MORPHOLOGY AND HISTOLOGY OF THE MALE
REPRODUCTIVE ORGANS OF UTETHEISA
PULCHELLA L. (LEPIDOPTERA : ARCTIIDAE)

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INTRODUCTION

Although the importance of reproductive organs as the basic taxonomic characters has been realised by many a worker (Stitz, 1903; Zender, 1904; Ruckes, 1919; Freeman, 1960; Munroe, 1964, etc.), it has not been possible to use them in several orders of insects. An obvious reason of the latter fact is the existence of a number of lacunae in our present knowledge of these vital organs.

Among Lepidoptera, the classification of several families consisting of large number of insects of agricultural importance, is based on the diversity of genital characters. As such, morphological studies substantiated by histological observations of the genital organs of the members of Lepidoptera presents a wide scope for investigation. Among the earlier contributions on the reproductive organs of lepidopterous insects the works of Norris (1932) and Williams (1947) on the internal reproductive organs of Ephesia and Plodia and certain Teneoidae respectively are of great significance. The histology of the genital organs of the different members of this order has, however, been studied by various workers like Eidmann (1929); Hewer (1932); Musgrave (1937); Srivastava (1960); Callahan and Chapin (1960), etc.

Surprisingly enough little is known regarding the morphology and histology of the male reproductive organs of the members of the family Arctiidae. The present study on the morphology and histology of the reproductive system of Utetheisa pulchella has, therefore, been undertaken to fill in the existing gap.

MATERIAL AND TECHNIQUE

The insects for the present study were collected from the sunhemp growing area near Jaipur. The adults were killed in 70% alcohol and dissected under
stereoscopic binocular microscope. The reproductive organs were dissected out on a glass slide, dehydrated, stained with eosin and mounted in Canada balsam. For histological studies serial sections were cut at 8μ and staining was done in haematoxylin and eosin. The diagrams were drawn with the help of a camera lucida.

DESCRIPTION

The External Genital Organs

The genital apparatus is composed of the terminal abdominal segments (Fig. 1). Only the eighth abdominal segment is visible externally as the ninth and tenth segments get invaginated into the eighth.

The eighth segment is least modified and forms the protactile base for the genital apparatus. It comprises large sclerites which are sclerotized at the posterior margins. The margins of the tergum and sternum do not form any process.

FIG. 1. The external genital organs.

FIG. 2. Gross anatomy of the internal genital organs (Diagrammatic).
The tergum of the ninth segment is the tegumen (TG). It forms a large plate which covers the whole genitalia and the sternites of the segment. Posteriorly, the tegumen ends into a more or less semicircular arch through which opens the rectum and the internal genitalia. The antero-lateral margins of the tegumen are fused to form the vinculum (VM) and the antero-ventral sides are guarded by a pair of leaf-like valvae (V). The vinculum is highly el itinised with horse-shoe shaped sclerotized band and the lateral arms are completely fused with the tegumen. The valvula constitute the largest part of the male genitalia. They are adorned by long tufts of hair and scales. The costa, the valvula and the sacculus are completely fused. A chitinised harp (HRP) and a marginal spine (MS) are present on each valve.

The tenth segment is much reduced and represented by a knob-like structure, the uncus (U). The tip of the uncus is ring-like and is devoid of any tubercles or bristles. The gnathos (GN) is a stout rod-like projection at the tip of the uncus. A sharp inwardly pointed spine originates from the middle of the gnathos.

The Internal Genital Organs

They comprise the testes (T), the vasa deferentia (VD), the accessory glands (AG), the ejaculatory ducts (PED, CED) and the aedeagus (Fig. 2, AE). The testes are completely fused and enclosed in a single testicular sac, the scrotum. It is placed in the dorsal position, close to the alimentary canal and just beneath the fourth and fifth terga. The vasa deferentia originate broadly from a depression on the ventral side of the testes. Each of them gradually narrows and suddenly dilates near its middle to form the vesicula seminalis (VS). The distal end of each vas deferens joins at right angles to the anterior portion of the paired ejaculatory duct or ductus ejaculatorius duplex of its side. A pair of long tubular and twisted accessory glands is opened into the upper end of the paired ejaculatory duct of its side. The two ejaculatory ducts unite to form a common ejaculatory duct or the ductus ejaculatorius simplex. The latter is a long tube and lies in the posterior abdominal segments to form a coiled structure. Before it communicates with the aedeagus at its anterior end, it expands into a recurved bulbus ejaculatorius (BE). Finally, it opens through the gonopore in the ninth segment.

