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### Taxonomic Significance of External Genitalia in Differentiating four Species of Genus *Carbula* Stål (Heteroptera: Pentatomidae) from North India

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The male and female external genitalia of four species belonging to the genus *Carbula* Stål i.e. *scutellata* Distant, *socia* (Walker), *biguttata* (Fabricius) and *insocia* (Walker) have been studied in detail. The work includes the descriptions and detailed illustrations of external male and female genitalic structures which have not been published so far for these species. A key to the studied species is also given with emphasis on the genitalic characters.

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**Keyword:** Male, Female, Key, Illustrations

#### 1. Introduction

Pentatomidae is the 3<sup>rd</sup> largest family after Myriidae and Reduviidae under suborder Heteroptera and is represented by 4722 species within 896 genera<sup>[1]</sup>. The taxonomic status of genus *Carbula* has not been changed much since its establishment<sup>[2]</sup>. These bugs are characterized by being broadly obovate; head rounded or somewhat truncated at apex, lobes about equal in length; 2<sup>nd</sup> labial joint subequal to or a little longer than the last two joints taken together and pronotum with the anterior lateral margins generally obtuse, never acute, terminated by a levigate edge which is rarely crenulated. They damage plant species during their active season, but have not yet been recorded damaging any food crops. The genus is well distributed in the Oriental and Ethiopian regions. It is similar to its closely allied genus *Eysarcoris* Hahn except scutellum which is apically narrowed and distinctly shorter than corium as compared to it being apically broad and equal to corium in *Eysarcoris*.

The genus is represented by 76 species from the world with 6 species from the Oriental region (excluding India), 9 species from India and 2 species from North India. A total of 75 representatives were collected from different far flung localities of North India during the present study and were separated as four species on the basis of their morphological characters i.e. morphometry, dorsal and ventral body colorations and markings, shapes of different parts viz., head, pronotum, metathoracic scent gland osteolar peritreme, ventroanterior and ventroposterior margins of abdominal sternite VII of both the sexes. Identification was done with the help of available published literature and further confirmed by comparison with the preserved collection available in different museums viz, Indian Agricultural Research Institute (IARI), New Delhi, Forest Research Institute (FRI), Dehradun, Zoological Survey of India (ZSI), Solan and Dehradun and Natural History Museum (NHM), London. The present work deals with the external genital attributes of the

male and female external genitalia, which have not been dealt with in detail so far for these species.

## 2. Materials and Methods:

The bugs were collected from different localities of North India that includes the states of Punjab, Haryana, Himachal Pradesh, Uttarakhand, Union territory of Chandigarh, NCR region of Delhi and parts of Jammu and Kashmir. Out of the four species included in the present work, all except *C. socia* have been reported from our neighbouring country Pakistan but without sufficient details of their male and female external genitalic structures. For preparing the slides of external female genitalia, the abdomen was potashed in 10% KOH and boiled for 5-10 minutes on a gas burner. The potashed sclerites were removed to expose the genital plate and spermatheca. For external male genitalia, the entire abdomen was potashed in 10% KOH, boiled for 3-5 minutes, and then kept in oven at 65 °C for 15-20 minutes. The pygophore was dehydrated in various grades of ethyl alcohol and preserved in clove oil for further studies. Later, it was dissected to separate out the internal parts viz., parameres and aedeagus. The photographs of various external genitalic structures were taken with the help of an image processing unit installed in the DRS laboratory of the Department of Zoology and Environmental Sciences, Punjabi University, Patiala. The photographic details of all the genitalic structures have been provided for the first time for the included species.

### 2.1 Genus *Carbula* Stål

*Carbula*, Stål (1864) <sup>[2]</sup> *Hem. Afr.*, 1: 140

**2.1.1 Type species** - *Carbula decorata* Signoret, an African species.

### 2.2 *Carbula scutellata* Distant

*Carbula scutellata*: Distant (1887) <sup>[3]</sup> *Tr. E. S.*, p. 347.

