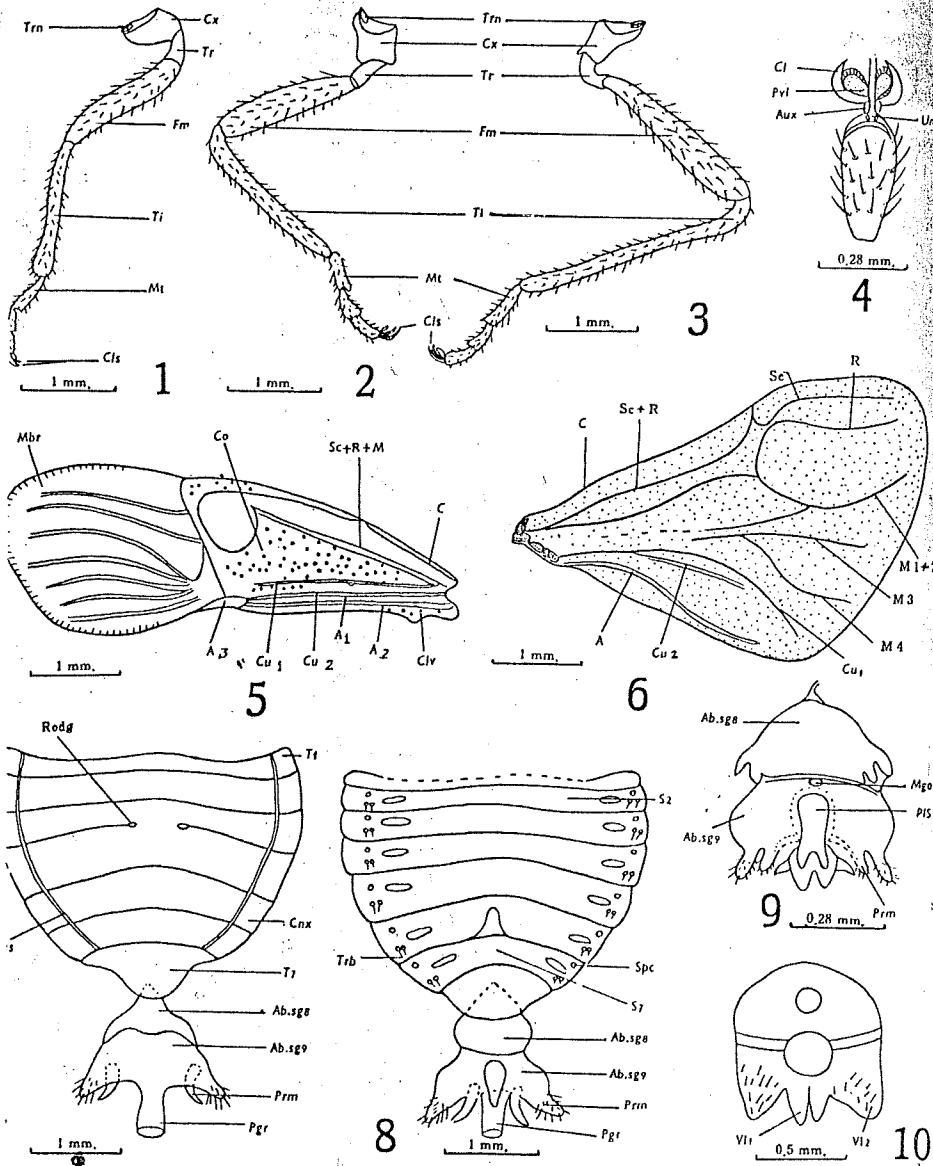


PLATE II



THE INTERNAL ANATOMY OF *BAGRADA CRUCIFERARUM* KIRK.
(HETEROPTERA: PENTATOMIDAE)

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ABSTRACT

Internal anatomy of *Bagrada cruciferarum* Kirk, was studied and a few interesting features were noted. The pharynx is very much reduced and there are no gastric caeca. The repugnatorial glands consist of a sac-like structure. There is a great concentration of the nervous ganglia and the pleurothoracic and abdominal ganglia are fused into a single ganglionic mass. A pair of bacterial sacs are present in the male genital system and these open to the exterior independently by a common duct. Each ovary consists of six telotrophic ovarioles and the spermatheca possesses an apical receptacle.