Testes.—The fused testis is more or less circular in shape and is 0.9 mm. in diameter. The scrotum is highly pigmented and encloses eight follicles. The latter are spirally wound up around the longitudinal axis of the gonad. The testicular follicles are lined with a layer of epithelium whose cells lie
externally upon a thin basement membrane. This membrane is surrounded outside by a peritoneal coat consisting of two distinct layers of cells. The outer cellular wall (OCW) is composed of compact cells having elongated nuclei and granular cytoplasm (Fig. 3). It is traversed by numerous tracheoles (TR). The inner cellular wall (ICW) sends off finger-like projections towards the hilum which marks the partitions of the follicles. It is composed of pigmented cells and is also permeated by tracheoles.

Within the testicular chamber, the spermatogonia (SPG), the spermatocyst (SPC) and the sperms are distinctly visible. The primary germ cells are more abundant towards the periphery. The spermatozoids form large bundles (SB) which are scattered throughout the chamber. There is no trace of trachea in the follicular epithelium.

Vasa deferentia and vesicula seminalis.—The two vasa deferentia originate deep into the fused testis (Fig. 4). Each vas deferens is about 6 mm. long. The scrotum (SC) of the testis continues with the basement membrane (BM) of the vas deferens (VD). On the inner side of the basement membrane is the epithelium (EPIT) which is composed of long columnar cells. The cells are uneven and bear rod-like or oval nuclei (N). The epithelium has
a prominent striated border (SBD) limited only at the origin of the vas deferens. The lumen is filled with the secretion (SEC) and germ cells.

Each vesicula seminalis is a sac-like dilation of the vas deferens. It has a prominent basement membrane (BM) which supports the outer wall of the epithelium (Fig. 5, EPIT). The latter is composed of irregularly marked columnar cells. The spermatozoa are found closely massed in the vesicula which shows that this region acts as a store of the discharging germ cells. The lumen of the lower vas deferens is quite narrow and the small cells of the epithelium lie on the basement membrane. The cells possess irregular nuclei.

**Accessory glands.** —The junction between the accessory glands and the paired ejaculatory ducts are marked by constrictions. The glands are closely united along their entire length by a fine network of tracheoles. Each gland is about 15 mm. long. Histologically they are bound externally by the basement membrane (Fig. 6, BM). The syncytial epithelium (EPIT) appears to have formed of a single row of cells. The nuclei (N) are small, round and scattered indifferently in the granular cytoplasm. The lumen is filled with vacuolated secretion specially at the free ends. The muscular coat outside the basement membrane is not present.

![Fig. 5. T.S. vesicula seminalis.](image1)

![Fig. 6. T.S. accessory gland.](image2)

**Paired ejaculatory duct.** —The two ducts of either side are joined at their distal end to form a U-shaped connection. The anterior end of each duct receives an accessory gland. Each duct is about 3 mm. long. The lumen of the duct is enlarged and the epithelium (EPIT) is bound by a well-developed basement membrane (Figs. 7 and 8, BM). The epithelium is composed of large columnar cells. The cell-walls are distinct and the cytoplasm is granular.
The nuclei (N) are large, granular and greatly elongated. The disintegration of cells is continuous with the secretory activity of the cells. Sperm cells are seen floating in the secretion (SEC) and their accumulation in the duct results in the size of lumen. The basement membrane has neither circular nor longitudinal muscles which are perceptible.

**Common ejaculatory duct.**—The duct is extremely variable and differs in width throughout its length. It forms convolutions in the posterior abdominal segments and is about 41 mm. Histologically, the duct shows three distinct glandular regions and a chitinous region.

