Biodiversity of predaceous ladybird beetles (Coleoptera: Coccinellidae) in jackfruit ecosystem from the Gangetic Alluvial Zone of West Bengal, India

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Abstract

A potentially profitable crop, jackfruit has a large market. Insect pests of jackfruit not only reduce the production but also affect their food quality. For the biocontrol of various insect pests, ladybird beetles are important group of insects having immense potential. That's why an extensive survey was conducted in jackfruit fields in 2023 to determine the prevalence of common ladybird beetles. A total of 1301 specimens of ladybirds were collected from six different sites in the *Gangetic* Alluvial Zone of West Bengal. Thirteen different ladybird species belonging to 12 genera of 5 tribes and 2 sub-families were recorded. The following 7 species belonged to sub-family Coccinellinae and tribe Coccinellini: *Illeis confusa*, *Coccinella transversalis*, *Megalocaria dilatata*, *Anegleis cardoni*, *Micraspis discolor*, *Propylea dissecta*, *Cheilomenes sexmaculata*. Only one species namely *Novius pumilus* represents tribe Noviini of the sub-family Coccinellinae. Three species from tribe Chilocorini of sub-family Coccinellinae: *Chilocorus nigrita*, *Chilocorus circumdatus*, *Brumoides suturalis* were documented. Only one species namely *Jauravia pallidula* represents tribe Sticholotidini of the sub-family Coccinellinae. One species *Ortalia vietnamica* belonged to sub-family Ortaliinae and tribe Ortaliini. Three species *viz*., *C. nigrita*, *A. cardoni* and *N. pumilus* are maximally observed and illustrated here with diagnostic notes to facilitate their identification.

Introduction

The mulberry family (Moraceae), that also includes the jackfruit tree (*Artocarpus heterophyllus*), is believed to have originated from India's southwest rain forests (Boning 2006). Theophrastus, a Greek philosopher who was alive around 300 B.C., reported that the tree was enormous and produced large, delicious fruits that the Indian sages used for nourishment (Matin 2015). A large number of people consume tropical fruits on a regular basis. Throughout Asia and the Pacific Islands, jackfruit is one of the most important evergreen trees in tropical regions and nations. Jackfruit is a crop with significant economic value and a potential market, particularly for processed foods. India's native jackfruit crop has not yet received enough commercial attention. Numerous insect species have evolved to feed on a wide range of plants. Pest-related losses in modern agriculture have been rising despite all the advancements in crop protection systems. Jackfruit is susceptible to insect pest attacks, much like any other crop. There have been reports of approximately 250 insect species, 8 mite species, 7 nematode species, and more infesting jackfruit plants worldwide (Alam 1962). Biotic factors like insect pests on jackfruit not only lower yields but also have an impact on fruit quality. So, study of pest and their management is important. In the era of over exploitation of pesticides, resistance to systemic insecticides is quite common and thus techniques of biological controls are gaining attention

For the biocontrol of various insect, ladybird beetles are important group of insects having immense potential. The ecology, prey predator interaction and food relationship of the ladybugs have been studied in great detail in the past (Hodek et al. 2012; Omkar and Pervez 2004). These insects also constitute important natural predatory or enemy complex of many horticultural crop pests (Khan et al. 2007). Because of their predatory behaviour, these beetles are considered as beneficial insects and are used as

effective biological control agents against several insect pests (Obrycki and Kring 1998; Hodek and Honek 2009). The introduction of the vedalia beetle, Rodolia cardinalis, from Australia to California in 1888 to combat the cottony-cushion scale, *Icerya purchasi* is a classic example of the effective utilisation of predatory coccinellid (Harmon et al. 2006).

Coccinellidae is a speciose family of beetles with a worldwide distribution, currently including about 6000 species classified in 370 genera (Ślipiński 2007). The Indian subcontinent is enriched with ladybird diversity which house more than 400 reported species belonging to 79 genera and 22 tribes that prey upon a wide range of aphids, scale insects, mealy bugs, phytophagous mites, whiteflies, nymphs of pentatomid bugs etc. (Poorani 2002a). Very little study has been done on the prevalence of ladybird beetles specifically in jackfruit ecosystem from West Bengal as well as India. The population dynamics study of lady bird beetle can comprehensively provide an in-depth idea regarding when to rely on bio-controls agents and when to apply some insecticides to safeguard economic output. Therefore, the current investigation was carried out to comprehend the phenomenon of common predaceous ladybird beetles in jackfruit ecosystem from Gangetic Alluvial Zone of West Bengal.

Materials and Methods

Study area and duration

Ladybird beetles were collected from six different sampling sites (Haringahta, Chakdah, Ranaghat, Santipur, Chapra and Tehatta) in the *Gangetic* Alluvial Zone of West Bengal (Fig. 1). The survey localities are situated in the geographic range of latitudes 22.71°N to 23.40ºN and longitudes 88.55°E to 88.71ºE. Year-round surveys were done in the year 2023 from January to December fortnight interval for systematic sampling of coccinellid species.

Insect sampling method

Visual contacts, such aspiration and hand picking, were used to sample the beetle specimens. Every ladybird beetle that had been collected was taken to the lab for dry preservation and identification.

Preservation and identification of specimen

The insects were immediately placed into killing jars containing cotton that had been soaked with ethyl acetate. After being killed, the insects were placed in a glass vial, properly marked, and sent to the lab. Beetles were then attached on the triangular card point by stretching and glueing. To preserve the card mounted specimens, they were placed in the wooden boxes and oven dried for 72 hours at roughly 60°C. Every specimen was given away with a location and host tag. Naphthalene balls were stored in the corner of the insect preservation box to prevent detritivorous insect infestations on the specimens. A stereoscopic trinocular microscope (Model: SZM-T, Make: OPTIKA, Italy) equipped with a camera was used to meticulously examine the beetle specimens of each species in order to study their morphological characteristics. Male voucher specimens of lady bird beetles from each locality were kept

in 70% ethanol in properly labelled glass vials to study the male genitalia. The vials were sealed with parafilm strip to check the evaporation of ethanol. Macrophotographs and Microphotographs were taken using One plus 7 and Samsung S22 ultra smartphone fitted with skyvik macro lens. Later the images were edited in Adobe Photoshop 2020 and arranged in CorelDRAW 2018. Line Drawings were done by smart pen with the software 'Concepts' on Samsung S22 Ultra smartphone.

Dissection of male genitalia

Coccinellid specimen were kept in freshly prepared 10% KOH for overnight at room temperature to facilitate digestion of soft tissues. However, the specimen was kept in hot air oven at 50–60˚C for 10–15 minutes for better digestion whenever needed. In case of outdated sample, they were kept for 4–5 hours in the KOH solution. After that the specimen were gently placed on a clay block to facilitate the detachment of its abdomen from the thoracic region under microscope with the help of sharp micro needles by pressing at the junction of thorax and abdomen. The dissection of the male genitalia of the lady bird beetle were made under stereoscopic bionocular dissecting microscope, to be cleaned in 10% KOH and processed thereafter for making permanent slides so that key parts of taxonomic significance can be easily studied for identification under a microscope and for long term storage. Then with the help of a camel hair brush or tweezers, the detached abdomen was transferred carefully to the cavity block containing distilled water and to be pressed gently by blunt needles to remove the digested soft tissues. After repeated washings in distilled water the abdomen was transferred onto an acrylic glass slide containing one or two drops of glycerine for genitalia dissection. Terminology used for adult morphology, including the genitalia, largely follows Ślipiński (2007).

Estimation of ladybird diversity

Shannon-Weaver index (H) was calculated to estimate lady bird species diversity in the six locations in the study region. The index formula can be expressed as: H= $-\sum P_i \times \log P_i$, here P_i=N_i/N, N_i= total number of counts in an individual species, N = total number of lady bird count. Another diversity index namely Simpson index (D) has been formulated in the study, represented by D = $\sum P_i^2$. However, evenness was deduced using Pielou's Evenness index (J), J = H/ln(S), H is the Shannon diversity index and S is the number of species present. The operations were carried out with the help of "vegan" package in Rv3.2.

Statistical analysis

To identify location and season wise variation in lady bird species, one way ANOVA were performed. Duncan multiple range test was performed subsequently and depicted in bar plots prepared in Rv3.2. Species wise variability was presented in form of box-whisker plot prepared with help of "ggplot2", "ggpubr" and "ggsci" in Rv3.2.

Results

Population dynamics

The present study confirmed the occurrence of 1301 specimens of ladybird beetle which belongs to 12 genera of 5 tribes and 2 sub-families and 13 species were collected throughout the sampling period (Fig 2; Fig 3). Of these 320, 246, 224, 187,124 and 200 ladybird specimens were collected from six respective sites Haringhata, Chakdah, Ranaghat, Santipur, Chapra, Tehatta (Table 3).

Shannon Wiener index (H) was 2.36, 2.21, 2.22, 1.97, 2.13, and 2.04 for the Haringhata, Chakdah, Ranaghat, Santipur, Chapra and Tehatta, respectively (Table 1). The maximum Shannon Wiener index was estimated to be 2.36 in Haringhata indicating the maximum species diversity of the predatory coccinellids.

Simpson's index is used to measure the dominance of individual species in the sampling unit or sampling area. This index could be understood by deciphering the values from 0 to 1, as 0 indicates low dominance and 1 means high dominance. This shows precisely that dominance of a particular ladybird species influences the dominance of other species in a community. The calculated values of Simpson's diversity index (D) of ladybird species were 0.8925, 0.8662, 0.8713, 0.8028, 0.8621 and 0.8466 for Haringhata, Chakdah, Ranaghat, Santipur, Chapra and Tehatta respectively (Table 1). The high values of this index in the current study revealed that Haringhata had the high dominance of coccinellids.

