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TAXONOMIC SIGNIFICANCE OF MALE GENITALIA IN CERTAIN MICROLEPIDOPTERAN MOTHS

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Ten microlepidopteran species have been dissected to describe the taxonomic morphology for the male genitalia from different families namely Cosmopterygidae, Gelechiidae, Pterophoridae, Tineidae, Tortricidae and Yponomeutidae. Elucidation in variations of taxonomic structures have also been attempted and tabulated.

INTRODUCTION

The components of the male genitalia involved in sexual mating are collectively derived from 8^{th}, 9^{th} and 10^{th} abdominal segments and their diversification makes them of great value in taxonomy. Bethune-Baker (1914) pioneered the taxonomic value of the genital armature in Lepidoptera. Eyer (1924) described the chitinized aedeagus and well defined juxta of great fundamental importance in classification. Accordingly the development of uncus, gnathos and reduction in the size of the vinculum have been of noticeable significance in the families of higher Tineoidea. Eyer (1926) further described the morphology of the male genitalia whereas Stekolnikov (1967) studied the functional morphology of the copulatory apparatus. The study of systematic importance of the male genitalia in Microlepidoptera was emphasized by Busck & Heinrich (1921). However, the role of functional morphology of the male genitalia was also discussed to establish the phylogenetic relationship in Tortricidae, a family of Infraorder Papilionomorpha and this was further discussed more recently by Kuznetsov & Stekolnikov (1977 & 1981), respectively. Microlepidopteran moths are poorly described in Oriental India, hence present study being undertaken to elaborate the male genitalic structures of taxonomic significance in different microlepidopteran moths surveyed from Uttaranchal, the plains of Himalayas in north-western region of Uttar Pradesh and Madhya Pradesh (India).

MATERIALS AND METHODS

The genitalia of Microlepidoptera was taken out with dried specimens from the collection made with the help of a portable light trap from different interior localities. The ethyl acetate killed and preserved specimens were then macerated by the use of KOH for the preparation, and isolation of genital tract. The KOH treated material was then washed with distilled water. The residual traces of KOH were later removed by putting the material in 1% glacial acetic acid. Preparation of the genital tract *in situ* based on dried specimens surveyed from different families (Table I) representing various parts were passed through different alcoholic grades for dehydration before mounting in DPX.

In order to facilitate a complex examination of different parts of the genitalia, the aedeagus and one of the valvae were detached and placed separately on slide. Close to the male genitalia, proportionate sketches were drawn.

Table I : Mapping of different microlepidopteran moths surveyed from different localities.

S.No.	Family	Species	Distribution
1.	Gelechiidae	*Lecithocera aulias* (Meyr.)	Shukratal, Hastinapur, Meerut, Muzaffarnagar
2.	Gelechiidae	*Lecithocera fortis* (Meyr.)	Hastinapur, Muzaffarnagar, Shukratal
3.	Yponomeutidae	*Plutella maculipennis* Curt.	Muzaffarnagar, Agra, Gwalior
4.	Cosmopterygidae	*Lecithorus trigonopis* (Meyr.)	Pantnagar, Muzaffarnagar, Shukratal, Meerut, Bijnore
5.	Cosmopterygidae	*Caloptilia tetratypa* (Meyr.)	Muzaffarnagar, Saharanpur, Baraut, Gwalior
6.	Tortricidae	*Bactra truculenta* (Meyr.)	Muzaffarnagar, Ghaziabad
7.	Tortricidae	*Enarmonia koenigiana* Fabr.	Muzaffarnagar
8.	Tortricidae	*Eucosma critica* (Meyr.)	Muzaffarnagar
9.	Pterophoridae	*Exelastis pumilio* (Zeller)	Hastinapur, Muzaffarnagar, Shukratal, Gwalior
10.	Tineidae	*Hapsifera seclusella* (Wlk.)	Shukratal, Gurukul Narsan, Hastinapur, Muzaffarnagar

OBSERVATIONS

Male genitalia in different microlepidopteran species

Lecithorus trigonopis (Meyr.) (Figs. 1 & 2)

The male genitalia is a compact ring-like sclerotized structure situated in the terminal abdominal lumen. It is a modified part of the tergite into a tegumen dorsally, whereas the latero-ventral in to a vinculum. The vinculum is a thin, flattened, conical part extending cephalad into the preceding segment known as the saccus.