(a) The glandular region.—Just after the junction of the paired ejaculatory ducts the common duct occupies a large lumen which is lined by cuboidal epithelial cells (Fig. 9, EPIT). The cell-walls are quite distinct with coarsely granular cytoplasm and the nuclei (N) are more or less circular in shape. The edges of the cells along the lumen are even and closely resemble the secretory areas of the accessory glands. The lumen is filled with spermatophores and the secretion (SEC) exuded by the epithelial cells. The outer wall of the epithelium has a prominent basement membrane (BM) which has no muscular coatings.

Unlike the first region the second region has a syncytial epithelium (Fig. 10, EPIT). The cytoplasm is glandular and bears a large number of round nuclei (N) which are placed near the outer margin of the epithelium. The
lumen is quite narrow and filled with the secretion (SEC). The inner wall of the epithelium is even and the outer wall is lined by a basement membrane (BM).

The region is again expanded and bears a conspicuous lumen (Fig. 11). The epithelium (EPIT) has small cuboidal cells possessing highly glandular cytoplasm. The nuclei (N) are round and prominent. The cells have smooth inner edges and are bound externally by a common basement membrane (BM). The lumen is filled with the vacuolated secretion (SEC).

**(b) The chitinous region.—**The distal end of the common ejaculatory duct before entering the aedeagus recurses to form an inverted C-shaped structure the bulbous ejaculatorius. The epithelium of the inner duct is distinct while that of the outer tube is degenerated except a few flexible cells. The area between the two epithelia is filled with weakly developed chitin which gives the whole structure a stiff appearance. Posteriorly, the lumen of the main duct continues into the aedeagus.

**Aedeagus.—**The terminal section of the ejaculatory duct is enclosed into a rod-like evagination the aedeagus (Fig. 12). It has an inner sheath which is sclerotised. When at rest the endophalous is folded and retracted.

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**Fig. 9.** T.S. through the anterior region of the common ejaculatory duct.

**Fig. 10.** T.S. through the middle region of the common ejaculatory duct.
with the gnathos. The space between the aedeagus and the endophalous is filled with long fibres of longitudinal muscles.

**Fig. 11.** T.S. through the posterior region of the common ejaculatory duct.

**Fig. 12.** Aedeagus.

**DISCUSSION**

Snodgrass (1935) described that the genital complex of male Lepidoptera includes the eighth, ninth and tenth abdominal segments. Freeman (1960) observed that the male genitalia in the needle miners of the families Gelechiidae, Yponomentidae, Olethreutidae and Torticidae is derived from the modified ninth, tenth and eleventh abdominal segments. The present study, however, supports Snodgrass's view. In *Utetheisa pulchella* the ninth tergite and the ninth sternite are represented by the tegumen and the vinculum while the tenth tergite is modified into the uncus. As such, it is clearly inferred that the eighth segment also plays an important role in the composition of the male reproductive organs.

**Testes.**—The primitive testes are found in *Hepialus* where each follicle is digitate and encloses in a separate scrotum (Imms, 1957). In Micropterygidae and certain Saturniidae four follicles are enclosed in a sheath to form two distinct testes, whereas in the specialised groups all the follicles are enclosed in a common scrotum and thus presents a single testis. The last type has been observed in certain Tineoidae (Williams, 1947), *Leucinodes orbonalis* (Srivastava, 1960) and the insect under study.

Ruckes (1919) reported that the tracheoles innervate the follicular epithelium of the lepidopterous testes. In *U. pulchella*, tracheoles are com-
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...completely absent in the follicular epithelium. Cholodkovsky (1884) and Demokidoff (1902) have also observed the absence of tracheoles in the follicular epithelium of the insects belonging to this order.