**2.2.1 Body length:** ♂ - 7.5 mm, ♀ - 8 mm (Fig. 1A)

**2.2.2 Male Genitalia:** Pygophore (Fig. 1B) distinctly longer, uniformly broad throughout its

length, lateral margins slightly sinuate; dorsolateral lobes angulated at apex; dorsomedian surface almost straight; dorsal opening small and inverted V-shaped; ventroposterior margin with a small median concavity, laterally slightly sinuate; paramere (Fig. 1C) bilobed, inner lobe small, narrowed at base, broadly sinuate at apex with outer margin concave; outer lobe of paramere broad, acute at apex, its outer margin convex, inner margin slightly convex, and obtuse at apex; aedeagus (Fig. 1D) with sclerotized broad theca; bilobed, bag like dorsolateral membranous conjunctival appendages, fused basally; a pair of small sclerotized medial penial lobes, placed moderately apart distally that are not fused basally; vesica very short, enclosed in theca; ejaculatory reservoir elongate.

**2.3 Female Genitalia:** 1<sup>st</sup> gonocoxae triangular, medially wide apart with posterior margins sinuately convex and acute apices; 2<sup>nd</sup> gonocoxae fused medially, with posterior margin sinuately convex; 8<sup>th</sup> paratergites moderately broad, triangular with posterior margins convex; 9<sup>th</sup> paratergites elongated, lobulate, outer margins concave, passing beyond fused posterior margins of 8<sup>th</sup> paratergites (Fig. 1E); spermatheca (Fig. 1F) with distinct proximal and distal flanges; pump region moderately long, sclerotized, tube like and shorter than distal spermathecal duct; bulb rounded; medial dilation broad, somewhat pumpkin shaped with small proximal dilation, directed posteriad; proximal spermathecal duct distinctly longer than distal.

### 2.4 Material Examined:

**2.4.1 Himachal Pradesh:** Paonta Sahib, 3-26. x. 2009 - 9♀♀, 11♂♂

**2.4.2 Distribution:** Myanmar; Pakistan; India (Himachal Pradesh, Maharashtra, Meghalaya).

**2.4.3 Remarks:** The species closely resembles *Carbula socia* in having humeral angles of pronotum prominent, with long acute or subacute spines; scutellum yellowish-green, slightly punctured with black, basal angles with yellowish-green spots and apex impunctate; head somewhat subtriangular; pygophore longer than broad; theca vase like and paramere with lateral

process narrow at base, broad and bifurcated at apex. However, it can be easily separated from the same in having humeral angles of pronotum with long acute spines; 9<sup>th</sup> paratergites elongate,

distinctly passing beyond 8<sup>th</sup> paratergites and inner margin of blade of paramere slightly convex and obtuse at apex.

