCUSSION

From arecanut inflorescence infested with caterpillar, a total of 42 earwigs were collected. Out of them, 12 were males and 21 were females and nine were nymphs. Based on the keys of Srivastava (2013), they were identified as two species of *Chelisoches viz*., *C. brevipennis* and *C. morio*. It appears that they co-existed as both the species were found in a single infested inflorescence (Fig 1e). During the survey (2021-2022) to different arecanut growing regions of Karnataka two species of black earwigs were collected and identified as *C. morio* and *C. brevipennis*. In India little published information available on the ecological role of earwigs

Fig.1. Habitus of earwigs in arecanut ecosystems; a) Earwigs within unopened infloresence; b) Earwigs with in spadix; c) Half decayed infloresencce; d) and e) Ants and earwigs on infloresence; f) Earwig feeding on *Thirathaba* larvae

in different cropping ecosystem. The present study highlights the predatory role of black earwigs on arecanut inflorescence caterpillar. Different species of earwigs are the efficient predators of many lepidopteran insects (Schlinger *et al*., 1959). Chomphukhieo *et al*. (2008) observed the predation of *C. morio* on coconut leaf beetle, *B. longissima*

Taxonomy

Order Dermaptera de Geer, 1773
Infraorder Epidermaptera Engel, 2003
Parvorder Eteodermaptera Engel, 2003
Nanorder EudermapteraVerhoeff, 1902
Family Chelisochidae Verhoeff, 1902

1. *Chelisoches brevipennis* Borelli, 1923

Diagnosis

Body dark black in colour (Fig 2a), measures 14.16 mm length without forceps. Head triangular, frons moderately and occiput distinctly raised, median suture deep, dividing occiput into two halves, measures 1.84 mm length and 2.00 mm width (Table 1). Eyes distinct, shorter than the post-ocular length. Antennae 19-segmentd or more first segment stout, slightly expanded apically, shorter than the distance between antennal bases; second short, about as long as broad; third about twice as long as broad; fourth subclavate, slightly shorter than third; fifth and sixth segments subclavate, remaining gradually increasing in length (Fig 2b). Pronotum slightly broad, measures 1.69 mm length and 1.84 mm width (Table 1) anterior margin convex, lateral margin straight and posteriorly widened, hind margin and angles rounded; differentiated prozona and metazona. Sternal region of body depressed (Fig 2d); well developed elytra, sparsely punctate. Wings little projecting beyond elytra (Fig 2c), tegmen measures 4.31 mm length and 3.08 mm width (Table 1). Legs typical, hind tarsi with first segment about as long as third segment, on underside covered with thick pubescence (Fig 2e). Abdomen apically widened, punctate, convex tergites, lateral folds on third weakly and on fourth distinctly marked. Penultimate sternite rounded with little emargination in middle (Fig 1f). Ultimate tergite transverse and measures about 2.77 mm width (Table 1), disc faintly punctate, convex, tumid above the bases of forceps, in between little depressed with two pairs of compressed tubercles, their inner pair larger and contiguous, laterally above the bases of