Pielou's evenness index is a measure of equitability which suggests how evenly the individuals are distributed among different species. The values of this index were 0.9207, 0.8632, 0.8689, 0.7702, 0.8305 and 0.7986 for the six respective sites of the present study. *C. nigrita* was the maximally observed species (23.36 %) followed by *N. pumilus* (13.45%) and *A. cardoni* (12.99%) (Table 2; Figure 4). Figure 5 indicated location wise variation in lady bird count in the study region. Haringhata indicated highest lady bird (median count-20) incidence whereas lowest incidence was recorded in Chapra (median count-15). All the other locations indicated similar kind of ladybird incidence. Similarly, there was seasonal variation in lady bird incidence (Figure 7). The seasonal incidence of lady bird in the region can be summarised as Winter (~40) >Summer (~30) >Post Monsoon (~20) >Monsoon (~10) which indicates that the presence of lady bird is highly influenced by rainfall. Drier months are the golden period for ladybirds. From this figure we can deduce that except *B. suturalis*, *C. circumdatus* and *M. dilatata* all the species were present in winter season. *C. circumdatus* was the least abundant species with 0.61% frequency percentage. Majorly noticed three coccinellid predators are illustrated here with diagnostic notes to facilitate their identification and remain others are provided with short description.

Family Coccinellidae

Subfamily Coccinellinae

Tribe Noviini

Novius pumilus Kapur

(Figures 3 m1-m4, 8, 9, 10, 11)

Rodolia pumila Weise, 1892: 26.

Rodolia okinawensis Miyatake, 1959: 127.-Nakane 1963: 207.-Sasaji 1971: 239.

Novius pumilus: Pang et al. 2020: 20.

Diagnosis: Form is subrounded, with a moderately convex dorsum and a distal half which constricts substantially towards the apex (Figure 9 a). Head and pronotum with brownish red or orange in colour without any markings in clypeaus and frons (Figure 9 b, d). Eyes small, oval shaped, moderately separated, interocular distance about 1.25-1.5x as wide as an eye (Figure 9 d). Ventral side of the body orange in colour (Figure 9 c). Antennae 9 segmented, broadly clubbed and terminal antennomere U-shaped (Figure 9 e; 11 b). Elytra completely orange in colour (Figure 9 f). Elytral epipleuron broad and thick (Figure 9 g; 11 c) Mouthparts (maxilla, labium, labrum and mandible) as illustrated (Figure 9 h-k) Abdominal postcoxal line complete with semicircular shape (Figure 9 l; 11 a).

Male genitalia (Figure 10 a-e) as illustrated, tegmen stout, penis guide in dorsal view and ventral view as long as parameres, paramere gently curved on basal portion in latero-ventral view and strongly curved on basal portion in dorsal view with dense seate inner on the inner side and distal end; penis guide in dorsal view mostly wider at base, gradually narrowed towards apex and form a little stem; penis guide in lateral view as same as dorsal view only the little stem slightly curved on the apex (Figure 10 a, b; 11 d, e). Penis stout (Figure 10 c, d; 11 f), greatly curved with a well-defined penis capsule, penis capsule slightly curved outer arm and typical looking inner arm, penis apex (Figure 10 e; 11 g) not modified gradually narrowed towards tip and form a thread like structure at the end.

Immature stages: Larvae (Figure 8 c, d) pinkish red in colour. Pupae (Figure 8 e) reddish orange in colour. Reflex bleeding can be seen from eclosing adult most in case (Figure 8 f).

Tribe Chilocorini

***Chilocorus nigrita* Fabricius**

(Figures 2 c1-c4, 12, 13, 14, 15)

Coccinella nigrita Fabricius, 1798: 79.

Chilocorus nigritus: Mulsant 1850: 463; Crotch, 1874: 184; Korschefsky 1932: 240; Greathead & Pope 1977: 264.

Chilocorus nigrita: Bielawski 1957: 86; Samways 1989: 345; Booth et al. 1990: 90; Booth 1998: 362; Poorani 2002: 312; Kovář 2007: 593; Li et al. 2018: 9.

Diagnosis: Body nearly hemispherical, strongly convex, shiny and glabrous (Figure 12 d; 13 a). Head dull orange to brownish in colour (Figure 13 d). Pronotum blackish in middle, slightly light tone in the sides and brownish-yellow colour on the frontal-lateral side (Figure 13 b). Eyes approximately oval, moderately

separated, interocular distance 1.5x as wide as an eye (Figure 13 d). Ventral side of the body brownish-yellow in colour (Figure 13 c). Antennae 8 segmented, stout and terminal antennomere U-shaped (Figure 13 e; 15 b). Dorsal side of the elytra black in colour (Figure 13 f). Elytral epipleuron greatly broad, thick, inner half of elytral epipleuron neutral-yellow in colour and outer margin brownish to black in colour (Figure 13 g; 15 c). Mouthparts (maxilla, mandible, labrum, labium) as illustrated (Figure 13 h-k). Abdominal postcoxal lines incomplete, reaching posterior margin of abdominal ventrite 1 and running along posterior margin, then almost reaching lateral margin (Figure 13 l).

Male genitalia (Figure 14 a-e) as illustrated, tegmen stout and bulky (Figure 14 a-c; 15 d, e), Penis guide in dorsal view and ventral view longer than pararmeres, parameres in dorsal view strongly tapering at base then gradually broadened up with a dense short setae on the inner sides and distal end and in lateral view parameres slightly curved at basal ½ then widen with a group of long setae; penis guide in dorsal view slightly narrow at base, gradually broadened up to basal ½, narrowing from apical ¼ to apex and form a needle like shape; penis guide in lateral view mostly wider at base, slightly narrow at basal ½ then broadened up apical ¼ and gradually tapering towards apex to form a sharp Knife-like structure . Penis slender (Figure 14 d; 15 f), penis capsule with long outer and short inner arm, apex of penis (Figure 14 e; 5 g) truncate with membranous appendages.

Immature stages: Larvae (Figure 12 a) have a nearly cylindrical body with the dorsal and lateral surfaces covered with spine like projections. Pupae (Figure 12 b, c, e) are exarate and enclosed in longitudinally and medially split open larval exuvium.

Tribe Coccinellini

Anegleis cardoni Weise

(Figures 2 d1-d4, 16, 17, 18, 19)

Verania cardoni Weise, 1892: 19 (Holotype, ZMB; Type locality: ‘Chota-Nagpore’-Mandar).

Coelophora cardoni: Gorham 1894a: 202; 1894b: 209.

Micraspis cardoni: Timberlake 1943: 27.

Anegleis cardoni: Iablokoff-Khnzorian 1982: 295; Poorani 2002a: 321

Diagnosis: Form round and strongly convex (Figure 16 e, f; 17 a). Head oyster yellow colour, posteriorly blackish (Figure 17 d). Pronotum creamy yellow colour with a pair of triangular dots (sometimes fused with each other) in the middle and a pair of triangular markings on the posterior margin (Figure 17 b). Eyes semicircular, fairly separated, interocular distance 2x wide as an eye (Figure 17 d). Ventral portion of body brown to yellowish-orange in colour (Figure 17 c). Antennae long, 11 segmented, densely clubbed and terminal antennomere U shaped (Figure 17 e; 19 b). Elytra creamy yellow in colour, each elytron has two thin black stripes: an inner stripe that is curved posteriorly towards the lateral border and

an outer stripe that is bent anteriorly towards the suture, a tiny round spot close to the apex (Figure 17 f). Medial black suture line present (Figure 17 a). Elytral epipleura broad and thick (Figure 17 g; Figure 19 c). Mouthparts (labium, labrum, mandible and maxilla) as illustrated (Figure 17 h-k). Abdominal postcoxal lines incomplete, reaching posterior margin of abdominal ventrite 1 and running along posterior margin (Figure 17 l; 19 a).

Male genitalia (Figure 18 a-e) as illustrated, tegmen stout (Figure 18 a-c; 19 d-f) penis guide dorsally or ventrally almost same as long as parameres, parameres in dorsal view thick, strongly tapering at base then gradually broadened up with a dense short setae on inner side and distal end and in lateral view parameres slightly curved at base; penis guide in dorsal view extremely narrow at base, gradually broadened towards apex and form a distinct inverted Y-shaped structure; penis guide in lateral view immensely narrower at base, greatly wider at basal ½, then tapering towards apex and form a curved tweezer shape. Penis stout (Figure 18 d, e; 19 g, h) moderately curved with well-defined penis capsule, penis capsule with moderately long outer and short inner arm, inner arm forms a hooklike shape, apex of penis (Figure 18 e; 19 h) distinct and wrench shaped.

Immature stages: Larva purplish brown to dark brown with creamy white to light yellow in colour (Figure 16 a, b, c). Pupa reddish brown with light shade of pink colour (Figure 16 d).

Species account

Illeis confusa Timberlake(Figure 2 a1-a4)

Description: Body is elongated oval with a glabrous, mildly convex dorsum. Elytra yellow in colour, head and pronotum creamy white colour. Pronotum always with a pair of black dots.

Chilocorus circumdatus Gyllenhal (Figure 2 b1- b4)

Description:Body is broadly oval to nearly circular, with a hemispherical, highly convex, and smooth dorsal surface. The elytra are reddish-brown with a narrow black border along the lateral edges, approximately 1/10th of the elytral width.

Micraspis discolor Fabricius (Figure 2 e1-e4)

Description: Body is semicircular to oval with moderately convex dorsum. Elytra reddish brown in colour.

Cheilomenes sexmaculata Fabricius (Figure 2 f1-f4)

Description:Form oval to subrounded. Dorsal side of the body mostly convex, glabrous and shiny. Ground colour is orange or yellowish orange. Pronotum with T shaped median marking. Elytra have two zigzag black lines, a posterior subapical black spot and black suture line.

Jauravia pallidula Motschulsky (Figure 3 g1-g4)

Description:The shape is generally semicircular, with a moderately convex back that is densely covered in silvery white hairs, and the colour is orange to reddish brown.