*Carbula scutellata* Distant

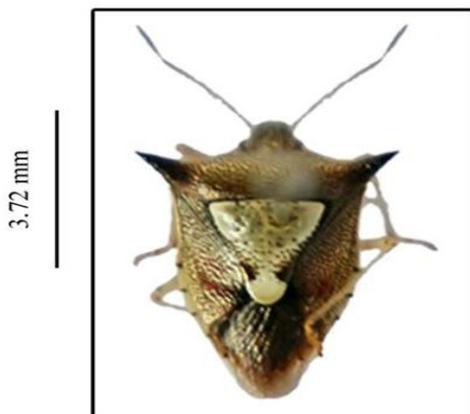


Fig. 1A ADULT

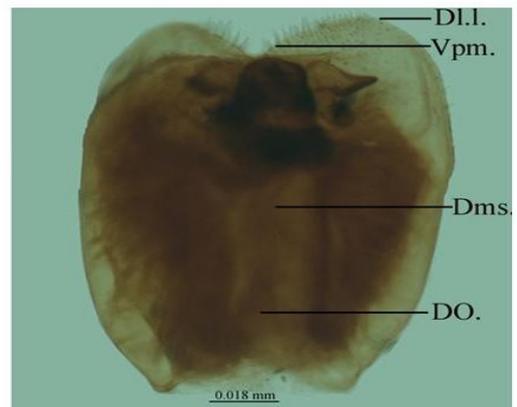


Fig. 1B PYGOPHORE

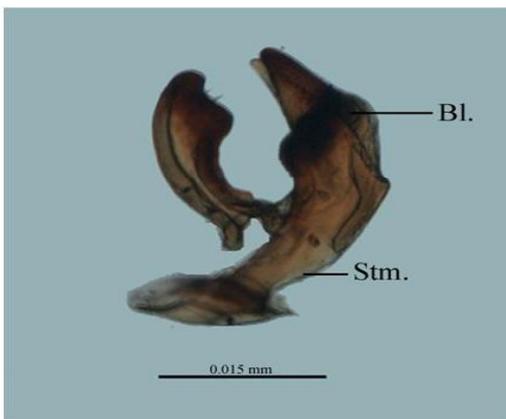


Fig. 1C PARAMERE

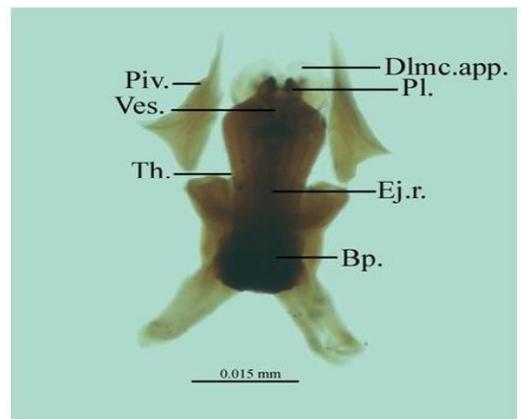


Fig. 1D AEDEAGUS

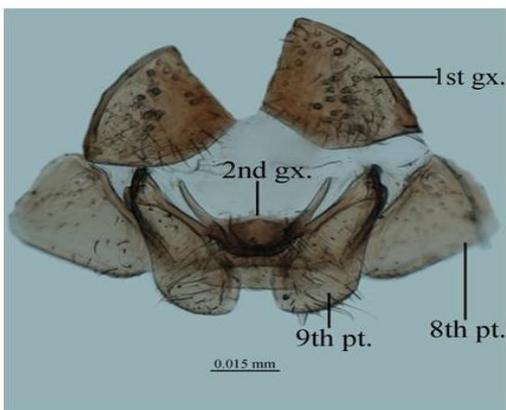


Fig. 1E GENITAL PLATE

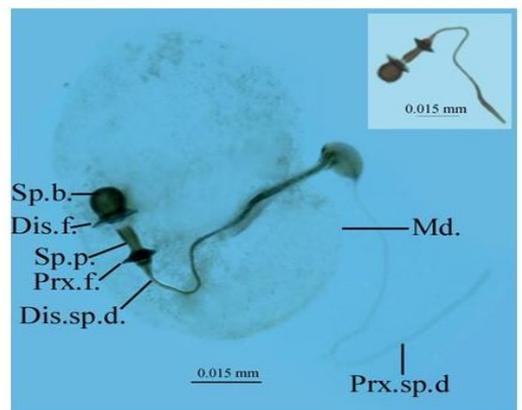


Fig. 1F SPERMATHECA

*Carbula socia* (Walker)