INTRODUCTION

Bagrada cruciferarum Kirk. is one of the serious pests of cruciferous plants in the Punjab during March to May after which its intensity decreases. The study of internal anatomy of Heteroptera has been practically neglected in India, although a few scattered and quite meagre accounts are available in other countries. Malouf (1933) and Akbar (1957) dealt with the internal anatomy of *Nezara viridula* (L.) and *Leptocoris varicornis* (Fabr.) respectively. Sexana (1954) gave an account of the physiology of the alimentary canal of *Leptocoris varicornis*. Woodward (1950), Bonhag and Wick (1953) and Pendergrast (1957) worked on the reproductive organs of Heteroptera. However, there exists a lot of confusion about the various anatomical structures which needed further clarification. Therefore, these investigations were taken up and efforts were made to study the internal anatomy of the pest in detail.

Histological study of the digestive and reproductive systems was also carried out and the account will be published in a separate paper.

MATERIAL AND TECHNIQUE

The insects were collected from the cruciferous crops and the anatomy of the internal organs was studied both in the preserved and living insects. Parts of the viscera were stained with borax-carmin. The tracheal system looked very clear and silvery-bright in the specimens dissected in glycerine. For studying the brain and various nerves the insects were treated in 90% alcohol for a few days to harden the nervous tissue. The sketches were drawn with the help of a graph eyepiece micrometer.

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OBSERVATIONS

The digestive system (Pl. I, fig. 1)

The intestine is about twice the length of the body and as in other insects is divided into stomodaeum, mesenteron and proctodaeum.

The stomodaeum consists of pharynx and oesophagus. The pharynx is poorly developed; the oesophagus is a narrow tube, anterior half of which is enclosed within the head capsule, while posteriorly it joins the mid-gut in the region of mesothorax. Sexana (1954) did not consider the fore-gut going beyond oesophagus whereas Akbar (1957) considered the anterior region of the mid-gut of *Leptocoris varicornis* (Fabr.) as crop and proventriculus on the basis of their histological structure.

The mesenteron, also known as 'ventriculus' or 'stomach', forms the largest part of the digestive tract. The ventriculus, as in other Heteroptera, is divided into four distinct regions but the gastric caecae are absent.

The proctodaeum consists of two parts, pylorus or anterior intestine and posterior intestine. Two pairs of Malpighian tubules enter laterally, one on each side, into the anterior part of the pylorus.

Salivary glands (Pl. I, fig. 2).—The salivary or labial glands lie closely attached dorsally to the first ventriculus on the thoracic region. The two principal salivary glands are unequally bilobed, the anterior smaller lobe covers the posterior portion of the oesophagus while the larger posterior lobe extends into the abdominal cavity. Each principal gland is provided with a filiform accessory gland which opens through an accessory duct at the junction of the two lobes. The salivary duct arises from each gland near the opening of the accessory duct. The saliva is alkaline. Malouf (1933) noted bacteria in the salivary glands of *Nezara* but these were not observed in the salivary glands of *Bagrada*.

The excretory system

The four Malpighian tubules constitute the organs of excretion. They are highly convoluted in the caudal end of the abdomen and form a tangled mass. These tubules, as already mentioned, open into the pylorus part of the hind-gut.

The repugnatorial glands

The metathoracic glands of Heteroptera, variously referred to as 'stink', 'odoriferous' or 'repugnatorial' glands, are located in the ventral part of the abdomen. As is the case in the majority of Pentatomidae, *B. cruciferarum* possesses a single sac-like gland adhering to the metathoracic basisternum and to the sternum of the second abdominal segment. The sac lies immediately beneath the alimentary tract. It leads into a chitinous duct or vestibule, one on each side, which opens to the exterior by an ovoid slit known as ostiole. Each ostiole is surrounded by an ostiolar peritreme.

The secretion of the repugnatorial glands possesses a very obnoxious odour resembling that of the trypsin enzyme.

The vascular system (Pl. I, fig. 3)

The circulatory system consists of the dorsal organ and the dorsal diaphragm. The dorsal organ is differentiated into a posterior heart and an anterior part known as dorsal

aorta. The three-chambered heart extends from the eighth to the second abdominal segment. It possesses three pairs of transverse slits or ostia. At the caudal end the heart is blunt whereas anteriorly it is continued into the dorsal aorta. The dorsal aorta is a narrow, slender and tubular structure extending from the second abdominal segment to the base of the brain where it bifurcates.

The dorsal diaphragm is present as a membranous sheet extending from the posterior margins of the second to eighth abdominal terga. There are three pairs of alary muscles.