Coccinella transversalis Fabricius(Figure 3 h1-h4)

Description: The body is elongated, oval, and convex. The head is black with two creamy yellow, subtriangular spots near the inner edges of the eyes. The pronotum is black with light cream at the anterolateral corners. The scutellar shield is black. The elytra are bright orange featuring an oval spot near the scutellum, a large trilobed spot on the humeral region, a transverse band at the apical third that doesn't reach the lateral margin, and three smaller apical spots—one sutural and two lateral, often fused into a transverse marking.

Propylea dissecta Mulsant(Figure 3 i1-i4)

Description: The body is oval with moderately convex dorsum. Anchor-shaped black markings are present on each elytron on the humeral region. A transverse band with circular endings like a dumbbell shape formation present on the apical third. Black suture line is present. Pronotum with large transverse black marking.

Brumoides suturalis (Fabricius)(Figure 3 j1-j4)

Description: The body is oval with a convex dorsum. The head and pronotum are orange. The elytra are gleaming white, featuring three black stripes: one on each elytron in a mid-dorsal position that doesn't reach the apex, and one sutural stripe that also doesn't extend to the apex.

Ortalia vietnamica Hoang(Figure 3 k1-k4)

Description: Body is elongated oval with convex dorsum. Elytra orange in colour with densely covered silvery white hairs. Pronotum and head is creamy yellow in colour.

Megalocaria dilatata (Fabricius)(Figure 3 l1-l4)

Description: Body is round with greatly convex dorsum and glabrous. Elytra reddish brown in colour, five black spots on each elytron arranged in 1-2-2 pattern. Pronotum with two black oval spots on the posterior margin.

Discussion

Considered as the "poor man's fruit," jackfruit is currently regarded as a miracle meal in South and Southeast Asia because it can save millions of people from going hungry if important staple crops like wheat, maize and rice fail due to unfavorable weather conditions (Matin 2015). According to Tandon (1998), 38 species of insects are known to attack jack fruit in India. Butani (1979) recorded 39 different insect pest species on jackfruit belonging to six orders viz., Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera and Thysanoptera. The general knowledge of both newly emerged and

existing pests is still lacking, which makes it difficult to handle them effectively. The application of pesticides is rising consistently, yet this isn't a panacea. In our opinion, the best way to manage all of these pests, will be to research the relationships that exist between the pest and its natural enemies as well as their bio-ecology and seasonality. Based on the available literature, no authentic documentation of predacious ladybird beetles on jackfruit ecosystem from West Bengal state as well as India is available. Our study provided the first-time obvious information related to prevalent ladybird beetles in jackfruit ecosystem of West Bengal. This primary information can be utilized in developing effective pest management strategies.

During this exploration, 13 species under 12 genera in subfamilies Coccinellinae and Ortaliinae were identified. Subfamily Coccinellinae is represented by 4 tribes (Coccinellini, Noviini, Chilocorini, Sticholotidini), 12 species under 11 genera. Subfamily Ortaliinae is represented by 1 species. Among the collected ladybird beetles *C. nigrita*, *N. pumilus* and *A. cardoni* were the most abundant species. *C. nigrita* count was highest in year-round survey indicating a dominant presence in this region specially in Winter and Summer, however *N. pumilus* was observed highest in the winter season (Fig. 6). Larvae of *N. pumilus* was observed feeding on *Icerya seychellarum* in jackfruit (Fig. 8a, b). Adults and larvae of *N. pumilus* mainly prey on *Icerya spp.*, including *I. purchasi*, *I. seychellarum*, and *I. aegyptiaca* (Tang et al. 2022). *N. pumilus* has been widely used in the biocontrol of *I. aegyptiaca* and *I. seychellarum* in Spain, Peru and the islands of Micronesia, etc. (Beardsley 1955; Schmaedick 2007). Larvae of *A. cardoni* was observed to be preyed upon whitefly pupa in jackfruit (Fig. 16b, c). It is one of the most common species in South India with a propensity to feed on various whiteflies, which is unusual in Coccinellini (Poorani 2023).

Declarations

Conflict of interest

There is no conflict of interest, according to the authors.

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Tables

Table 1. Calculated value of each diversity indices for the six respective sites

Diversity indices	Haringhata	Chakdah	Ranaghat	Santipur	Chapra	Tehatta
Shanon_H	2.36	2.21	2.22	1.97	2.13	2.04
Simpson_1-D	0.8925	0.8662	0.8713	0.8028	0.8621	0.8466
Pielou_ e^H/S	0.9207	0.8632	0.8689	0.7702	0.8305	0.7986

Table 2. Subfamilies, Tribes, Number and Frequency of ladybird species collected from jackfruit ecosystem of six different sites of Nadia District

S.N.	Subfamily	Tribe	Species	Number	Frequency (%)
1.	1. Coccinellinae	1. Coccinellini	*I. confusa*	43	3.3
2.			*C. transversalis*	112	8.6
3.			*M. dilatata*	41	3.15
4.			*A. cardoni*	169	12.99
5.			*M. discolor*	73	5.61
6.			*P. dissecta*	81	6.22
7.			*C. sexmaculata*	160	12.29
8.		1. Noviini	*N. pumilus*	175	13.45
9.		1. Chilocorini	*C. nigrita*	304	23.36
10.			*C. circumdatus*	8	0.61
11.			*B. suturalis*	18	1.38
12.		1. Sticholotidini	*J. pallidula*	63	4.84
13.	2. Ortaliinae	Ortaliini	*O. vietnamica*	54	4.15
Total				**1301**	**100**

Table 3. Number of individuals of different ladybird species recorded from jackfruit ecosystem of six different sites of Nadia district

Ladybird species	Haringhata	Chakdah	Ranaghat	Santipur	Chapra	Tehatta	Total
1. *Illeis confusa*	15	5	8	11	1	3	**43**
1. *Anegleis cardoni*	35	48	27	32	16	11	**169**
1. *Chilocorus nigrita*	60	55	46	69	27	47	**304**
1. *Coccinella transversalis*	25	20	16	5	16	30	**112**
1. *Megalocaria dilatate*	10	6	3	7	14	1	**41**
1. *Novius pumilus*	40	23	44	11	21	36	**175**
1. *Micraspis discolor*	20	9	23	10	4	7	**73**
1. *Propylea dissecta*	20	17	15	14	10	5	**81**
1. *Chilocorus circumdatus*	2	1	2	1	1	1	**8**
1. *Brumoides suturalis*	10	3	1	1	1	2	**18**
1. *Ortalia vietnamica*	30	12	8	1	1	2	**54**
1. *Cheilomenes sexmaculata*	41	32	20	22	11	34	**160**
1. *Jauravia pallidula*	12	15	11	3	1	21	**63**
Total	**320**	**246**	**224**	**187**	**124**	**200**	**1301**

Figures

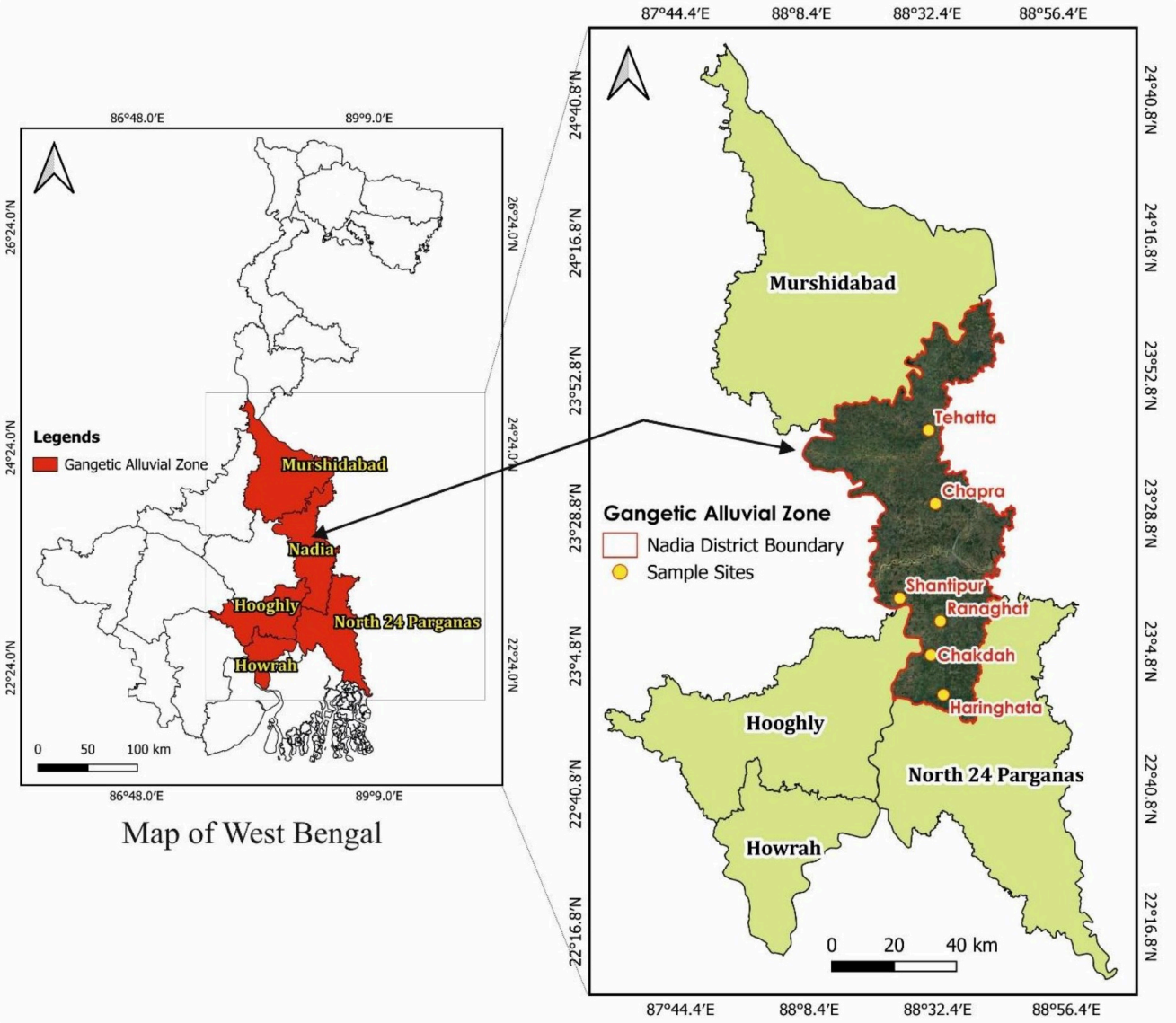

Figure 1. Sampling sites of ladybird beetle in the *Gangetic* Alluvial Zone, West Bengal, India

Figure 1

See image above for figure legend.