**Vasa deferentia and vesicula seminalis.**—Rakshpal (1944) in *Galleria mellonella*, Williams (1947) in Tineodae and Srivastava (1960) in *Leucinodes orbonalis* showed that the vasa deferentia originate from the ventrolateral angles of the testis and are widely placed from each other. Hewer (1932) in *Zygaena*, Norris (1932) in *Ephestia* and *Plodia* and Musgrave (1937) in *Ephestia* observed that these structures lie one above the other from the origin on the ventral side of the testis. The vasa deferentia in *U. pulchella* originate from the deep median groove on the ventral side of the testis and lie side by side very close to each other. The epithelial cells of the vasa deferentia are provided with a fine striated border at the point of origin and do not continue along their whole length. Such brush borders were also noticed by Musgrave (1937) and Srivastava (1960) in *Ephestia kuhinella* and *Leucinodes orbonalis* respectively.

**The accessory glands.**—The accessory glands are secretory in nature and help in the formation of spermatophores (Khalifa, 1950). The epithelial cells of the secretory glands in the present insect possess glandular cytoplasm of the secretory nature. Omura (1938) has earlier demonstrated that the secretion exuded by such glands in *Bombyx mori* hardens and blocks the copulatory opening after copulation. The secretory nature of accessory glands is also reported by Eltringham (1925) in *Parnassius apollo*, Srivastava (1960) in *Leucinodes orbonalis* and Callahan and Cascio (1963) in *Heliothis zea*.

**The ejaculatory ducts.**—The ejaculatory duct of the male reproductive organs of Lepidoptera was distinguished by Cholodkovsky (1884) as the U-shaped paired part and the unpaired part. This terminology was used by later workers but Stitz (1903) observed glandular epithelium in the walls of the ductus ejaculatorius duplex and the greater part of the ductus ejaculatorius simplex and termed them as paired and unpaired glands respectively. He further observed that the terminal point of the ejaculatorius simplex bears a prominent muscular coat and termed it as the bulbus ejaculatorius. Norris (1932) and Musgrave (1937) supported the view put forward by Stitz but there is no reason to believe in applying these ducts as paired and unpaired glands particularly in view of the fact that there are other secretory or glandular structures in the insect body which are not termed as glands. Rakshpal (1944) gave correct interpretations to these ducts while working on the develop-
ment of the reproductive organs in *Galleria mellonella*. He termed the ductus ejaculatorius duplex as paired ejaculatory duct and the ductus ejaculatorius simplex as the common ejaculatory duct. He further pointed out that the paired ejaculatory ducts are developed from the common ejaculatory duct. Hence this terminology is more applicable and found to be convenient to describe these ducts.

**Summary**

The external and internal reproductive systems of the male *Utetheisa pulchella* has been studied. The external genitalia is composed of the eighth, ninth and tenth abdominal segments. The costa, valvula and sacculus are completely fused. The tegumen is fairly broad, the vinculum is horse-shoe-shaped and the valvula are leaf-like. The tenth segment is much reduced and represented by a round uncus. A gnathos is present which bears a sharp-pointed incurved spine.

The testicular follicles are without tracheoles and enclosed in a single scrotum. The vasa deferentia are broader at the base but dilate slightly in the middle to form the vesicula seminalis. The posterior ends of vasa deferentia open into the paired ejaculatory ducts of each side. A pair of accessory glands opens at the free ends of the paired ejaculatory ducts. The latter unite to form a common ejaculatory duct which is much coiled. A prominent bulbus ejaculatorius is present at the terminal end of the common ejaculatory duct prior to its opening in the aedeagus. The histological structures of different parts have been described in detail.

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ABBREVIATIONS USED IN FIGURES

(AE, aedeagus; AG, accessory glands; BE, bulbous ejaculatorius; BM, basement membrane; CED, common ejaculatory duct; EPIT, epithelium; GN, gnathos; HRP, harp; ICW, inner cellular wall; MS, marginal spine; N, nuclei; OCW, outer cellular wall; PED, paired ejaculatory duct; SB, sperm bundles; SBD, striated border; SC, scrotum; SEC, secretion; SPC, spermatocyst; SPG, spermatogonia; T, testis; TG, tegumen; TR, tracheole; U, uncus; V, valvulae; VD, vasa deferentia; VM, vinculum; VS, vesicula seminalis.)