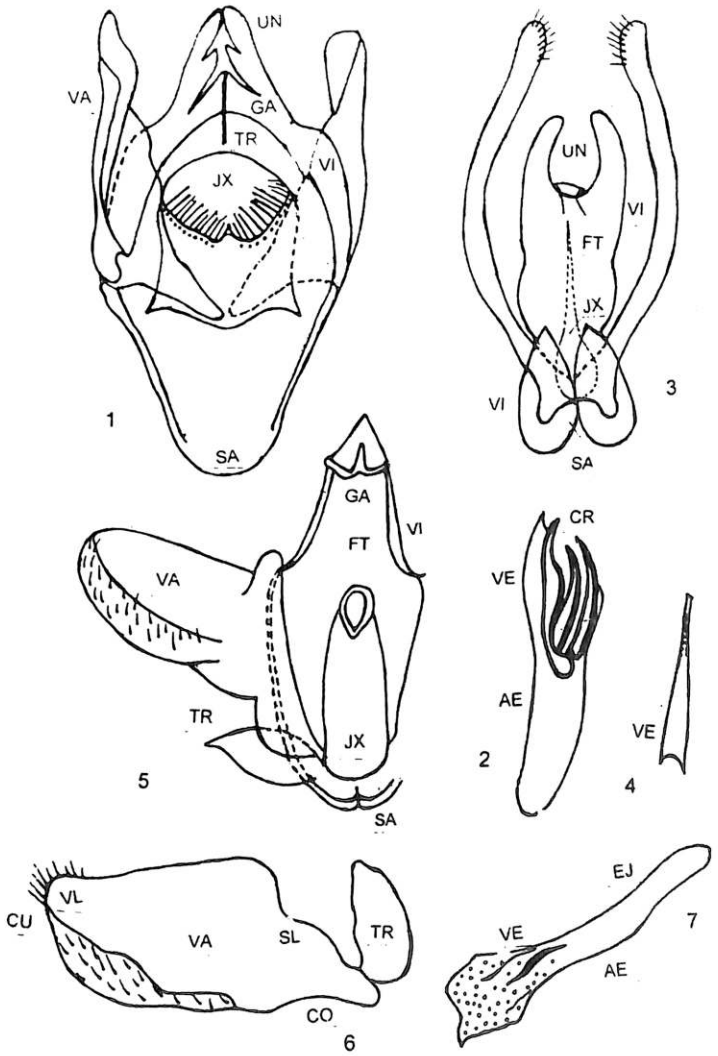
The uncus is a mid-dorsal, large, hook-like structure having sclerotized small outgrowth ventrally. The uncus originates and attaches with the hinder margin of tegumen to form a functional unit of the 10^{th} abdominal segment. Attached to the caudal margin, each side ventrad to the tegumen is the gnathos. The two halves of the gnathos remain separated and are heavily sclerotized and denticulate. Hence, ventrad to the tegumen and uncus, the last part of the digestive tract known as tuba analis ending into an anus is rather supported by gnathos, forming a flattened and trough-like plate.

A transverse, membranous, thin sheet, across the body form the tegumen and tuba analis ventrally along the vinculum, and up to the base of the valvae is the diaphragm. Anellus, the dorsal part of the diaphragm is now called as fultura superior. The transtilla is distinct.

The pair of moveable claspers or valvae are hinged with the vinculum, formed by the tegumen and supported by the juxta. Each valva is elongated, strongly sclerotized and curved structure distinct dorso-ventrally. It is paired and with a deep notch on ventro-lateral margin. The valvae help in approximation of the female abdomen during mating. Proximally the valva has a well developed margin as costa whereas remaining sclerotized and membranous part is the harpes, which is ventro-proximally known as sacculus. The dorso-distal part of the valva is cucullus and

ventro-distal is the valvula.