Figure 2. *Illeis confusa* (a1-a4), *Chilocorus circumdatus* (b1-b4), *Chilocorus nigritus* (c1-c4), *Anegleis cardoni* (d1-d4), *Micraspis discolor* (e1-e4), *Cheilomenes sexmaculata* (f1-f4)

Figure 2

See image above for figure legend.

Figure 3. *Jauravia pallidula* (g1-g4), *Coccinella transversalis* (h1-h4), *Propylea dissecta* (i1-i4), *Brumoides suturalis* (j1-j4), *Ortalia vietnamica* (k1-k4), *Megalocaria dilatata* (l1-l4), *Novius pumilus* (m1-m4)

Figure 3

See image above for figure legend.

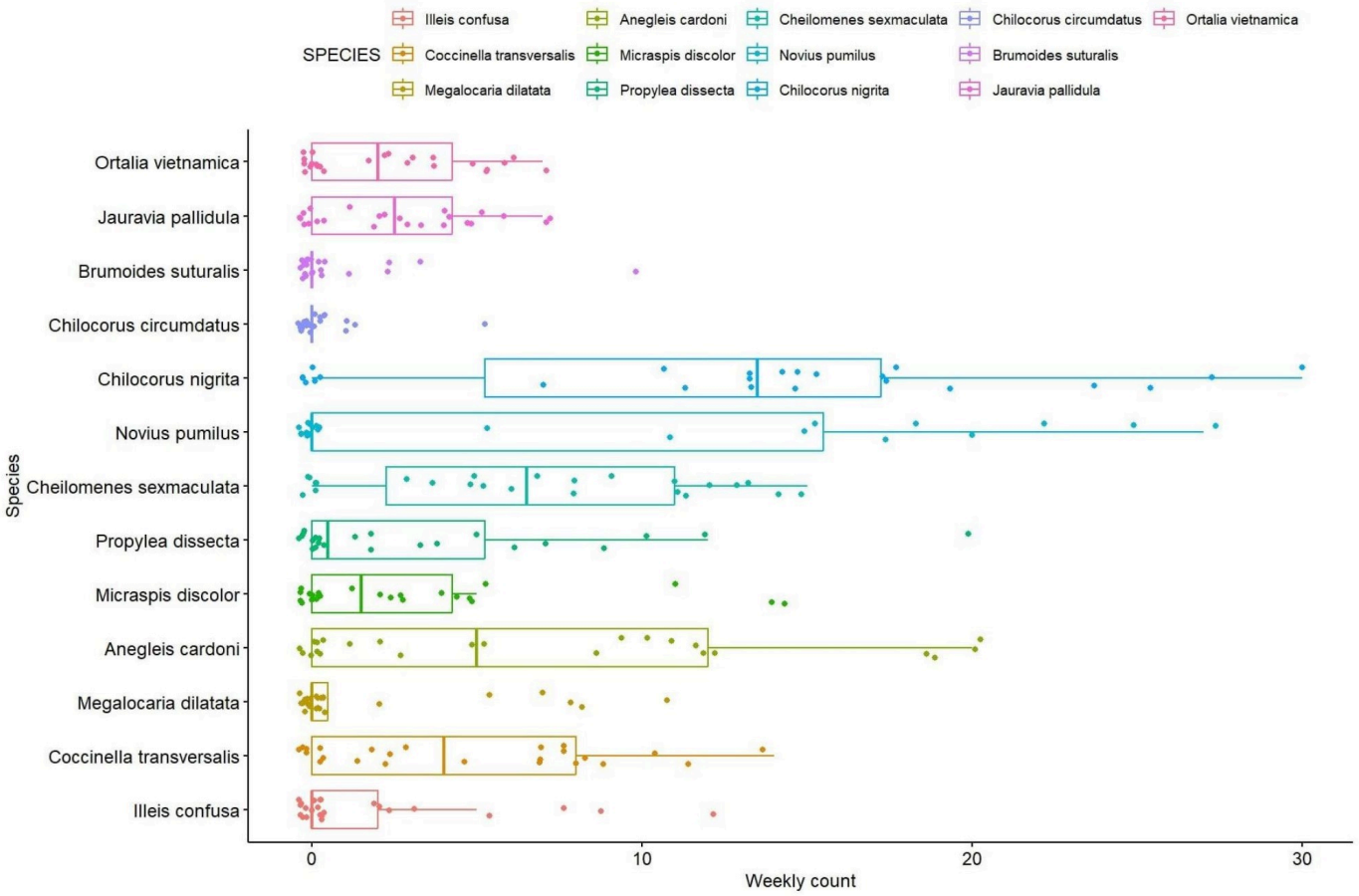

Figure 4. Variability of species wise weekly lady bird count presented as Box-whisker plot

Figure 4

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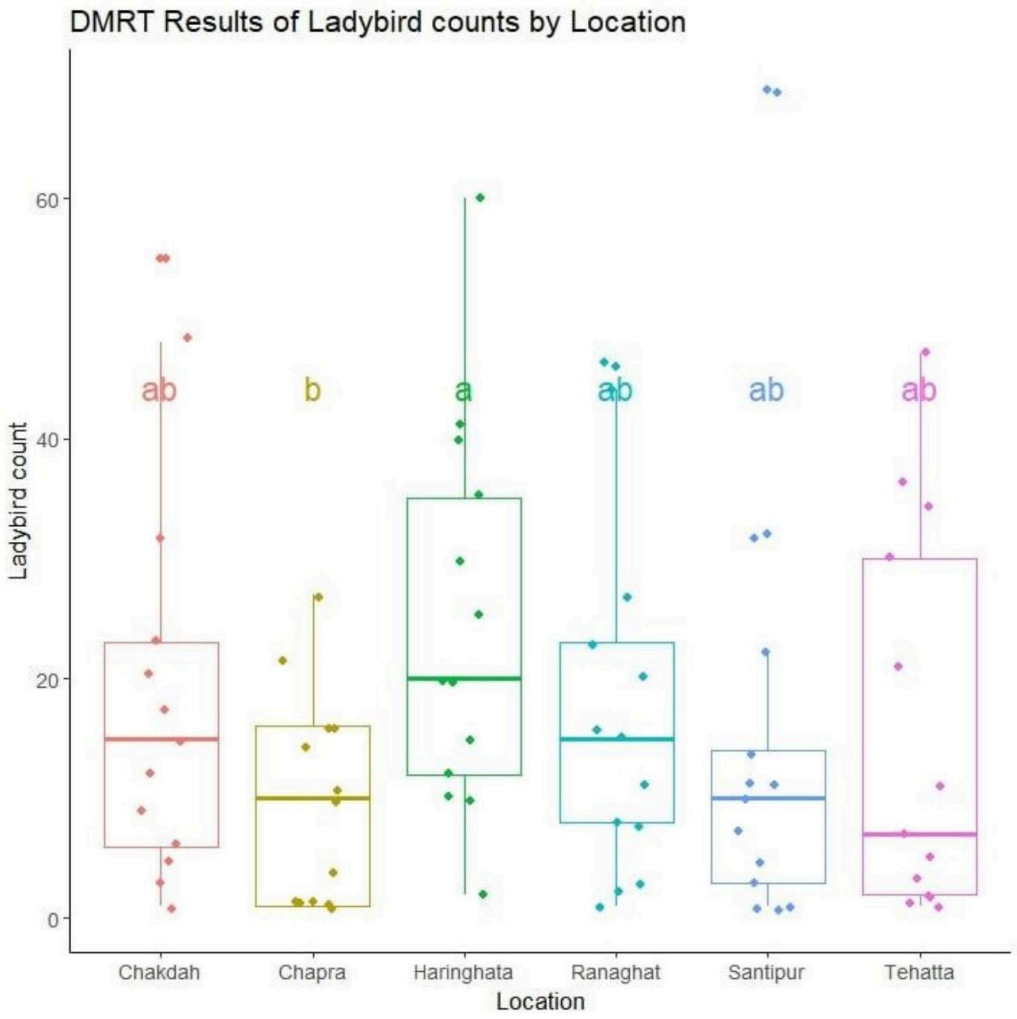

Figure 5. Location wise variability of total lady bird count presented in Box-whisker plot

