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HEMELYTRA AND MEMBRANOUS WING MORPHOLOGY WITH RESPECT TO DISTRIBUTION OF SENSILLA IN SOAPBERRY BUG, *LEPTOCORIS AUGUR* (HEMIPTERA:RHOPALIDAE).

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Abstract:
The soapberry bug, *Leptocoris augur* have structurally and functionally different wings called as hemelytra (forewings) and membranous wings (hindwings). At rest these wings cross over one another to lie flat along the insects back. The axillary of wing is its base attach to tergal plate of thoracic appendages. Hemelytra divided into three parts leathery corium (CO), clavus (CL) and membranous area (MN) and hindwing have uniform membranous suface. The prominent veinations of forewing and hindwing are costa(C), subcosta (SC), radius (R), median (M), cubitus (CU) and anal (AN). The different parts of forewing and membranous area of hindwing shows various type of sensilla like sensilla basiconica (SB), sensilla trichoidea (ST), sensilla trichoidea curvata (STC), microtrichia (Mt), rod like scales and campaniform sensilla specifically on hindwing.

Keywords: *Leptocoris augur***,** hemelytra, forewing, membranous wing, hindwing, sensilla.

Introduction

Leptocoris augur is economically important as it is the major pest of soapberry (Rittha), *Sapindus saponaria*. The soapberry bug, *Leptocoris augur* have very distinctive front wing called as hemelytra, in which basal half is leathery and apical half is membranous. At rest these wings cross over one another to lie flat along the insects back. Fully developed hemelytra are unique to the Heteropteran bugs and much of the bugs morphology is associated with operation of hemelytra in protection. The hindwings are membranous and shorter than the forewings. Membranous wings are used for flying. Both the wings are folded flat over the abdomen. The nymphal stages are wingless but wingbuds are develop from the third nymphal instar onwards (Snodgrass, 1935; Slater *et al*., 1963; Wollarman, 1971; Hennig, 1973; Imms, 1973; Chapman, 1982; Henry, 1988; Gibb, 2003). Generally the Heteropteran bugs are known as ‗stink bug' as they have scent gland secrete an unpleasant smelling substance in abdominal segments. *Leptocoris augur* doesn't consist of scent gland in abdominal segments, characteristic feature of Rhopalidea family (Mead and fasulo, 2005).

Material and method:

The adult red eye bug *Leptocoris augur* were collected from soapberry plant, *Sapindus saponaria L*. and rearing was carried out in the insectary of Department of Zoology, RTM Nagpur University, Nagpur. The forewing and hindwings were carefully and gently removed under the dissecting binocular microscope (Zeiss). For SEM study, dehydrated wings were dried at room temperature and mounted on carbon coated metallic stubs as per desired view and proceeded for platinum coating in poloron gold coating automatic unit. Finally scanned under Jeol (JSM 6380A) Scanning Electron Microscope (SEM) at desirable magnification at the SEM centre of Vishveshvaraya National Institute of Technology (VNIT) Nagpur, India.

Results :

Structure of Wings

During the post embryonic development, the wing develop as the external lateral wing pads in third nymphal instar and fully developed wings are present only in adult bugs. The forewing and hindwing bears group of sclerites at their base, longitudinal veins throughout the wing surface. (Table: 1).

Table 1: Length and width of wings of *L. augur*

Sr.No.	Wing		Length (mm)	Width (mm)
	Fore wing (Hemelytra)	Corium	7.2 ± 0.3	2.1 ± 0.3
		Clavus	5.1 ± 0.2	1.9 ± 0.3
		Membranous Area	3.1 ± 0.5	2.9 ± 0.4
	Hindwing (membranous wing)		7.3 ± 0.9	4.1 ± 0.4

1. Forewing (hemelytra).

Axillaries.