Fig. 2A ADULT

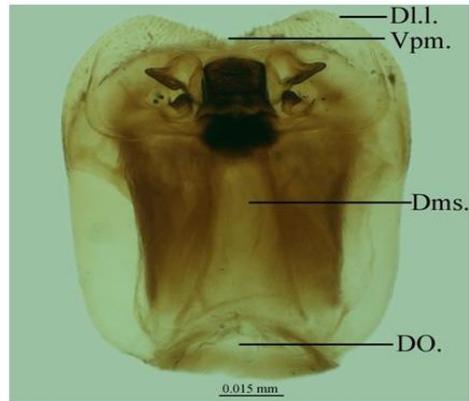


Fig. 2B PYGOPHORE

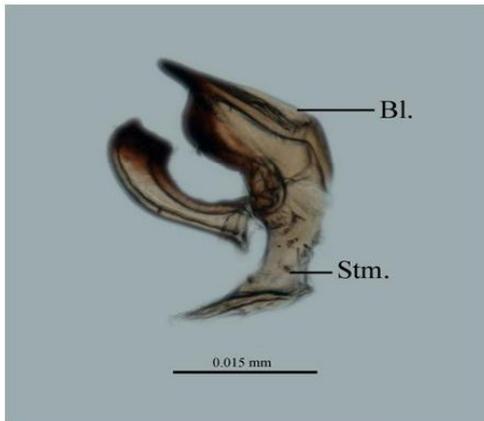


Fig. 2C PARAMERE

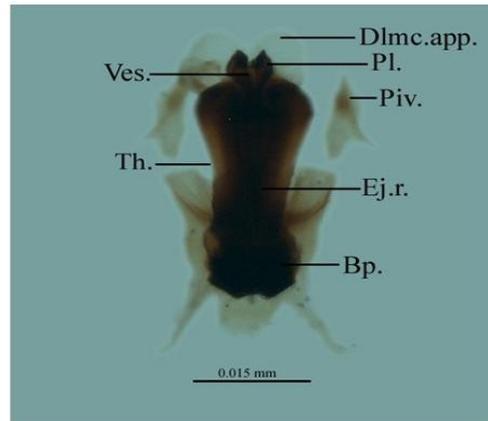


Fig. 2D AEDEAGUS

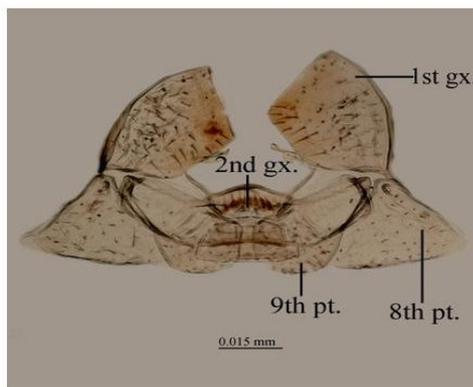


Fig. 2E GENITAL PLATE

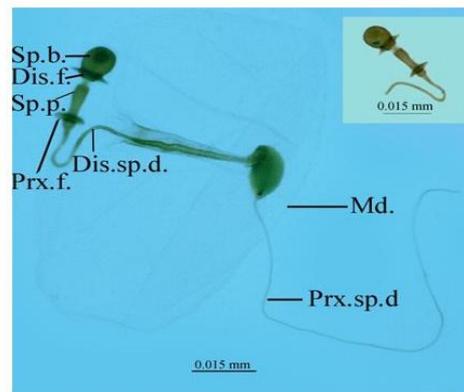


Fig. 2F SPERMATHECA

*Carbula biguttata* (Fabricius)