Figure 5

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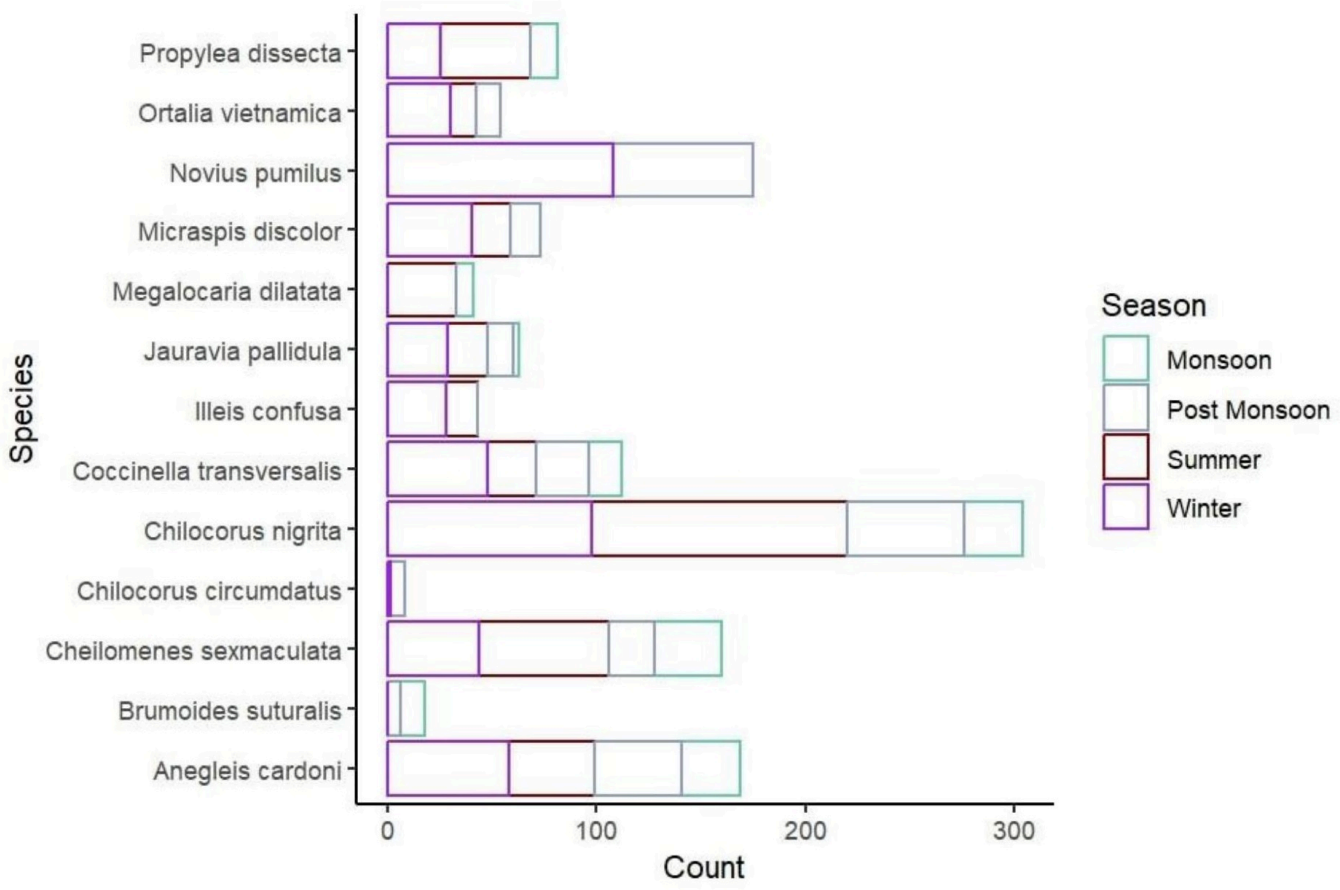

Figure 6. Season and species wise population of lady bird presented in form of stacked barplot

Figure 6

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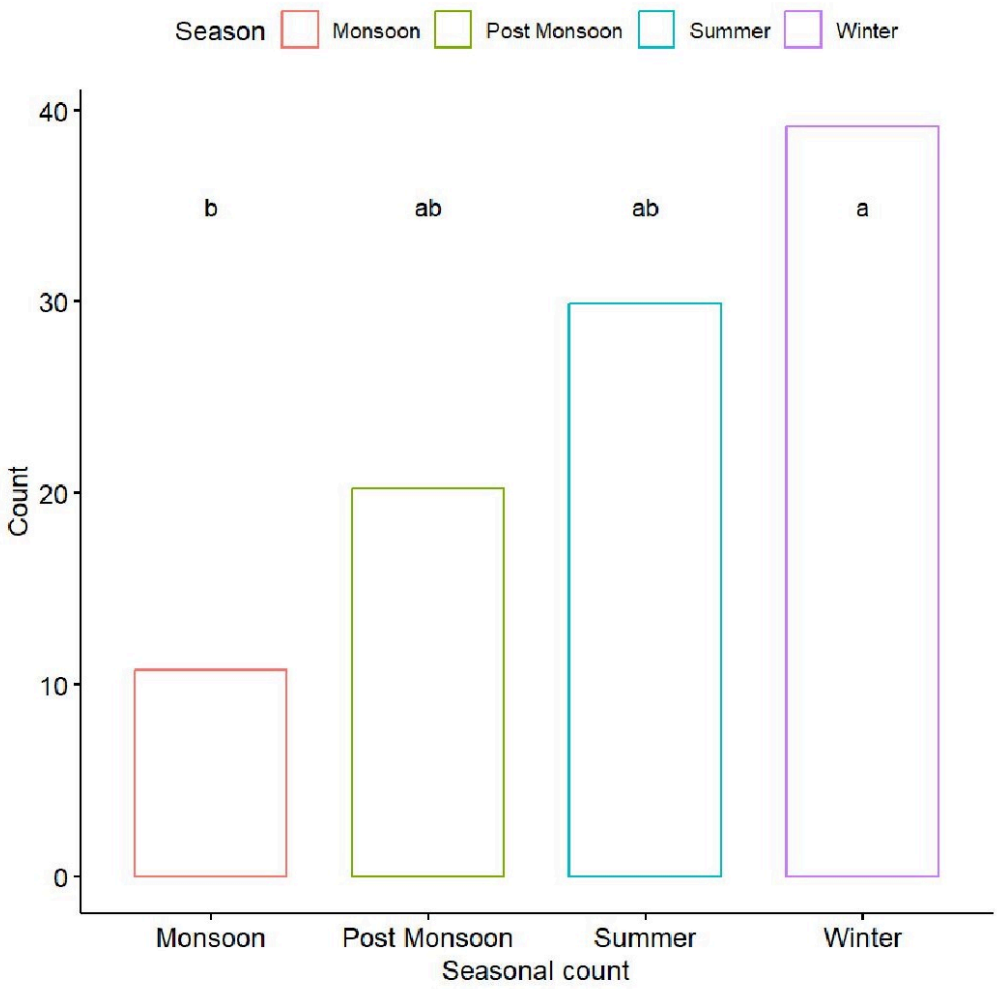

Figure 7. Overall mean comparison of seasonal lady bird occurrence

Figure 7

See image above for figure legend.

Figure 8. *Novius pumilus* (Weise): a, b. *Icerya seychellarum* infestation on jackfruit; c, d. larvae; e. pupa; f. eclosing adult

Figure 8

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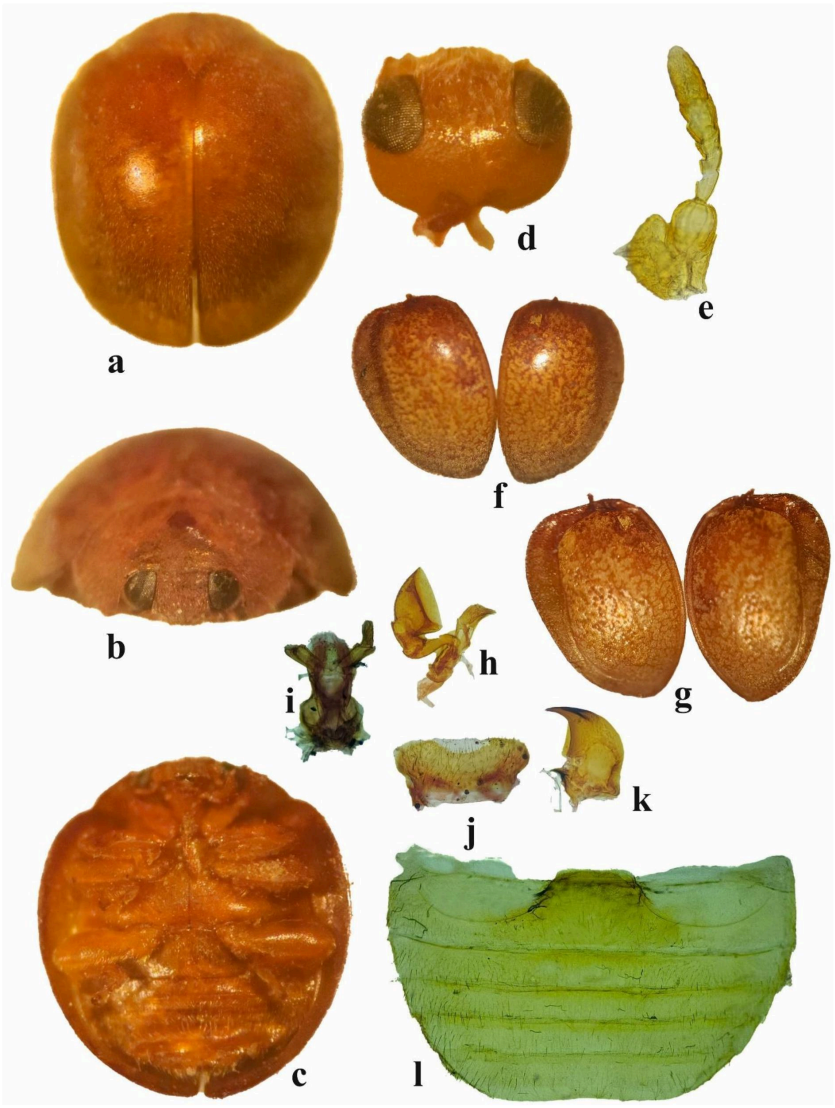

Figure 9. *Novius pumilus* (Weise): a. adult, dorsal view; b. adult, frontal view; c. adult, ventral view; d. head, dorsal aspect; e. antenna; f. elytra, dorsal view; g. elytra, ventral view, h-k. mouthparts: h. maxilla; i. labium; j. labrum; k. mandible; l. abdomen

Figure 9

See image above for figure legend.