At the base of forewing sclerotic plate like structure is observed called as the axillaries associated with the mesothorax by tergal plate (Tp). The axillary is divided into three and known as first axillary (Ax1), second

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axillary (Ax2) and third axillary (Ax3). The humeral plate (Hp) is a small movable sclerite present on the origin of costal vein (C) of the wing base. First axillary is situated adjacent to the humeral plate, which is associated with the base of the subcostal vein (Sc). The second axillary sclerite (Ax2) is obliquely hinged to the outer margin of the body of the first axillary and the radial vein (R) is flexibly attached to its anterior end. There are paired medial plates (Mp) associated with the base of media and cubitus vein. The third axillary is present below the proximal medial plate (Mp2). The third axillary is associated with the bases of the group of veins in the anal region of the wing and work as the posterior hinge plate of the wing base (fig.1.1,1.2).

Venations

The forewing is divided into three parts, leathery corium (CO), clavus (CL) and membranous area (MN). The proximal leathery corium and clavus are reddish in colour while, the distal membranous area is blackish colour. The veins serve to strengthen the wing for flight. The characteristic network of veins runs throughout the wing. They are filled with hemolymph and contain a tracheal tube and a nerve.

The prominent veins of forewing are the costa (C), subcosta (SC), radius (R), median (M), cubitus (CU) and anal (AN). All the veins and branches of veins are terminated in the distal membranous area of wing (Fig.). The costa is unbranched vein. It is the leading edge of the wing and is associated with the humeral plate at its base. The subcosta is the second longitudinal vein behind the costa, typically unbranched. The base of the subcosta is associated with the distal end of the first axillary. The radius (R) is the third vein starts from anterior end of second auxillary. The radius is the strongest vein situated at the middle of the wing. It forks into a first undivided branch R1 and a second branch, called the radial sector (Rs). The fourth vein is media (M). It starts from the distal medial plate (Mp1) and consists of two branches M1 and M2. The fifth vein is cubitus (CU) which is unbranch and arises from the proximal medial plate (Mp2). The last vein is anal (AN). It starts from the third auxillary and meet with the proximal part of membranous area of forewing. The anal vein is unbranched (fig.1.3,1.4).

Forewing Sensilla

The forewing divided into three parts the proximal corium and clavus and the distal membranous area. The surface ultrastructure (SEM) of forewing demonstrated different type of sensilla on various parts of forewing (Table: 2). The auxillary part of forewing consists of microtrachia (Mt) (fig.1.5).

Corium Sensilla

The entire corium bears two types of sensilla. The sensilla trichoidea (ST) and sensilla trichoidea curvata (STC). The sensilla trichoidea is broad at base and arises from bulbous basal ring. These sensilla are long and pointed towards the end. The surface of sensilla contain ridges. The basal ring is measured about 3.48 ± 0.9µm in diameter. Sensilla trichoidea curvata is present on the corium and structurally similar to that of ST except the apex of STC is curved (fig.1.6)

Clavus Sensilla

The clavus part of forewing contains two types of sensilla. The long sensilla trichoidea (ST) and sensilla basiconica (SB). The sensilla basiconica are broad at the base without basal ring and rounded towards the apex. On the basis of morphological differences Sensilla basiconica are differentiated as sensilla basiconica-I (SB-I) and sensilla basiconica-II (SB-II) (fig.1.7-1.9).

Membranous Area Sensilla

The distal membranous area of forewing consists of numerous scales. The scales are of various shapes like rounded, elliptical rod-like and few are conical in structure (Fig.1.10)