A median juxta is basally flattened, broad and almost rectangular, extending ventro-distally, both the sides of each projects into narrow spines armed with a row of marginal setae, having prominent basal alveoli. The aedeagus is long, cylindrical, straight and functions as intromittent organ, whereas distal part is vesica and the proximal part of the aedeagus is the ductus ejaculatorius. The vesica is the reversible part of the aedeagus and often bears three sclerotized spines termed as cornuti which penetrates into the bursa copulatrix of the female during copulation.



Figs. 1-7 : 1. *L. trigonopis* male genitalia; **2.** Aedeagus; **3.** *C. tetratypa* male genitalia; **4.** Aedeagus; **5.** *L. aulias* male genitalia; **6.** Valva; **7.** Aedeagus.

Caloptilia tetratypa (Meyr.) (Figs. 3 & 4)

Uncus long and broad, having bifid tip; gnathos well developed; vinculum u-shaped ventrally, having two bulb-like structures; saccus short and hemispherical; valvae long, narrow and setosed at the tip; cucullus, valvula, costa and sacculus poorly differentiated; juxta swollen at the base having pointed distal end; transtilla sclerotized narrow and large in size. Aedeagus short, slender, pointed, spine-like posterior end and broader at the anterior end; vesica absent, black spot-like markings present on the spine-like structure.

Lecithocera aulias (Meyr.) (Figs. 5, 6 & 7)

Uncus curved, narrow posteriorly and ventrally sclerotized; gnathos well developed, enlarged, triangular as spine-like; vinculum u-shaped; saccus short and semicircular; valvae large, broad and spoon-like having few setae onwards; valvula, cucullus, sacculus and costa well differentiated; juxta like a barrel, having a cap-like strucutre apically; transtilla sclerotized, small and flat. Aedeagus short, open s-shaped structure, with a fine spine-like cornuti seen through vasical membrane, anterior part broad as the vesica, and posteriorly a cylindrical part as ejaculatorius.

Lecithocera fortis (Meyr.) (Figs. 8 & 9)

Uncus sclerotized, small, bifid with few setae on either side; gnathos indistinct; tegumen well developed, flattened, rectangular, plate-like, articulating at the two points with the valvae; vinculum enlarged, wide, and posteriorly narrow distally; saccus and valvae setosed dorso-laterally, longer than uncus, pointed distally; sacculus and costa well developed; juxta flattened and triangular, transtilla present as spine-like. Aedeagus elongated, cylindrical with short vesica and long proximal part ductus ejaculatorius; vesica armed with double, long and slender cornuti.

Exelastis pumilio (Zeller) (Figs. 10 & 11)