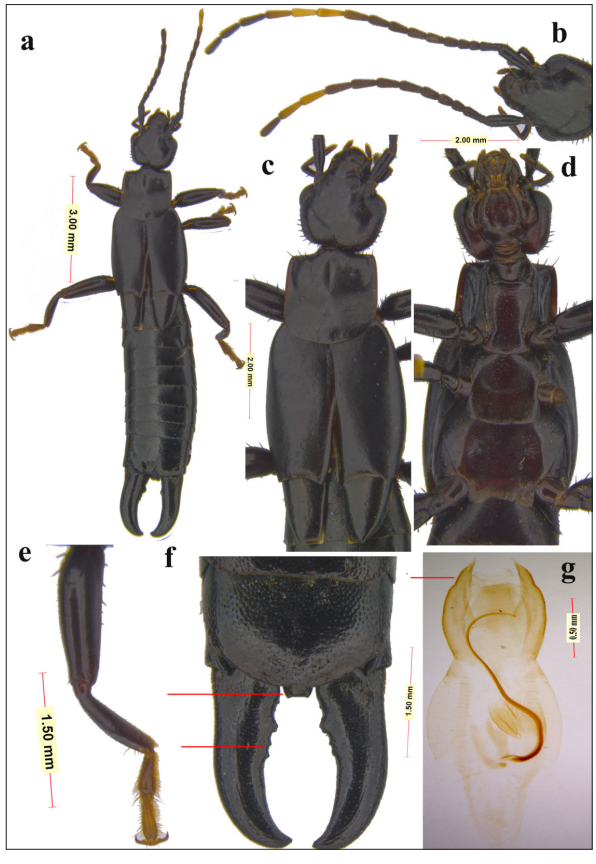

Fig.2. *Chelisoches brevipennis* Borelli, 1923; a) Habitus; b) Antenna; c) Pronotum, tegmina and wings; d) Thoracic sterna e) Right foreleg; f) Penultimate sternite and forceps; g) Genitalia

Table 1. Morphometric measurements of *C. brevipennis* and *C. morio*

***C. brevipennis* (Male)**		***C. morio* (Male)**	
Length	**Measurement in mm**	**Length**	**Measurement in mm**
Body without forceps	14.16	Body without forceps	15.09
Head	1.84	Head	1.69
Pronotum	1.69	Pronotum	2.00
Tegmen	4.31	Tegmen	4.92
Forceps	2.46	Forceps	4.15
Width		**Width**	
Head	2.00	Head	2.00
Pronotum	1.84	Pronotum	2.15
Tegmen	3.08	Tegmen	3.23
Ultimate tergite	2.77	Ultimate tergite	2.80

forceps oblique and hind margin trisinuate. Slanting pygidium, with bilobes and narrowed apically. Forceps branches (Fig 2f) depressed, stout, straight, apices gently incurved, inner margin of forceps armed with blunt tooth, but posterior one smaller, branches comparatively longer, less stout, variable internal armature with minute teeth in two thirds of base followed by another larger one in apical one third. Forceps measures about 2.46 mm length (Table 1). Genitalia with parameres slightly enlarged externally in middle and with a slight emargination before spex (Fig 2g); virga tubular, short, without accessory plates at base.

Material examined: 1. INDIA, Karnataka, Davanagere, Channagiri, 14°1'36"N, 75°54'52"E, 636m, 29.vi.2022, Coll. Karthik, C. M., ex. Arecanut. 2. INDIA, Karnataka, Shivamogga, 13°35'22"N, 75°17'58"E, 680m, 22.vii.2022, coll. Karthik, C. M., ex. Arecanut). 3. INDIA, Karnataka, Chikkamangalore, Koppa, 13°32'48"N, 75°24'7"E, 724m, 1.x.2021, Coll. Karthik, C. M., ex. Arecanut.

2. *Chelisoches morio* (Fabricius, 1775)