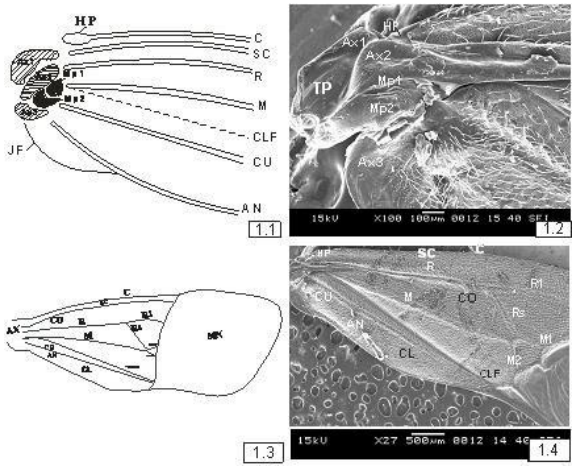

Fig. 1.1: Diagrammatic representation of Forewing axillary.
Fig. 1.2: SEM structure of forewing axillary.
Fig. 1.3: Diagrammatic representation of Forewing venation.
Fig. 1.4: SEM structure of forewing showing wing venation.
Abb. Ax: axillary; Hp: humeral plate; Mp: medial plate; Tp: tergal plate; C: costa; SC: subcosta;R: radius; Rs: radial sector; M:median; CU:cubitus; AN: anal region; CL: clavus; CO: corium; MN: membranous area; JF: jugal fold.

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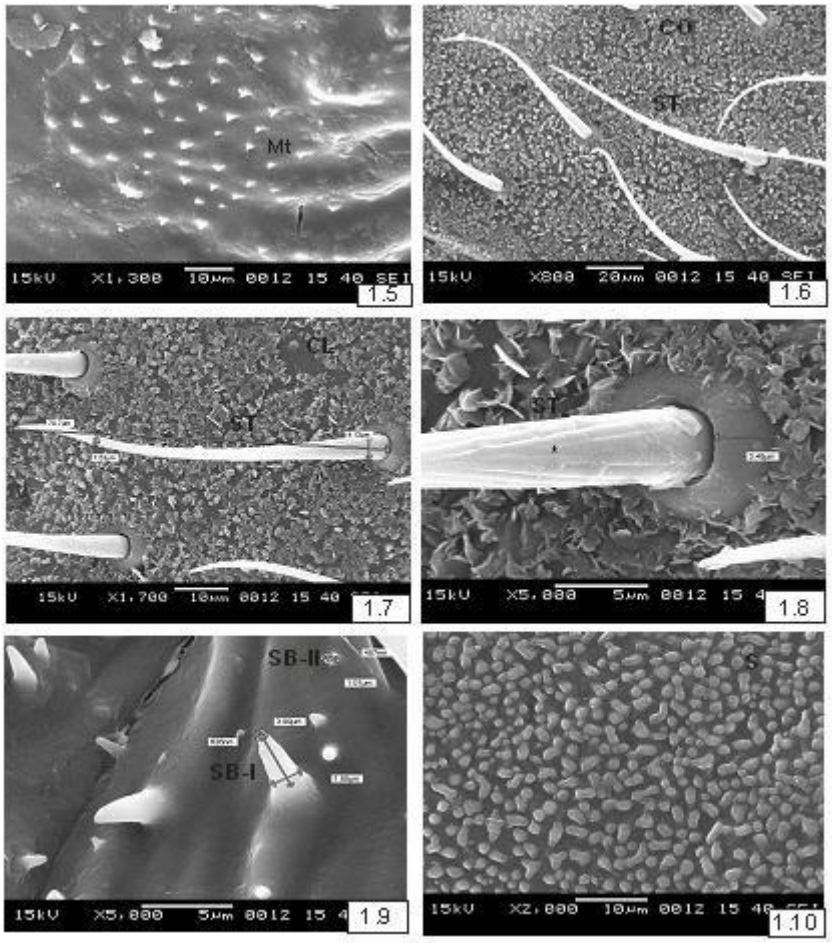

Fig:1.5: SEM structure magnified view of forewing axillary showing microtrichia (Mt).
Fig:1.6: SEM structure of corium (CO) showing sensilla trichoidea (ST).
Fig:1.7: SEM structure of clavus (CL) showing sensilla trichoidea (ST).
Fig:1.8: SEM structure magnified view of ST showing ridges (*) on surface and ring at base.
Fig:1.9 SEM structure magnified view of anal region showing SB-I, SB-II.
Fig.1.10: SEM structure magnified view of membranous area showing various types of scales (S).
Abb: AN: anal; CO: corium; CL: clavus; SB: sensilla basiconica; ST: sensilla trichoidea.