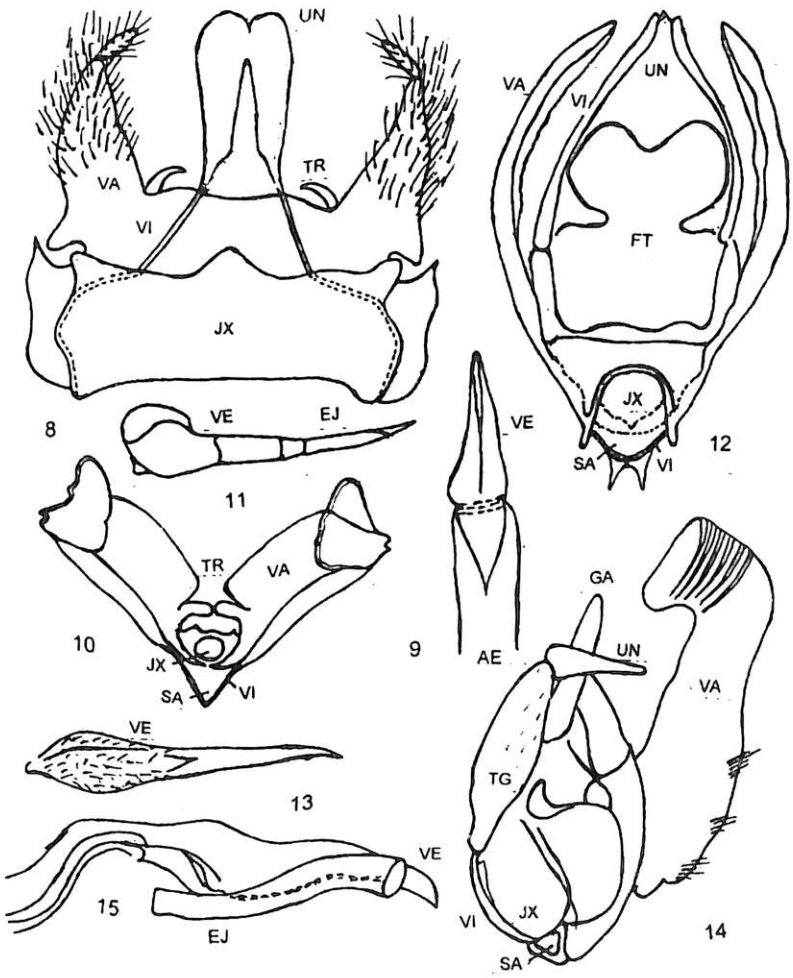
Uncus delicate and poorly developed; vinculum short and v-shaped; saccus triangular, valvae with sacculus and well developed costa; valvula well developed with large bifid cucullus, having broad tip-like crown; juxta small and round shaped; transtilla sclerotized and poorly developed. Aedeagus short, segmented and narrow proximally, vesica with prominent cornuti.

Hapsifera seclusella (Wlk.) (Figs. 12 & 13)

Uncus broad and narrow having trifid tip with a few setae on either side; gnathos poorly developed; tegumen reduced; vinculum long and v-shaped ventrally, saccus semicircular, valvae long and flattened with a ring, spine at tip; juxta flattened and triangular; transtilla sclerotized, large in size. Aedeagus long slender pointed at posterior end and bulges as bulb-like at the anterior end.

Bactra truculenta (Meyr.) (Figs. 14 & 15)

Uncus large, triangular, spine-like; the uncus and scaphium fit perfectly into a spiny, dorsal and ventral furrow, situated longitudinally between the papillae. This is described as a secondary lock-and key system in contrast to the primary lock-and key systems formed by the interaction of juxta, aedeagus and vesica in male on one hand and the sterigma, ductus bursae (caudal part of bursa) and cervix bursae in female on the other hand. The primary lock-and key clearly works during the copulation and the transfer of spermatophore. The secondary lock-and key is supposed



Figs. 8-15 : 8. *C. tetratypa* male genitalia; **9.** Aedeagus; **10.** *E. pumilio* male genitalia; **11.** Aedeagus; **12.** *H. seculusella* male genitalia; **13.** Aedeagus; **14.** *B. truculenta* male genitalia; **15.** Aedeagus.

to work as a guiding system in the beginning of the copulation. Gnathos well developed and equal to uncus in length; vinculum w-shaped; saccus short and triangular; valvae setosed, long, broad and curved having long setae at distal part, medially two spine-like outgrowths, originating in dorso-lateral position; cucullus, valvula, costa and sacculus well differentiated; juxta small and triangular; transtilla sclerotized and moderate in size. Aedeagus long, slender slightly curved, vesicae armed with a single ventrally, long, slender, cornutus.

Enarmonia koenigiana Fabr. (Figs. 16 & 17)

Uncus small, lobe-like, having bifid tip; gnathos reduced; vinculum u-shaped, having two spines downward where aedeagus moves; saccus short and triangular; valvae long, narrow,

Table II : Grouping of the male genitalic characters significant in taxonomy.