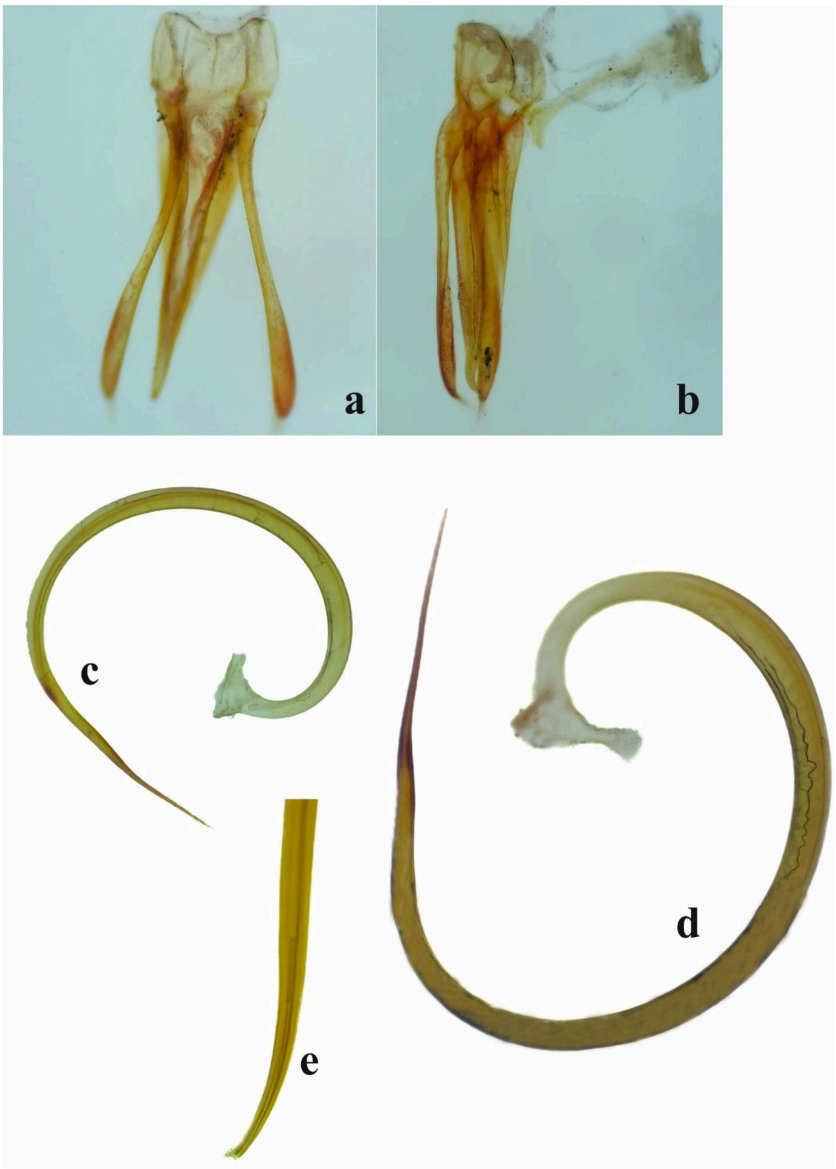

Figure 10. *Novius pumilus* (Weise): a-e. male genitalia: a. tegmen, dorsal view; b. tegmen, lateral view; c-d. penis; e. penis apex

Figure 10

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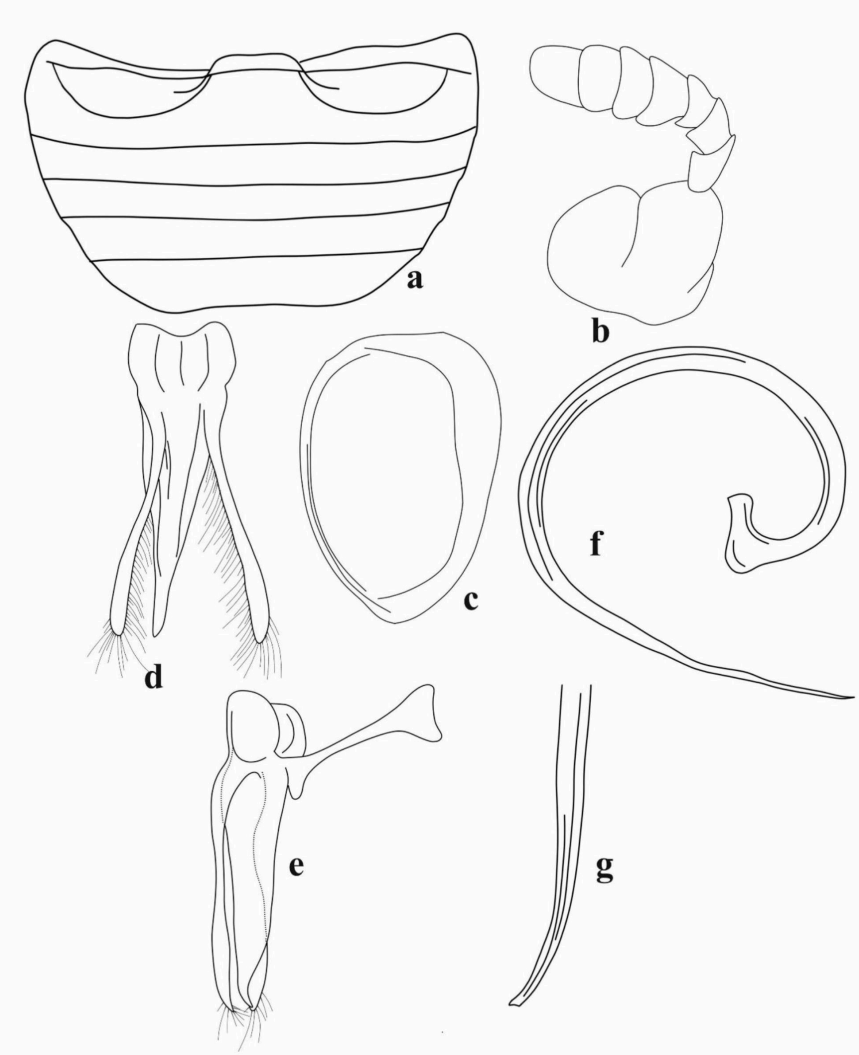

Figure 11. *Novius pumilus* (Kapur) (line drawing): a. abdomen; b. antennae; c. elytral epipleuron; d. tegmen, frontal view; e. tegmen, lateral view; f. penis; g. penis apex

Figure 11

See image above for figure legend.

Figure 12. *Chilocorus nigrita* (Fabricius): a. larva; b. pupa; c, e. adult with pupa; d. adult

Figure 12

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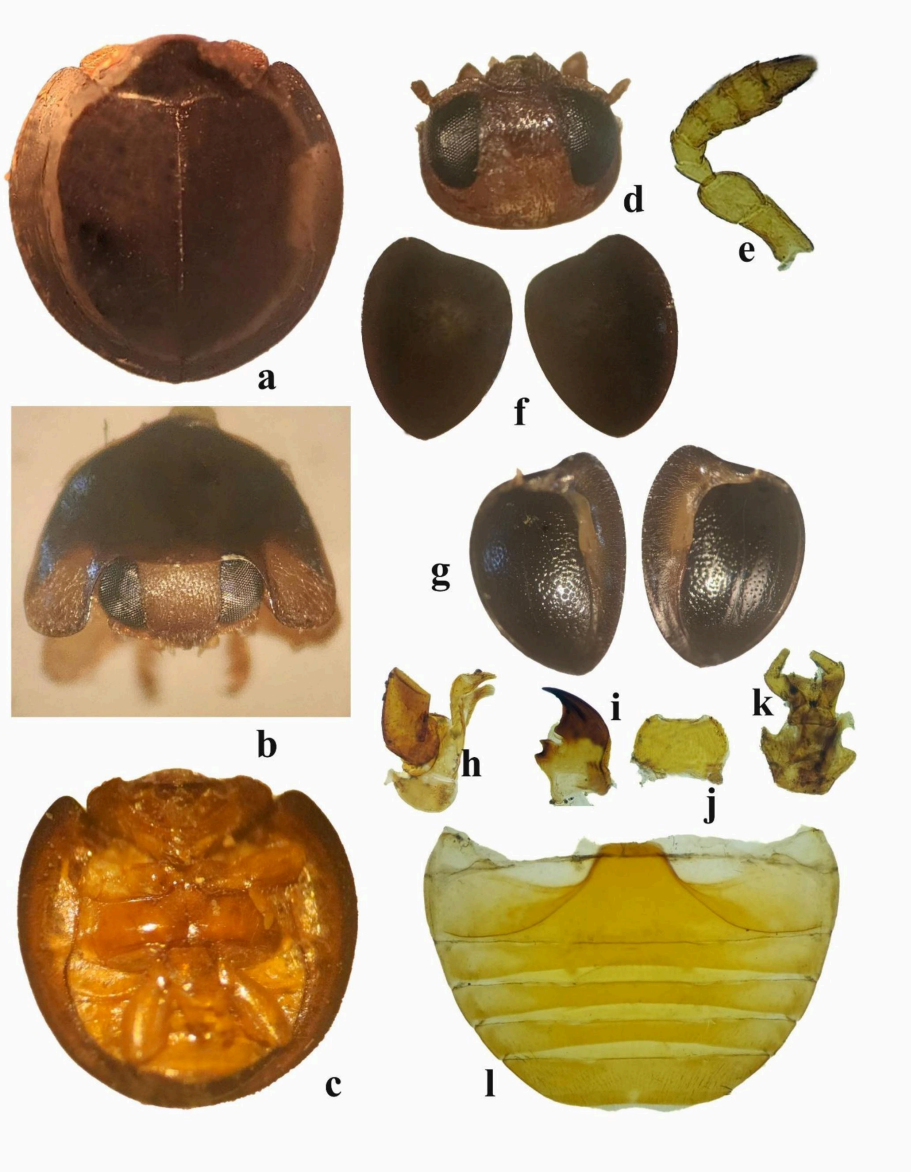

Figure 13. *Chilocorus nigritus* (Fabricius): a. adult, dorsal view; b. adult, frontal view; c. adult, ventral view; d. head, dorsal aspect; e. antenna; f. elytra, dorsal view; g. elytra, ventral view, h-k. mouthparts: h. maxilla; i. mandible; j. labrum; k. labium; l. abdomen

Figure 13

See image above for figure legend.