2. Hindwing (membranous wing).

Axillaries.

The axillaries of hindwing are the basal structure associated with the metathorax by tergal plate (Tp) necessary for the movements of flight. The hindwing axillary is divided into first axillary (Ax1), second axillary (Ax2) and third axillary (Ax3). The humeral plate (Hp) is articulated with the base of the costal vein (C). First axillary is associated with the base of the subcostal vein (Sc). Radial vein (R) is flexibly attached to anterior end of second axillary (Ax2). There are paired medial plates (Mp) associated with the base of media and cubitus vein. The third axillary is present below the proximal medial plate (Mp2) and associated with the bases of the group of veins in the anal region of the wing (fig.2.1-2.2)

Venations

The hindwing is entirely membranous. The first marginal vein costa (C) is unbranched. The second vein is subcosta (SC) arises from the first axillary. The subcosta is linked with radius (R) by cross vein (SC-R) and it gives two branches SC1 and SC2. The third vein is radius (R). The radius starts from anterior end of the second axillary. Radius divides into two branches anterior radius (R) and posterior radius known as radial sector (Ra). The anterior radius (R) consist of one branch R1 and Ra is unbranched. The fourth major vein is Median (M) which is fused anteriorly with Radius and is unbranched. The fifth vein is cubitus (CU) arises from the third axillary. It is unbranched and short. The sixth major vein is anal (AN) which is anteriorly fused with cubitus and is unbranched (fig.2.3-2.4).

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Hindwing Sensilla

The hindwing axillary bears two types of sensilla basiconica SB-I and SB-II and sensory peg (fig.). Two types of sensilla are present on the hind wing, sensilla basiconica (SB) and campaniform sensilla (SC). The veins of hindwing bears sensilla basiconica-I (SB-I) and sensilla basiconica-II (SB-II). The sensilla basiconica (SB) are broad at the base and narrow towards the apex, and are categorized into sensilla basiconica-I (SB-I) and sensilla basiconica-II (SB-II) according to the length of the sensilla. The campaniform sensilla (SC) are present in between the area of veins. Campaniform sensilla (SC) are the dome shaped outgrowth from the circular cuticular depressions (fig.2.5-2.10).

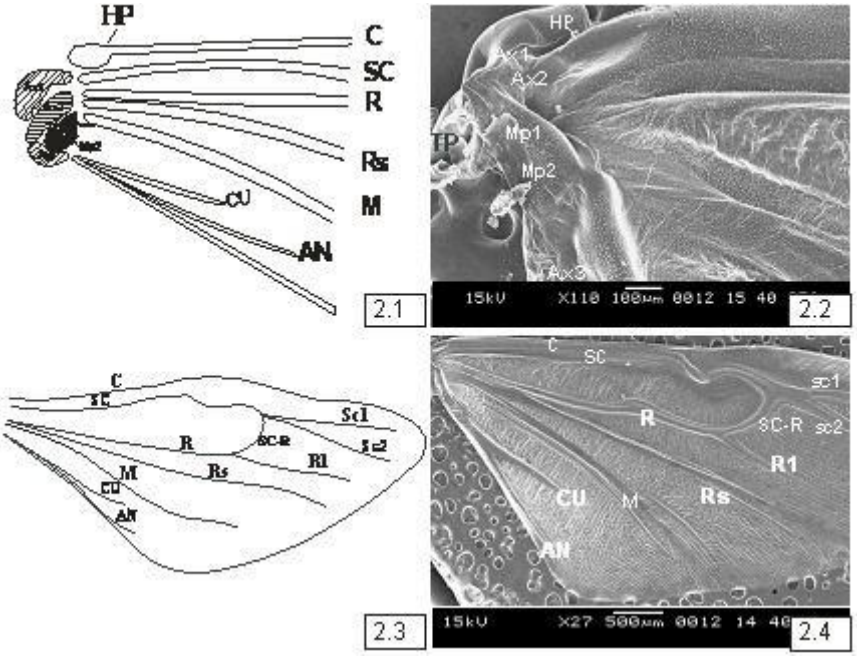

Fig.2.1: Diagrammatic representation of Hindwing axillary.
Fig.2.2: SEM structure of hindwing axillary.
Fig.2.3: Diagrammatic representation Hindwing venation.
Fig.2.4: SEM structure of hindwing showing wing venations.
Abb: Ax: axillary; Hp: humeral plate; Mp: medial plate; Tp: targal plate; C: costa; SC: subcosta; R:radius; Rs: radial sector; M: median; CU: cubitus; AN: anal region.