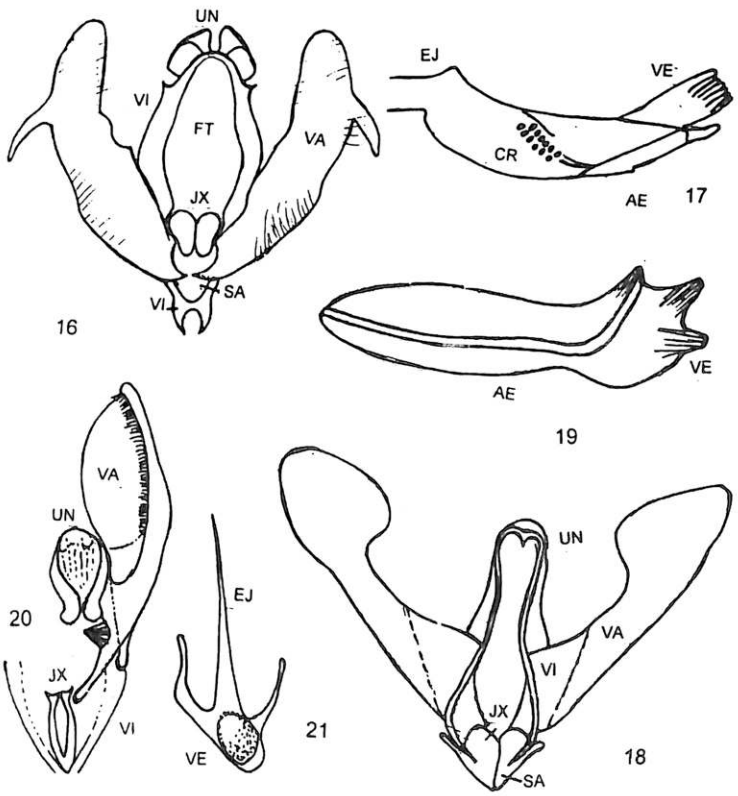
Uncus	Gnathos	Vinculum	Saccus	Juxta	Transtilla	Aedeagus
Small, narrow at tip (5,18)	Reduced (1,12,16)	Narrow dorsally, wide & enlarged ventro-laterally (8)	Small, semi-circular (3,5,8,18)	Small, semi-circular (10)	Reduced or indistinct (16,18)	Short , selender (4,7,11,19,21)
Small, bifid (8,16)	Narrow, spine-like (5)	Wide, u-shaped (1,3,5,16,18)	Short, triangular (10,14,16,20)	Small, circular (20)	Moderate (5,10,14,20)	Elongate, selender with cornuti (2,9,13,15,17)
Small, trifid (12)	Enlarged (3,14)	Wide, v-shaped (12,20)	Large, semi-circular (1)	Small, triangular (14)	Enlarged (1,3,8,12)	
Large, narrow at tip (1,2,14)	Indistinct (8,10,18,20)	Wide, w-shaped (14)	Indistinct (8)	Flattened, rectangular (1,8,12)		
Indistinct (10)		Short & v-shaped (10)		Flattened, bilobed (16)		
Broad & lobe-like (20)				Flattened, spear-like (18)		
				Barrel shaped, cupped terminally (5)		
				Base swollen, narrow posteriorly (3)		

Figs. 1-21 (Fig. numbers in parentheses denote the name of the species) : **1. & 2.** *Lecithorus trigonopis* (Meyr.); **3. & 4.** *Caloptilia tetratype* (Meyr.); **5. 6. & 7.** *Lecithocera aulias* (Meyr.); **8. & 9.** *L. fortis* (Meyr.); **10. & 11.** *Exelastis pumilio* (Zeller); **12. & 13.** *Hapsifera seclusella* (Wlk.); **14. & 15.** *Bactra truculenta* (Meyr.); **16. & 17.** *Enarmonia koenigiana* (Fabr.); **18 & 19.** *Eucosma critica* (Meyr.); **20. & 21.** *Plutella maculipennis* (Curt.).

cucullus, valvula, costa and sacculus very much differentiated; juxta bilobed; transtilla indistinct. Aedeagus long, slender, curved and hook-like showing black marking through membrane, vesica armed with a single, ventrally long, slender cornuti.