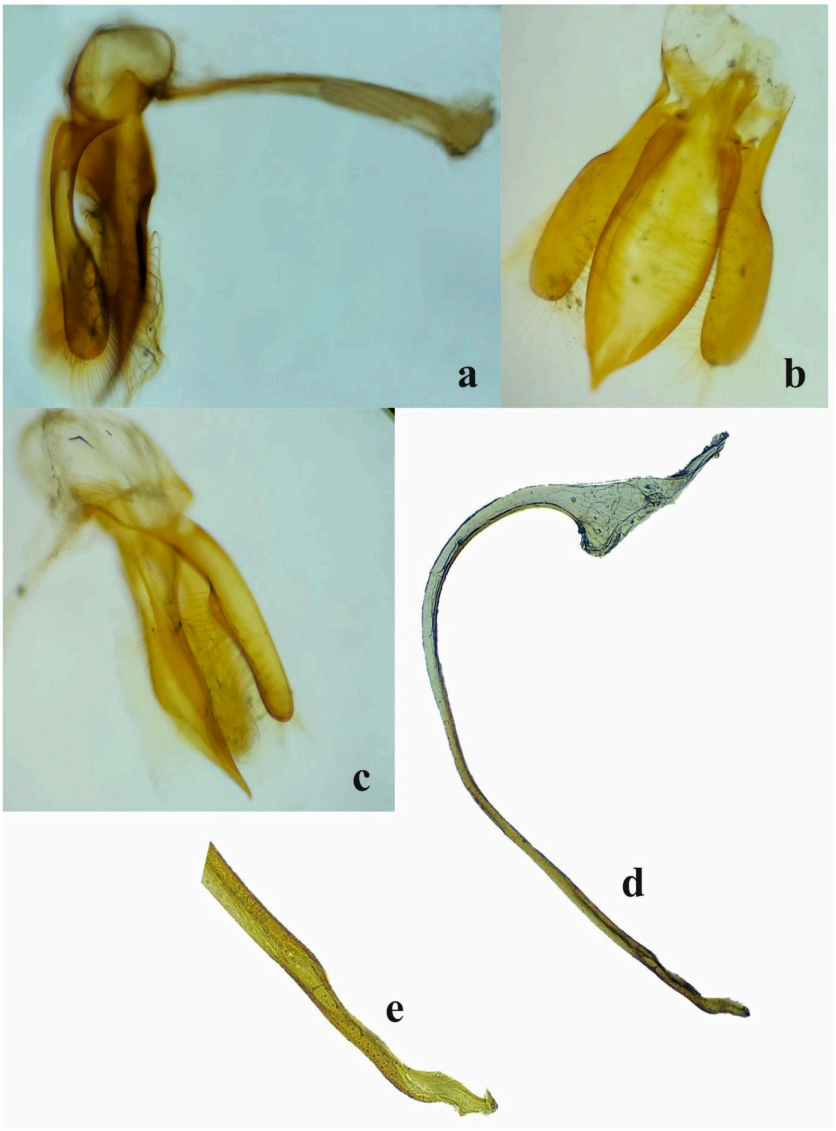

Figure 14. *Chilocorus nigritus* (Fabricius): a-e. male genitalia: a. tegmen, lateral view; b. tegmen, dorsal view; c. tegmen, ventral view; d. penis; e. penis apex

Figure 14

See image above for figure legend.

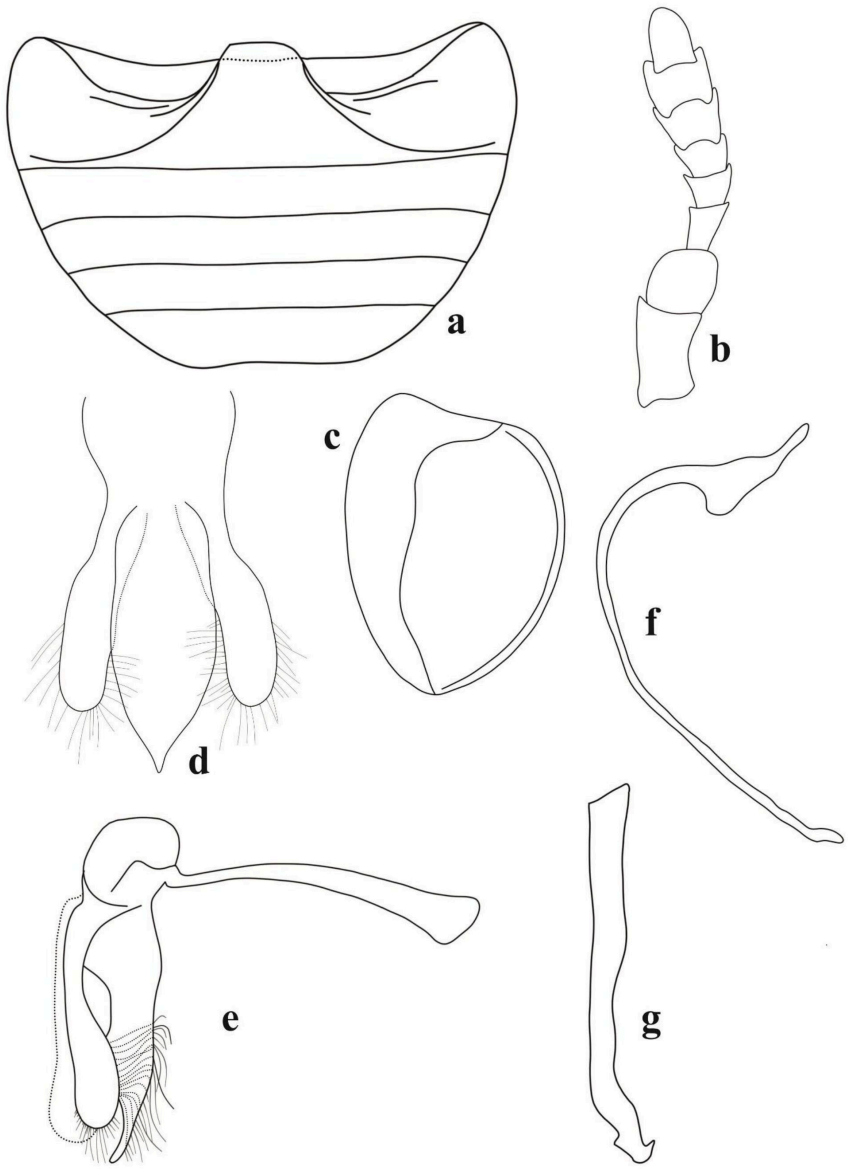

Figure 15. *Chilocorus nigritus* (Fabricius) (line drawing): a. abdomen; b. antennae; c. elytral epipleuron; d. tegmen, dorsal view; e. tegmen, lateral view; f. penis; g. penis apex

Figure 15

See image above for figure legend.

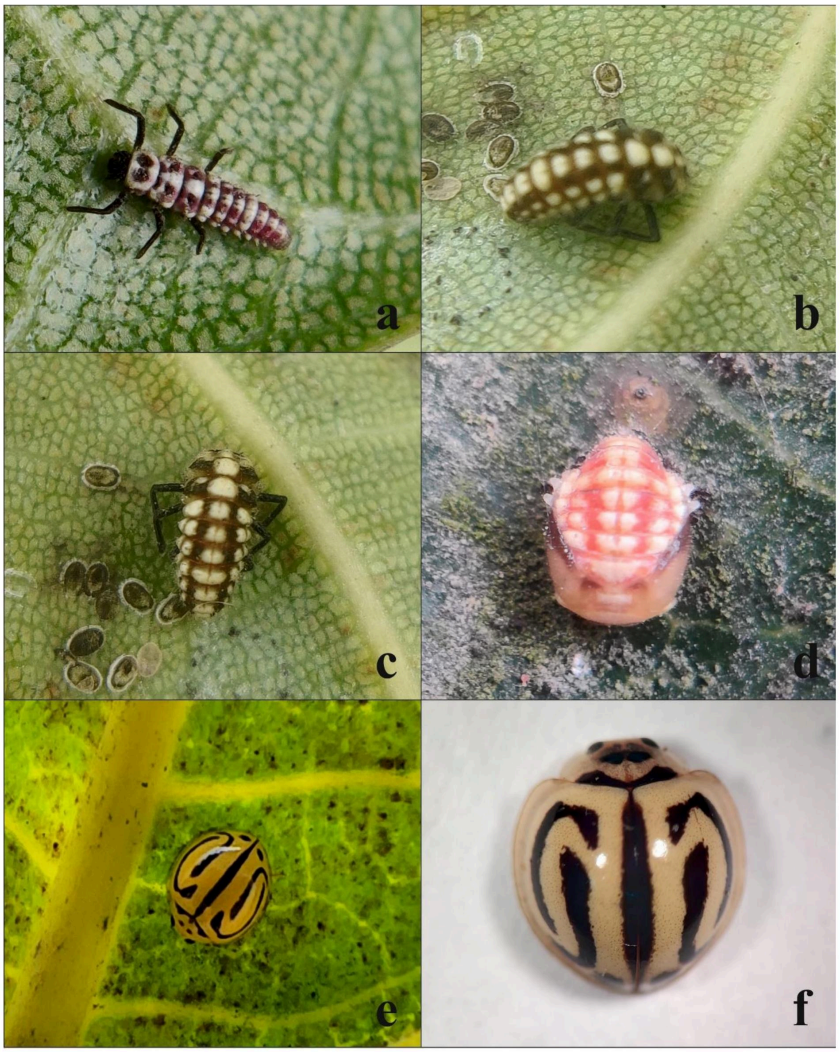

Figure 16. *Anegleis cardoni* (Weise): a. larva; b, c. larva undergoing pupa; d. pupa; e, f. adult

Figure 16

See image above for figure legend.