Table 2: Length and width of various types of sensilla present on wings of *L. augur*

S.n.	Wing		Sensilla	Length	Width
	Forewing axillary		Sensilla basiconica	521 ± 5.7 nm	320 ± 7.5 nm
	Fore wing	Corium	Sensilla trichoidea Sensilla trichodea curvata	70.7 ± 1.2 µm 67.7 ± 1.3 µm	4.12 ± 1.1 µm 3.01 ± 1.9µm
		Clavus	Sensilla trichoidea Sensilla basiconica-I Sensilla basiconica-II	98.9 ± 2.1 µm 3.99 ± 2.9 µm 1.01 ± 3.11µm	3.21 ± 1.5µm 3.00 ± 1.2µm 487 ± 7.5 nm
		Mem. area	Scales	350 ± 8.3 nm	250 ± 9.5 nm
	Hindwing axillary		Sensilla basiconica	3.48 ± 3.1 µm	2.06 ± 2.9µm
	Hindwing		Sensilla basiconica-I Sensilla basiconica-II Campaniform sensilla	1.33 ± 2.9 µm 483 ± 7.5 nm 2.41± 4.11 µm	934 ± 21.1 nm 339 ± 2.5 nm 1.13± 2.01µm

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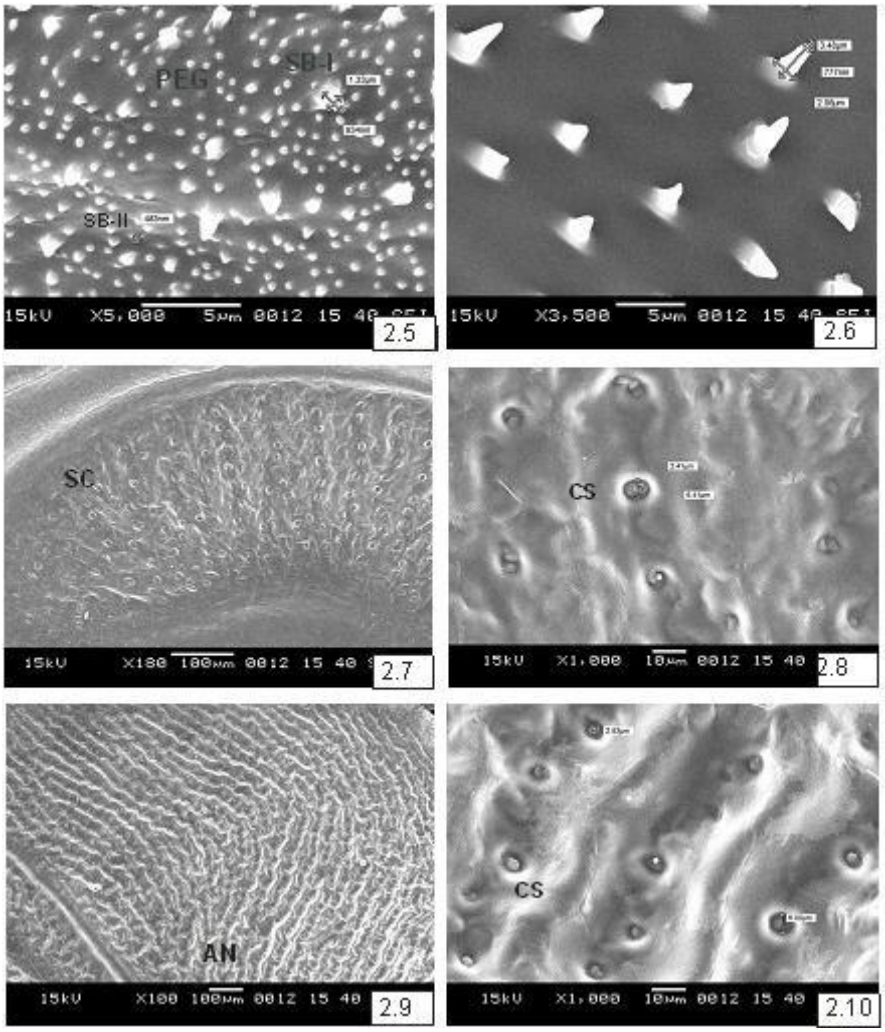