Eucosma critica (Meyr.) (Figs. 18 & 19)

Uncus small and reduced; gnathos indistinct; vinculum elongate and u-shaped; saccus small and semicircular; valvae large, broad, having a notch in the middle, presence of setae at the tip; valvula ventro-lateral, cucullus, sacculus and costa well differentiated; juxta spear-shaped with postero-lateral spines on either side; transtilla reduced. Aedeagus short, slender, curved and having three bulged structures at the anterior whereas vesica posteriorly cylinder-like structure known as ductus ejaculatorius.



Figs. 16-21 : 16. *E. koenigiana* male genitalia; **17.** Aedeagus; **18.** *E. critica* male genitalia; **19.** Aedeagus; **20.** *P. maculipennis* male genitalia; **21.** Aedeagus.

Plutella maculipennis Curt. (Figs. 20 & 21)

Uncus sclerotized, small curved below; gnathos indistinct, tegumen moderate, flattened and triangular, articulating at two points with valvae; vinculum long and v-shaped; saccus short and triangular; valvae setosed, longer than uncus, narrow and flattened towards distal end; valvular, cucullus, sacculus and costa well developed and differentiated; transtilla present; juxta round in

shape. Aedeagus short, slender, pointed posteriorly and differentiated into two parts, vesica and ductus ejaculatorius; vesica broad and arrow-shaped having two additional outgrowths.

REMARKS

Based on the present observation, the structure of the male genitalic characters used in taxonomy have been enumerated (Table I). The uncus, being a delicate to a well developed structure, apically narrow and was divided into lobes or processes, giving uncus a bi-or trilobed appearance postero-ventrally. Wherever it is well developed, it formed an efficient lock and key device. The gnathos had been poorly developed or reduced part of the genitalia in all the species studied. Both, narrow tegumen and poorly developed saccus together with distinct vinculum formed an elongated, wide cylinder to support the movement for the aedeagus. Valvae are highly sclerotized paired strucutres, generally well developed and longer, approaching beyond uncus and aedeagus. They are variously modified in shape from smooth to much setosed ones. In certain cases, the valvae supported the transtilla which have been moderate to well developed in shape, forming a bridge over the aedeagus. The juxta is mid-ventral in position, shaped differently but forms an important part of the genital complex to connect the two valvae on either side and floor for the movement of the aedeagus. The aedeagus functions in mating yet characterized. The cornuti present in a few species, works in primary lock and key system for the transfer of spermatophore.

The male genitalia is instrumental in mating and transfer of spermatophore to the female body (papillae anales). The uncus-scaphium complex though forms an internal lock and key system working like a pocket- knife mechanism but uncus being the caudal part of the 10th tergite works as an organ for clasping or may be called as genitalia corpus. The tegumen and vinculum form the frame of the clasping armature with a pair of normal, symmetrical valvae articulating at the side of tegumen-vinculum-complex. Uncus if further supported by different accessory structures, coupled with hairy lobes on both the sides, named socii.

While explaining the functional morphology of the male genitalia, Lodl (2000) described the fitting of uncus and scaphium in noctuids perfectly into the spiny dorsal and ventral furrows, situated longitudinally in between the female papillae anales. This is being described as a secondary lock and key mechanism. The interaction of juxta, aedeagus and vesica on one hand whereas strigma, ductus bursae, caudal part of bursa and cervix bursae on the other hand as the primary lock and key system. The latter (primary), hence, works during the copulation and in transfer of spermatophore, whilst the former (secondary) is supposed to work as a guiding system with the start of mating.

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Abbreviations : AE=Aedeagus; CO=Costa;; CR=Cornuti; CU=Cucullus; DA=Diaphragm; EJ=Ejaculatory duct; FT=Fultura superior; GA=Gnathos; HA=Harpes; JX=Juxta; SA=Saccus; SL=Sacculus; TG=Tegumen; TR=Transtilla; UN=Uncus; VA=Valvae; VE=Vesica; VI=Vinculum; VL=Valvula.

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