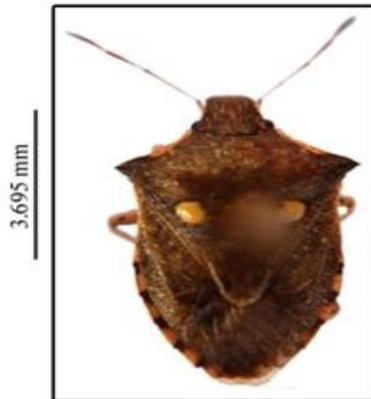


Fig. 3A ADULT

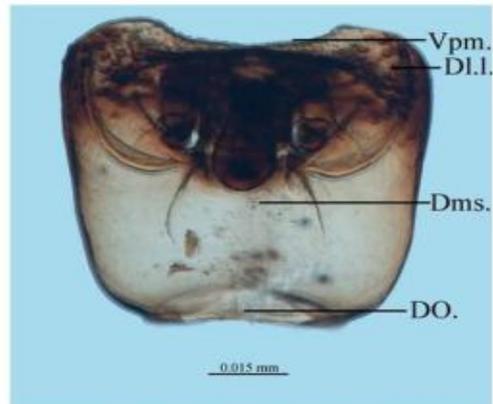


Fig. 3B PYGOPHORE

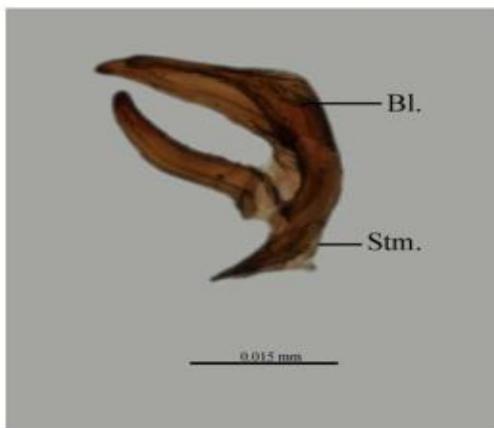


Fig. 3C PARAMERE

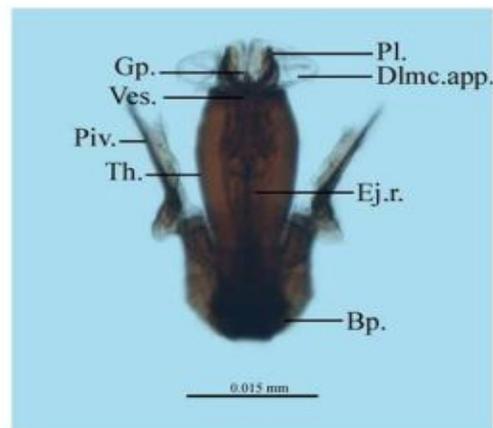


Fig. 3D AEDEAGUS

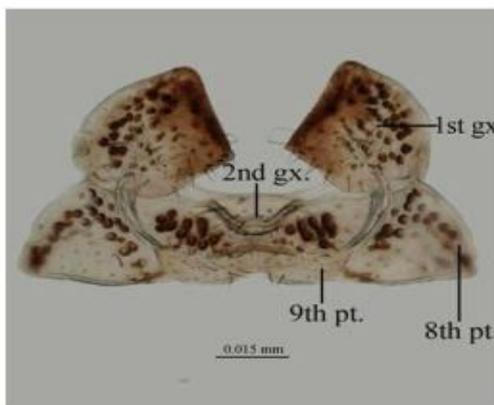


Fig. 3E GENITAL PLATE

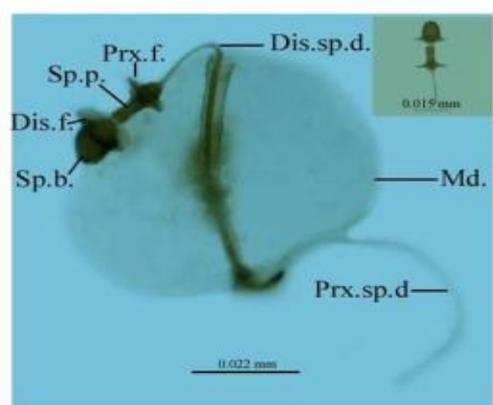


Fig. 3F SPERMATHECA

**2.5 *Carbula socia* (Walker)**

*Mormidea socia*, Walker (1867) [4] *Cat. Het.*, 2: p. 262.

*Carbula socia*: Distant (1902) [5] *Faun. Brit. Ind. Rh.*, 1: p. 172.

**2.5.1 Body length:** ♂ - 7.75 mm, ♀ - 8.25 mm (Fig. 2A)

**2.5.2 Male Genitalia:** Pygophore (Fig. 2B) distinctly longer than broad, lateral margins slightly sinuate; dorsolateral lobes angulated at

apex; dorsomedian surface almost straight; dorsal opening small, inverted V-shaped; ventroposterior margin with a small median concavity, laterally slightly sinuate; paramere (Fig. 2C) bilobed, inner lobe small, narrowed at base, broad and sinuate apically, outer margin concave; outer lobe of paramere broad, acute at apex, its outer margin convex and inner margin strongly convex and subacute at apex; aedeagus (Fig. 2D) with sclerotized, somewhat inverted Vase-shaped theca; bilobed and rounded bag like dorsolateral membranous conjunctival appendages that are fused basally and free apically; a pair of moderately long leaf like sclerotized medial penial lobes, fused basally; vesica very thin and short, not reaching margins of dorsal membranous appendages.

**2.6 Female Genitalia:** 1<sup>st</sup> gonocoxae triangular with posterior margins sinuately convex, medially wide apart, apices acute; 2<sup>nd</sup> gonocoxae fused medially with posterior margin sinuate; 8<sup>th</sup> paratergites broad, triangular with posterior margins convex; 9<sup>th</sup> paratergites distinctly broad, lobulate, rounded at posterior margin with outer margins concave, reaching fused posterior margins of 8<sup>th</sup> paratergites (Fig. 2E); spermatheca (Fig. 2F) with distinct proximal and distal flanges; pump region moderately sclerotized, tube like, slightly shorter than distal spermathecal duct; bulb rounded; medial dilation broad with small proximal dilation, directed posteriad; proximal spermathecal duct distinctly longer than distal.

### 2.7 Material Examined:

**2.7.1 Himachal Pradesh:** Paonta Sahib, 3-25. x. 2009 - 3♀♀, 3♂♂

**2.7.2 Uttarakhand:** Dehradun, 25. vii. 2009 - 1♀, 2♂♂; 25. vi. 2010 - 2♀♀, 1♂

**2.7.3 Distribution:** Sri Lanka; Pakistan; India (Himachal Pradesh, Uttarakhand, Maharashtra).

**2.7.4 Remarks:** The species closely resembles *Carbula scutellata* and can be easily separated from the same as given in the key. It has been reported for the first time from North India.

### 2.8 *Carbula biguttata* (Fabricius)

*Coreus biguttata*, Fabricius (1794)<sup>[6]</sup> *Ent. Syst.*, **4**: p. 129.