Fig.2.5: SEM structure of hindwing axillary showing sensory PEG and sensilla basiconica SB-I,SB-II.
Fig.2.6: SEM structure of subcostal vein showing sensilla basiconica (SB).
Fig.2.7: SEM structure of hindwing showing subcostal region (SC).
Fig.2.8: SEM structure of subcostal (SC) region showing campaniform sensilla (CS).
Fig.2.9: SEM structure of anal region.
Fig.2.10: SEM structure of anal region (AN) showing campaniform sensilla(CS).

Discussion:

Micro and nano structures on the external surfaces of insects are remarkable with amazing abilities to perform multiple functions. The presence of wing is one of the most distinguished characteristic features of insect (Richard, 1953; Imms, 1973). A pair of forewing and hindwing is present on the meso and meta thoracic segments of *L. augur* respectively.

Among the Coleoptera, the forewings are much harder to form elytra which protect body (Imms, 1973). In the Heteroptera, the forewing is half thickened and half membranous known as hemelytra (Imms, 1973). In *L. augur* the forewing are modified into thickened structure at the base and the membranous area at the apex known as hemelytra and divided into leathery corium, clavus and membranous area. The SEM study reveals that on the corium and clavus of forewing sensilla trichoidea (ST), sensilla trichoidea curvata (STC) and sensilla basiconica (SB) are present. While on the membranous area various type of scales are found. On the hind wings, the sensilla basiconica (SB) and companiform sensilla (CS) are reported. There is extensive investigations of nano- and microstructures on the wing surfaces of various flying insects, Lepidoptera *Papilio xuthus* (Linnaeus), Hemiptera *Plautia stali* (Scott), Coleoptera *Mimela testaceipes* (Motschulsky), Homoptera *Meimuna opalifera* (Walker), Orthoptera *Acrida cinerea cinerea* (Thunberg), Hymenoptera *Vespa dybowskii* (Andre), Odonata *Pantala flavescens*, Diptera *Tabanus chrysurus*

(Loew), Neuroptera *Grocus bore* (Tjeder), Ephemeroptera *Ephemera* sp. (Byun *et al*., 2009).

During the present study, the prominent veins of forewing and hindwing are observed as the costa (C), subcosta (SC), radius (R), median (M), cubitus (CU) and anal (AN). Only one cross-vein is reported on hindwing (SC-R). Forbes (1930) reported differentiation of wing venation in insects. SEM studies of *L. augur* shows detail about articulating structure i.e. axillaries, humeral plates and medial plates. There is no report on the SEM of wing articulation. Perhaps this is the first SEM report on the wing articulation of Hemipteran bug *L. augur*.

Conclusion: Although wings are the organ in insects primarily for flight yet there are other function in insect which helps them in survival. Sensilla trichoidea, sensilla trichoidea curvata, sensilla trichoidea, sensilla basiconica and various types of scales are present on forewing acts as chemo and mechanoreceptore to detect the activity of their predators. On the hind wings, the sensilla basiconica (SB) and companiform sensilla (CS) are reported. Campaniform sensilla specifically found on the membranous wings i.e. hindwings of *Leptocoris augur* are gyroscopic sensor of self motion during flight.

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