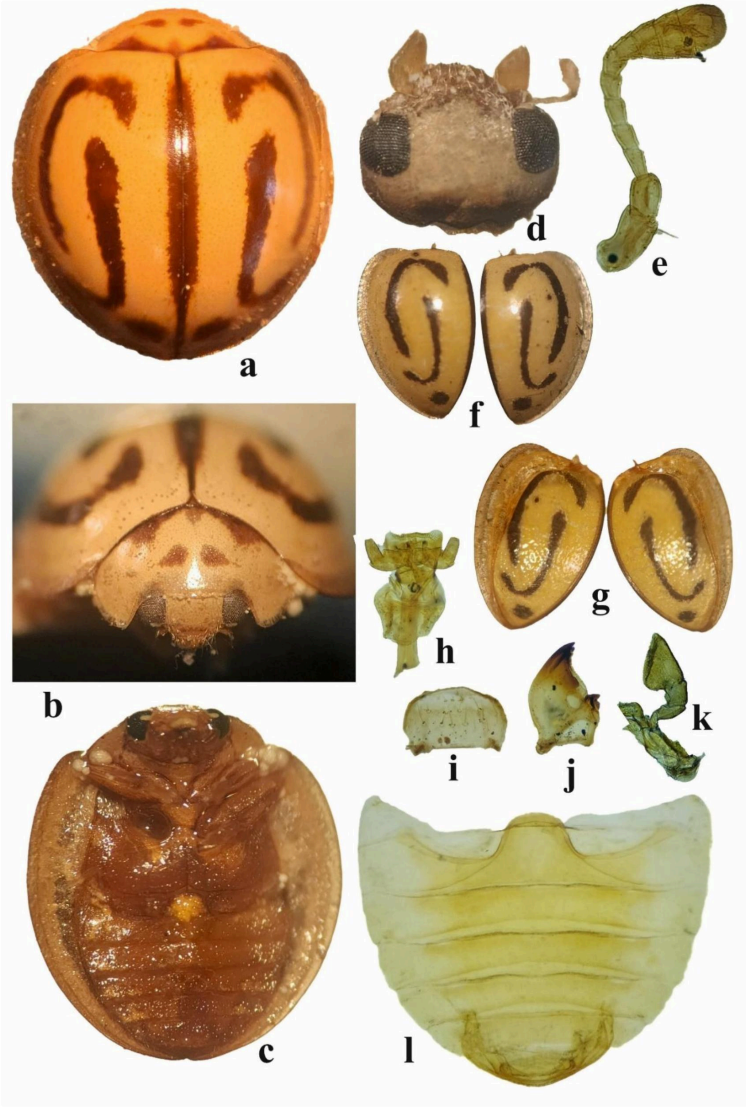

Figure 17. *Anegleis cardoni* (Weise): a. adult, dorsal view; b. adult, frontal view; c. adult, ventral view; d. head, dorsal aspect; e. antenna; f. elytra, dorsal view; g. elytra, ventral view, h-k. mouthparts: h. labium; i. labrum; j. mandible; k. maxilla; l. abdomen

Figure 17

See image above for figure legend.

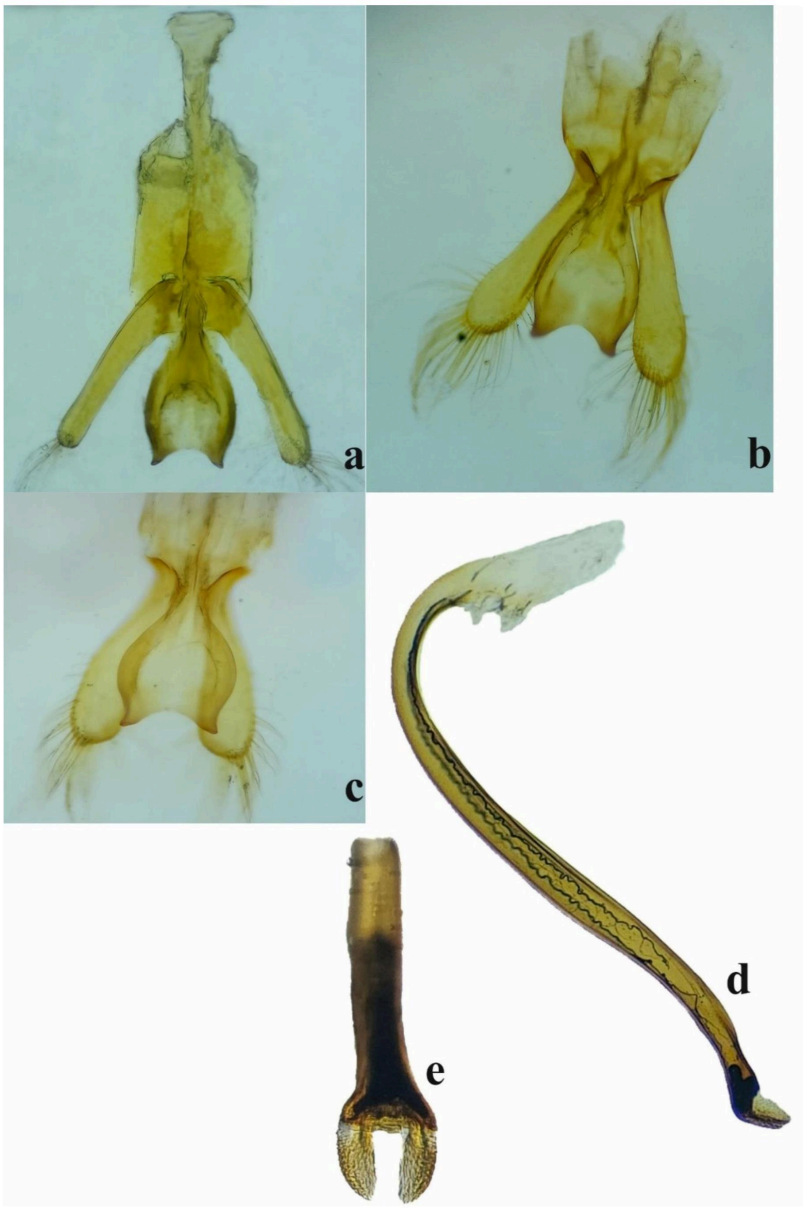

Figure 18. *Anegleis cardoni* (Weise): a-e. male genitalia: a-b. tegmen, dorsal view; c. tegmen, ventral view; d. penis; e. penis apex

Figure 18

See image above for figure legend.

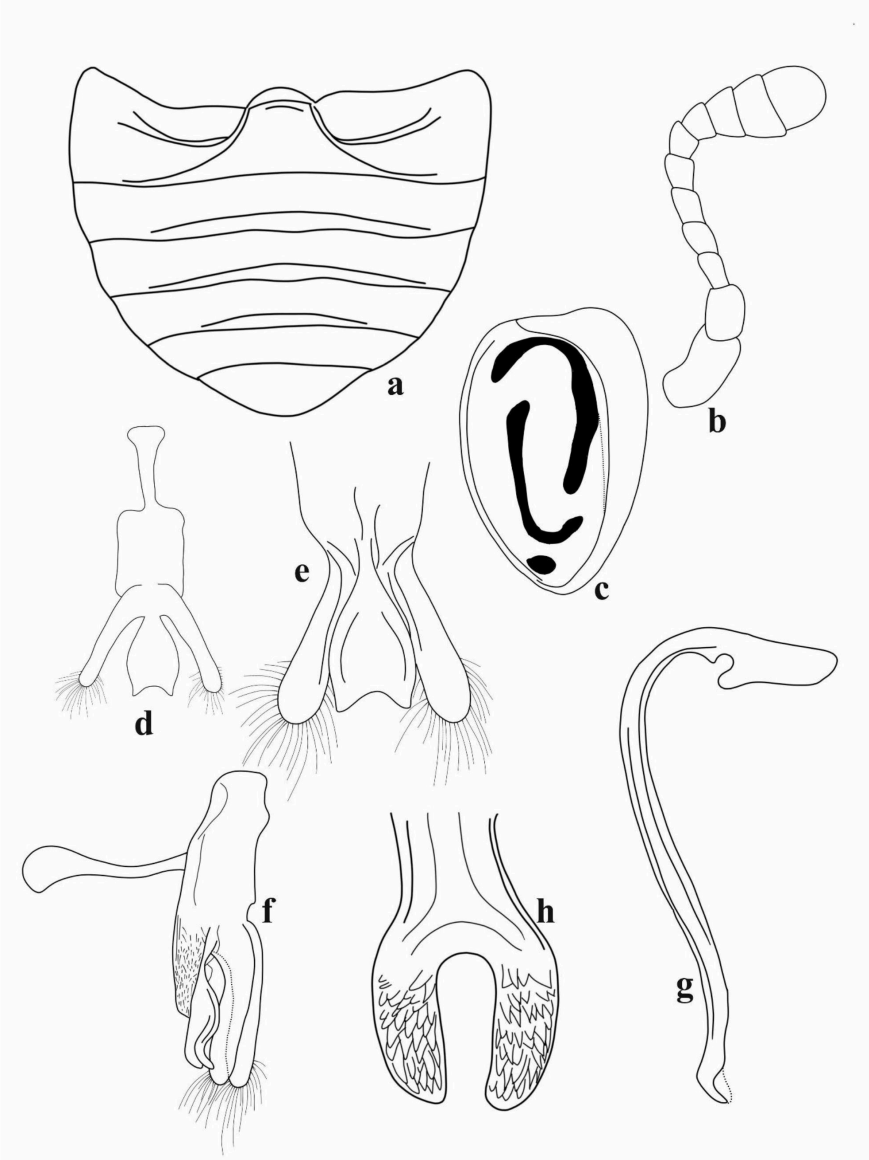

Figure 19. *Anegleis cardoni* (Weise) (line drawing): a. abdomen; b. antennae; c. elytral epipleuron; d. tegmen, dorsal view; e. tegmen, ventral view; f. tegmen, lateral view; g. penis; h. penis apex

Figure 19

See image above for figure legend.