*Cimex binotatus*, Fabricius (1803)<sup>[7]</sup> *Syst. Rhync.*, p. 165.

*Pentatoma obscura*, Westwood (1837)<sup>[8]</sup> *in Hope Cat.*, **1**: p. 35.

*Carbula biguttata*: Distant (1900)<sup>[9]</sup> *Proc. Zool. Soc. Lond.*, p. 812.

**2.8.1 Body length:** ♂ - 7.5 mm, ♀ - 8.5 mm (Fig. 3A)

**2.8.2 Male Genitalia:** Pygophore (Fig. 3B) about as long as broad, lateral margins obliquely straight; dorsolateral lobes subprominent, rounded posteriorly; dorsomedian surface sinuately concave; dorsal opening broadly concave, small; ventroposterior margin medially broadly concave; paramere (Fig. 3C) bilobed, inner lobe elongated, spoon like, narrowed at apex, outer margin concave; outer lobe of paramere slightly broad, bilobed apically, outer margin convex with a distinct medial hump; aedeagus (Fig. 3D) with distally broad sclerotized theca; dorsolateral membranous conjunctival appendages bilobed that are fused basally; a pair of small leaf like semisclerotized medial penial lobes, placed widely apart distally and fused medially; vesica very short, neither reaching middle of penial lobes nor posterior margins of dorsal membranous appendages.

**2.8.3 Female Genitalia:** 1<sup>st</sup> gonocoxae placed medially wide apart, broadly triangular with posterior margins sinuate and convex; 2<sup>nd</sup> gonocoxae fused medially with posterior margin sinuately convex; 8<sup>th</sup> paratergites broad, triangular with posterior margins sinuately convex; 9<sup>th</sup> paratergites distinctly lobulate, broadly rounded at posterior margins, placed close to each other with concave outer margins, reaching fused posterior margins of 8<sup>th</sup> paratergites (Fig. 3E); spermatheca (Fig. 3F) with distinct proximal and distal flanges; pump region sclerotized, tube like, shorter than distal spermathecal duct; bulb oblong; medial dilation broad with elongate proximal dilation directed posteriad; proximal spermathecal duct distinctly longer than distal spermathecal duct.

## 2.9 Material Examined:

**2.9.1 Punjab:** Patiala, 12. viii. 2009 - 1♀; Hoshiarpur, 19. viii. 2009 - 1♀; Talwara, 20. viii. 2009 - 1♀; Ropar 6-7. ix. 2010 - 6♀♀, 6♂♂

**2.9.2 Himachal Pradesh:** Solan, 18-19. viii. 2010 - 9♀♀, 5♂♂

**2.9.3 Distribution:** Pakistan; India (Punjab, Himachal Pradesh, Maharashtra, West Bengal)

**2.9.4 Remarks:** The species closely resembles *Carbula insocia* in having humeral angles of pronotum subprominent, either with short acute or without spines; scutellum yellowish-brown with dark brown punctation, basal angles with impunctate brownish yellow spots, apex concolorous and punctate; head somewhat subsquarish; pygophore as long as broad; theca elongate and paramere with lateral process elongate, subacute at apex without bifurcation. However, it can easily be separated from the same in having humeral angles of pronotum with short subacute spines, slightly directed backwards; 9<sup>th</sup> paratergites broad, subequal to 8<sup>th</sup> paratergites, not passing beyond the latter; vesica short, not reaching middle of penial lobes and outer margin of paramere with a distinct medial hump. It has been recorded as a pest of sesamum in India recently and is a new report from North India.

## 2.10 *Carbula insocia* (Walker)

*Pentatoma bimaculata*, Westwood (1837)<sup>[8]</sup> in *Hope Cat.*, **1**: p. 35.

*Eysarcoris insocia*, Walker (1868)<sup>[10]</sup> *Cat. Het.*, **3**: p. 556.

*Carbula insocia*: Distant (1901)<sup>[9]</sup> *Proc. Zool. Soc. Lond.*, p. 812.