Diagnosis

Stout body measures 6.46 mm length without forceps (Table 1). Black colour with intermediate shades (Fig 3a); two pre apical antennal segments yellow and tarsi brownish. Head slightly convex, triangular with obsolete sutures, hind margin emarginated, measures 0.07 mm length and 0.09 mm width (Table 2). Eyes slightly shorter than post-ocular length. Antennae 21-segmented, first stout, about as long as the distance between antennal bases, little expanded apically; second segment short, about as long as broad; third segment long and gently expanded apically; fourth segment shorter than preceding one, subclavate; fifth slightly longer than the fifth, subclavate, remaining segments length gradually increasing, each segment gently expanded apically (Fig 3b). Pronotum about as long as broad, somewhat widened posteriorly, rounded hind margin, median sulcus distinct (Fig 3c), measures 2.00 mm length and 2.15 mm width (Table 1); convex prozona and depressed metazona. Depressed ventral side of the body (Fig 3d). Well developed elytra and wings, tegmen measures 4.92 mm length and 3.23 mm width (Table 1). Underside of tarsi covered with golden pubescence (Fig 3e). Elongated abdomen, lateral margin gently widened in middle, tergites slightly convex, finely punctate, hind margin of tergites with a row of compressed tubercles, lateral folds on third tergite weakly and on fourth marked distinctly. Penultimate sternite with rounded posterior margin and slight emargination in middle (Fig 3f). Ultimate tergite transverse, disc slightly convex, sloping backwards, low folds above the forceps base and between a pair of compressed tubercles, contiguous, inner pair smaller, outer pair larger on inner margin of folds above the bases of forceps, trisinuate hind margin, hind margin on lateral side oblique, ultimate tergite measures about 2.77 mm width (Table 1). Pygidium declivitous, hind margin truncate or emarginated slightly. Forceps with branches stout measures 4.15 mm length (Table 1), elongated, depressed, gradually tapering and incurving at tip, deplanate internally in basal half, followed by one

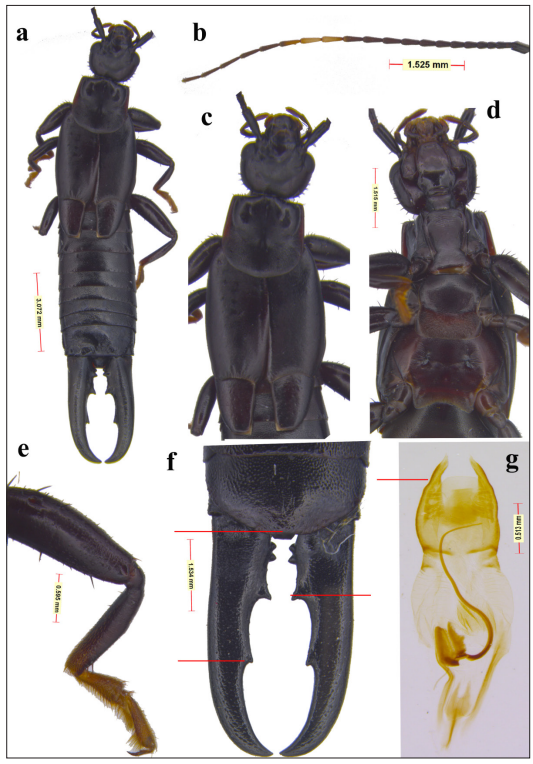

Fig.3. *Chelisoches morio* (Fabricius, 1775); a) Habitus; b) Left antenna; c) Pronotum, tegmina and wings; d) Thoracic sterna e) Right foreleg; f) Penultimate sternite and forceps; g) Genitalia

Table 2. Predatory efficiency of earwig, *C. brevipennis* and *C. morio* on larvae of *Thirathaba* sp.

Predatory potential of *C. brevipennis*						
Particulars	**Mean no. of larvae**	**Standard deviation**	**variance**	**t value**	**df**	**P- value**
Pre count	5.00	0.00	0.00	3.25	9	< 0.01
Post count	1.60	0.69	0.48			
Predatory potential of *C. morio*						
Pre count	5.00	0.00	0.00	3.25	9	< 0.01
Post count	2.10	0.73	0.54			

(SD- Standard deviation, df – Degrees of freedom,*Mean of ten observations)

or two teeth; short, internal margin with one or two teeth at base and minute teeth in middle, internal position of teeth variable. Genitalia with parameres narrow (Fig3g), external dilation in middle slight; thick, short tubular virga.

Material examined: 1. INDIA, Karnataka, Mysore, Hunsur, 12° 18' 3.39" N 76° 17' 18.45" E, 792m, 29.vi.2022, Coll. Karthik, C. M., ex. Arecanut.