The respiratory system (Pl. I, figs. 4-5)

The respiratory system consists of spiracles and the tracheal tubes. There are two pairs of thoracic spiracles, viz. mesothoracic and metathoracic. As regards the abdominal spiracles there are six pairs in the male and seven pairs in the female.

Each thoracic spiracle is provided with a pair of elongated valve-like lips or opercula while in all the abdominal spiracles the opercula are absent.

The tracheation of the body includes the short spiracular tubes which extend from the atrium and give rise to the dorsal, visceral and ventral tracheae. The dorsal tracheae unite in a series to form a longitudinal trunk on either side. The ventral tracheae of the corresponding sides extend transversely and join to form the ventral commissures. There are no visceral and ventral longitudinal trunks. All the tracheae give rise to several branches which are further subdivided into tracheoles. In the region of the thorax there are two well-developed flask-shaped air sacs. These sacs which function as air storage organs are the anterior dilatation of the lateral longitudinal trunks.

The nervous system (Pl. I, figs. 6-8)

The nervous system can be divided into the central nervous system and the stomodaeal nervous system. The central nervous system comprises the brain, the suboesophageal ganglion and the ventral nerve cord with all its ganglia fused into a single mass. The brain is divisible into three regions, viz. 'protocerebrum', 'deutocerebrum' and 'tritocerebrum', but these regions are not very clearly demarcated externally.

The 'protocerebrum' is the largest part of the brain. From each lobe there extends laterally a large optic lobe from which arise the optic and ocellar nerves.

The middle part of the brain lying ventral to the 'protocerebrum' is the 'deutocerebrum', the branches of which innervate the antennae. Beneath the 'deutocerebrum' are a pair of oblong lobes which represent the 'tritocerebrum'. From the suboesophageal ganglion arise three pairs of nerves which innervate the mandibles, the maxillae and the labium. The prothoracic ganglion gives out three pairs of nerves innervating the muscles and legs of the segment. The pterothoracic and all the abdominal ganglia are fused into a single mass known as pterothoracic-cum-abdominal ganglionic centre. It is the biggest ganglion and is placed on the basisternum of the mesothorax.

A large median nerve issuing from the posteriormost extremity of the ganglionic centre bifurcates distally in the middle of the seventh abdominal segment. Ten pairs of nerves arising from the ganglionic centre innervate the pterothoracic muscles and legs, and also the muscles and fatty tissue of the first four abdominal segments. Three pairs of nerves issuing from the median nerve innervate the musculature of the remaining abdominal segments.

The stomodaeal nervous system supplies nerves to the stomodaeal parts of the alimentary canal. It is situated dorsally and consists of a small frontal ganglion lying above the oesophagus, just in front of the brain. From its posterior region arises a single recurrent nerve which runs beneath the brain and expands a little behind the brain into a hypocerebral ganglion. Attached to the hypocerebral ganglion by two short nerves is a pair of ganglia known as corpora cardiaca. A non-nervous structure, corpus allatum, is contiguous with the posterior part of the corpora cardiaca.

Reproductive system

Male reproductive system (Pl. I, fig. 9).—It comprises a pair of testes, two vasa deferentia, a complex bulbus and ductus ejaculatorius, mesodermal and ectodermal accessory glands known as mesadenia and ectadenia respectively.

The elongate and ovoid testes lie in the body cavity in between the third and fifth abdominal segments. Each testis is enclosed in a scarlet-red scrotum. From the base of each testis arises the vas deferens which opens into the bulbus ejaculatorius. The proximal part of the ejaculatory duct is dilated to form a bulb-like structure designated as bulbus ejaculatorius, while posteriorly it is continued as a narrow tube called ductus ejaculatorius. The distal sclerotized portion of the duct lying within the aedeagus is termed as 'virga'. There is a pair of spherical transparent sacs, known as bacterial sacs, one on each side of the bulbus ejaculatorius. These bacterial sacs contain spherical bacteria and they open to the exterior by a common duct through a pore on the mid-ventral line of the membrane between the eighth abdominal segment and the genital capsule. These sacs may also be compared to the subgenital glands described by Bonhag and Wick (1953) in *Oncopeltus*.

Female reproductive system (Pl. I, figs. 10-11).—The female reproductive organs consist of a pair of ovaries, a pair of lateral oviducts and a common oviduct. The other associated structures are the spermatheca and a pair of accessory glands which open into the genital chamber.