**2.10.1 Body length:** ♂ - 7.5 mm, ♀ - 8.25 mm (Fig. 4A)

**2.10.2 Male Genitalia:** Pygophore (Fig. 4B) about as long as broad, lateral margins concavely sinuate; dorsolateral lobes subprominent, rounded posteriorly; dorsomedian surface sinuately concave; dorsal opening small; ventroposterior margin medially concave; paramere (Fig. 4C)

bilobed, inner lobe elongated, spoon like, narrowed at apex, outer margin concave; outer lobe slightly broad, bilobed apically, outer margin convex without a medial hump; aedeagus (Fig. 4D) with distally broad sclerotized theca; dorsolateral membranous conjunctival appendages bilobed that are fused basally, free at apex; a pair of elongated leaf like semisclerotized medial penial lobes, not fused basally; vesica slightly longer, reaching middle of leaf-like penial lobes but not reaching margin of dorsal membranous appendages.

**2.10.3 Female Genitalia:** 1<sup>st</sup> gonocoxae somewhat triangular with posterior margins sinuate and convex, placed medially wide apart, outer margins moderately convex, inner margins straight, apices acute; 2<sup>nd</sup> gonocoxae fused medially with posterior margin convex; 8<sup>th</sup> paratergites triangular with posterior margins convex; 9<sup>th</sup> paratergites lobulate, broadly rounded at posterior margin, placed wide apart, outer margins straight, passing fused posterior margins of 8<sup>th</sup> paratergites (Fig. 4E); spermatheca (Fig. 4F) with distinct proximal and distal flanges; pump region sclerotized, tube like, subequal to distal spermathecal duct; bulb rounded; medial dilation long with elongate proximal dilation, directed posteriad; proximal spermathecal duct distinctly longer than distal spermathecal duct.

## 2.11 Material Examined:

**2.11.1 Punjab:** Ropar, 7. viii. 2010 - 3♀♀, 1♂; Patiala, 6. ix. 2010 - 1♀

**2.11.2 Himachal Pradesh:** Bilaspur, 21. vii. 2010 - 1♀; Solan, 18-19. viii. 2010 - 6♀♀, 2♂♂

**2.11.3 Distribution:** Pakistan; India (Punjab, Himachal Pradesh, Maharashtra, Karnataka)

**2.11.4 Remarks:** *Carbula insocia* closely resembles *Carbula bigutatta* as given in the key and descriptions. It has been recorded as a pest of *Medicago sativa* Linnaeus (alfalfa). It is a new report from North India.

*Carbula insocia* (Walker)