Bio ecology

The earwig specimens were collected from *Tirathaba* sp. infested inflorescence of arecanut. They were known to breed inside the arecanut inflorescence due to their concealed habitat and availability of enough moisture within the unopened spadix, possibly taking advantage of protective and cool environmental condition.

Key to *Chelisoches* species known from India (Modified from Srivastava, 2013)

1(2). Genitalia with parameres slightly emarginated near apex (Fig 2g), forceps having blunt teeth at middle; posterior part of pygidium with distinct notch (Fig 2f) ..... *C. brevipennis*

2(1). Parameres not emarginated near apex (Fig 3g), forceps having internal armatures in basal half with internal margin crenulate; posterior part of pygidium truncated (Fig3f) ..... *C. morio*

Predatory potential of black earwig *C. brevipennis* on inflorescence caterpillar

Earwigs were collected from the inflorescence which is at maturity stage (Fig 1a and 1b). Due to attack by the *Tirathaba* sp. inflorescence was in half decayed condition (Fig 1c) with actively moving earwigs inside and holding *Tirathaba* sp. larvae with forceps. So the predation of *C. brevipennis* and *C. morio* on larvae of arecanut inflorescence caterpillar, *Tirathaba* sp. (Fig 1f) was studied in laboratory condition. The results indicated that, there was a significant difference in the number of larvae released into the insect breeding dish to the number of larvae remained in the insect breeding dish after predator release. The number of larvae released into insect breeding dish before predator release was (5.00±0.00) but after 48 hours of predator *C. brevipennis* activity the larval population had been reduced (1.60±0.69) indicating effective predation of *C. brevipennis* on *Tirathaba* sp. [t(9) = 3.25] (Table 2).

Predatory potential of black earwig *C. morio* on inflorescence caterpillar

Similarly, same results were obtained in case of *C. morio* which actively predated significant number of *Tirathaba* larvae (2.10±0.73) in the insect breeding dish to the released larvae into insect breeding dish (5.00±0.00) before predator release (Table 2). Earlier, Zhong *et al*. (2016) reported predatory role of *C. morio* on larval stage of *Tirathaba rufivena,* a pest of palms in Southeast Asia and China. These black earwigs are robust and larger in size and attack the inflorescence caterpillar with forceps, holding the larvae and starts feeding on it. These preliminary results indicated that, *C. morio* and *C. brevipennis* adults were able to predate on early instars larvae of *Tirathaba* sp. Previous studies by Zhong *et al*. (2016) confirmed the preference of *C. morio* on younger and smaller larvae, but that they had poor ability to feed on the later instar larvae. This difference may be due to the fact that later instar larvae are able to spin silken webs which could restrict black earwig activity. In majority of opened arecanut inflorescence we noticed the activity of ants and earwigs within the sheath (Fig 1d &e). Most probably ants are attracted to the sugary exudates from the inflorescence. The ecological role of ants and possible relation either with inflorescence caterpillar and earwigs need to be studied. Naranjo-Guevara *et al*. (2017) recent studies reported that some herbivore induced plant volatiles attract some predatory earwigs. In the present study earwigs may attracted towards arecanut inflorescence due to herbivore induced plant volatiles released due to damage by inflorescence caterpillar. Further studies should focus on this tropic interactions and their significance in different crop ecosystems. It has been reported that *C. morio* predates red palm weevil eggs and young larvae (Abraham and Kurian, 1974) and hence here in this there is a need of observation for establishing relationship in arecanut ecosystem. Similarly, *C. morio* is an important predator feeds on eggs and different stages of *Brontispa*. It was commonly associated with *B. longissima* in majority of plantations and complements *Tetrastichus brontispae* and other biocontrol agents (Li *et al*., 2011). The management of *Tirathaba* sp. by insecticide spray is often cumbersome because larvae occur within the concealed spathe and inaccessible parts of the plant. 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*., *C. morio* and *C. brevipennis* could efficiently be utilized for suppressing *Tirathaba* sp. and further strengthens the biocontrol research in arecanut pest management.

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