Each ovary is composed of six acrotrophic ovarioles. Woodward (1950) has described the presence of seven ovarioles in the ovary of Pentatomidae but in the present insect their number is six only.

An ovariole consists of the terminal filament, germarium, vitellarium and pedicel. The terminal filaments of the ovarioles of each ovary unite together to form a long suspensory ligament which implants itself in the thorax. The vitellarium presents a beaded appearance due to the presence in it of the oocytes at various developmental stages.

The median oviduct is a short thick tube connecting the lateral oviducts with the genital chamber. The spermatheca or sperm-storage organ of the female is an unpaired sac-like structure lying on the right side of the body.

The accessory glands are paired filiform thread-like structures opening into the genital chamber by a single aperture. Their secretion is used for gluing the eggs to the substratum.

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EXPLANATION OF PLATE I

FIGS. 1 TO 11. 1, alimentary canal; 2, salivary gland; 3, heart with dorsal diaphragm and muscles; 4, tracheal system (dorsal view); 5, tracheal system (ventral view); 6, nervous system (dorsal view); 7, nervous system (ventral view); 8, stomodaeal nervous system (dorsal view); 9, male reproductive system; 10, female reproductive system; 11, an ovariole.

Letterings for Figs. 1 to 11:

*Abd*₁ = First abdominal nerve; *Abd*₄ = Fourth abdominal nerve; *Abd*₇ = Seventh abdominal nerve; *Acd* = Accessory duct; *Aeg* = Accessory gland; *A.int* = Anterior intestine; *Alm* = Alary muscles; *An* = Anus; *Anc* = Anal canal; *Ant.T* = Antennal trachea; *Antn* = Antennal nerve; *Ao* = Aorta; *Bcs* = Bacterial sac; *B.ej* = Bulbus ejaculatorius; *Cca* = Corpora cardiaca; *C.ovid* = Common oviduct; *Cpal* = Corpus allatum; *Ddp* = Dorsal diaphragm; *Drll* = Dorsal longitudinal trunk; *Drt* = Dorsal trachea; *D₁sp₁* = First dorsal branch of first spiracle; *D₁sp₂* = First dorsal branch of second spiracle; *D₂sp₁* = Second dorsal branch of first spiracle; *Ecd* = Ectadenes; *Ej.d* = Ejaculatory duct; *E.T* = Eye trachea; *Foe* = Foramen for oesophagus; *Frg* = Frontal ganglion; *Gnc* = Genital chamber; *Gnp* = Gonopore; *Grm* = Germarium; *Ht* = Heart; *Hgg* = Hypocerebral ganglion; *Lg* = Suspensory ligament; *L.ovid* = Lateral oviduct; *Mb.sp₁* = Mesal branch of first spiracle; *Md.T* = Mandibular trachea; *Mht* = Trachea supplying muscles of the head; *Mn* = Median nerve; *Mpt* = Malpighian tubule; *Msd* = Mesadenes; *M.sp₂* = Median branch of second spiracle; *Mat* = Trachea supplying maxillary stylet; *Ocn* = Ocellar nerve; *Oes* = Oesophagus; *Opl* = Optic lobe; *Ost* = Ostiole; *Ovl* = Ovariole; *Pcag* = Prothoracic-cum-abdominal ganglion; *Pdc* = Pedicel; *Psy* = Principal salivary gland; *Ptg* = Prothoracic ganglion; *Rct* = Rectum; *Rnw* = Recurrent nerve; *Slt* = Salivary duct; *Slst* = Salivary syringe trachea; *Sog* = Suboesophageal ganglion; *Spt* = Spermatheca; *T.fl* = Terminal filament; *Tt* = Testis; *Vdf* = Vas deferens; *Vdl* = Ventral branch of first dorsal trachea; *V₁sp₁* = First ventral branch of first spiracle; *V₁sp₂* = First ventral branch of second spiracle; *V₂sp₁* = Second ventral branch of first spiracle; *V₂sp₂* = Second ventral branch of second spiracle; *V₃sp₂* = Third ventral branch of second spiracle; *V₄sp₂* = Fourth ventral branch of second spiracle; *Vst* = Visceral trachea; *Vt₁* = First ventriculus; *Vt₂* = Second ventriculus; *Vt₃* = Third ventriculus; *Vt₄* = Fourth ventriculus; *Vtm* = Ventral transverse commissure; *Vll* = Vitellarium.