Fig. 4A ADULT

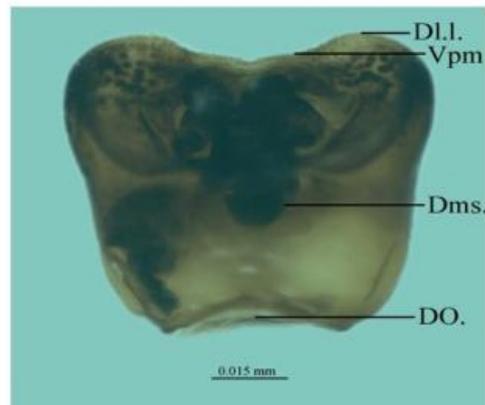


Fig. 4B PYGOPHORE

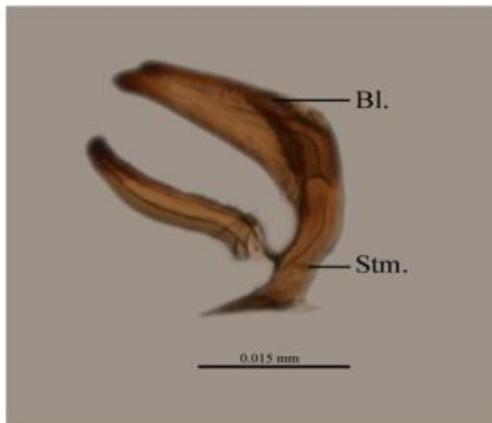


Fig. 4C PARAMERE

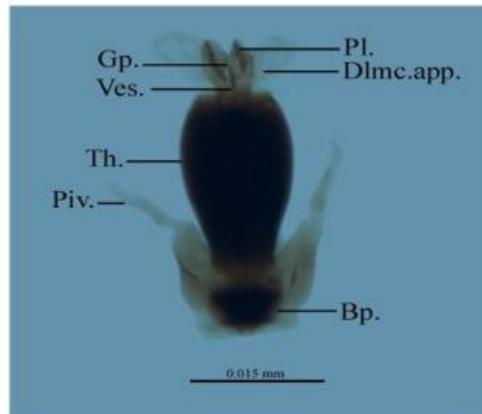


Fig. 4D AEDEAGUS

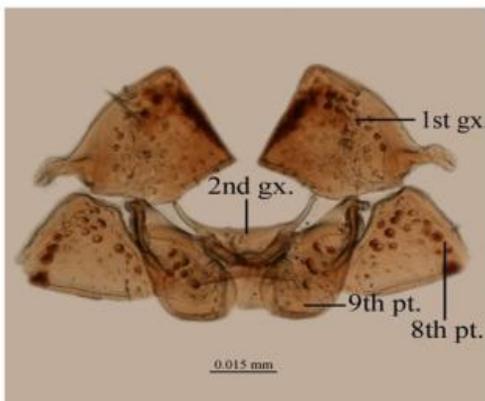


Fig. 4E GENITAL PLATE

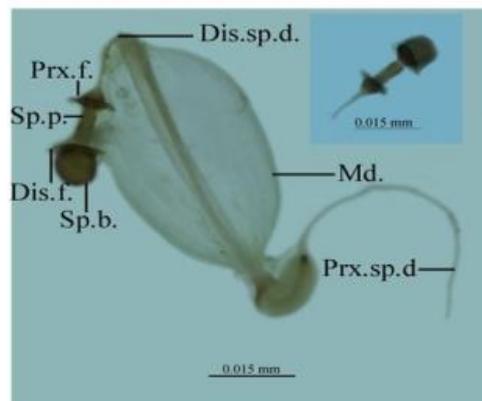


Fig. 4F SPERMATHECA

**Key to the studied species of genus *Carbula* Stål**

- 1 Humeral angles of pronotum prominent, with long acute or subscute spines; scutellum yellowish-green, slightly punctured with black, basal angles with yellowish-green spots and apex impunctate; head somewhat subtriangular; pygophore longer than broad; theca vase-like; paramere with lateral process narrow at base, broad and bifurcated at apex..... 2
  - Humeral angles of pronotum subprominent, either with short acute or without spines; scutellum yellowish-brown with dark brown punctation, basal angles with impunctate brownish yellow spots, apex concolorous and punctatae; head somewhat subsqaurish; pygophore as long as broad; theca elongate; paramere with lateral process elongate, subacute at apex without bifurcation; 3
  
- 2. Humeral angles of pronotum with long acute spines; 9<sup>th</sup> paratergites elongate, distinctly passing beyond 8<sup>th</sup> paratergites; inner margin of blade of paramere slightly convex, obtuse at apex..... *scutellata* Distant
  - Humeral angles of pronotum with obtuse spines; 9<sup>th</sup> paratergites broad, just reaching posterior margin of 8<sup>th</sup> paratergites; inner margin of blade of paramere strongly convex, subacute at apex..... *socia* (Walker)
  
- 3. Humeral angles of pronotum with short subacute spines, slightly directed backwards; 9<sup>th</sup> paratergites broad, subequal to 8<sup>th</sup> paratergites, not passing beyond latter; vesica short, not reaching middle of penial lobes; outer margin of paramere with a distinct medial hump..... *biguttata* (Fabricius)
  - Humeral angles of pronotum roundish or squarish without spines; 9<sup>th</sup> paratergites narrowed at base, lobe-like at apex, passing beyond posterior margin of 8<sup>th</sup> paratergites; vesica longer, reaching middle of leaf-like penial lobes; outer margin of paramere without a medial hump..... *insocia* (Walker)

**3. Acknowledgements:**

RK is thankful to UGC for providing financial aid in the form of scholarship.

**4. Abbreviations:**

8<sup>th</sup> pt. - Eight paratergites; 9<sup>th</sup> pt. - Ninth paratergites; Sp. b. - Spermathecal bulb; Dis. f. - Distal flange; Prx. f. - Proximal flange; Dis. sp. d. - Distal spermathecal duct; Prx. sp. d. - Proximal

spermathecal duct; Md. - Median dilation; Sp. p. - Spermathecal pump; Vpm. - Ventroposterior margin; Dl. l. - Dorsolateral lobes; Dms. - Dorsomedial surface; DO. - Dorsal Opening; Bl. - Blade; Stm. - Stem; Bp. - Basal plate; Piv. - Pivot; Th. - Theca; Ves. - Vesica; Gp. - Gonopore; Pl. - Penial lobe; Dlmc. app. - Dorsolateral membranous conjunctival appendages; Ej. r. - Ejaculatory reservoir.

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