FUNCTIONAL MORPHOLOGY OF THE GNATHOSOMA IN *MYOBIA MUSCULI* (SCHRANK, 1781) (TROMBIDIFORMES-ACARI)

BY T. P. PARAN [1]

ANATOMY
GNATHOSOMA
MYOBIIDAE

ABSTRACT : This is an original study of the external morphology and the functional anatomy of the gnathosoma of the adults and the immature stages of *Myobia musculi* (Schrank, 1781).

ANATOMIE
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RÉSUMÉ : Ceci est une étude originale de la morphologie externe et de l'anatomie fonctionnelle du gnathosoma des adultes, ainsi que des stades immatures, chez *Myobia musculi* (Schrank, 1781).

INTRODUCTION

RADFORD's (1954) review includes all the studies reported on the family Myobiidae. In the 1970s there has been an explosion of the knowledge of the Myobiidae as shown by the excellent reports and the comprehensive bibliography on the family included in FAIN and LUKOSCHUS (1977). All the studies included in the bibliographies of the reviews and the reviews themselves focus attention on one or more aspects of the external morphology of the adults and the immature stages (where the latter are available) and their taxonomy and phylogeny based on the host-parasite affinity as well as morphology. None of the above studies contains any significant reports on the gnathosoma of any myobiid. The brief illustrated notes by BREGETOVA *et al.* (1955), CLAPAREDE (1868), DUBININ & KARPOWITCH (1958), DUSBÁBEK (1969), FAIN (1969), GRANT (1942), LAVOIPIERRE and BECK (1970), LUKOSCHUS (1969), LUKOSCHUS & DRIESSEN (1971) and WHARTON (1960) on the external morphology, including the gnathosoma and on the feeding in some of the myobiids, are not conclusive and lack any information on the functional anatomy of the organ. HUGHES' (1949, 1953 & 1959) and SNODGRASS' (1948) treatment of the arachnid and acarine gnathosoma are undoubtedly useful to interpret the homology of the segmentation and of the various essential elements of the organ. PARAN (1966 *a* & 1966 *b*) has presented the general morphology of the myobiid gnathosoma in some detail. The present study is devoted to a brief report on the external morphology and the functional anatomy of the gnathosoma of the adults and the immature stages of *Myobia musculi* (Schrank) based on the histological and squash preparations besides the whole of the organ of the various stages of the mite.

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MATERIAL AND TECHNIQUES

The mites were fixed in alcoholic Bouin's, mounted on rat liver blocks and then sectioned. The details of the procedure are given below :

■ *Histological preparation :*

The mites fixed and preserved in alcoholic Bouins, were cleared of traces of picric acid by 3-4 prolonged changes of 70 % alcohol.

Embedding of the mites : blocks of rat liver (excluding the interlobular connective tissue) measuring 1 cm × ½ cm × ½ fixed in Alcoholic Bouins were cleared in 3-4 prolonged changes of 70 % alcohol to remove picric acid. Triangular grooves measuring about 3 mm wide and 2 mm deep were cut on one of the broad faces of the liver block as in fig. Tc 1.

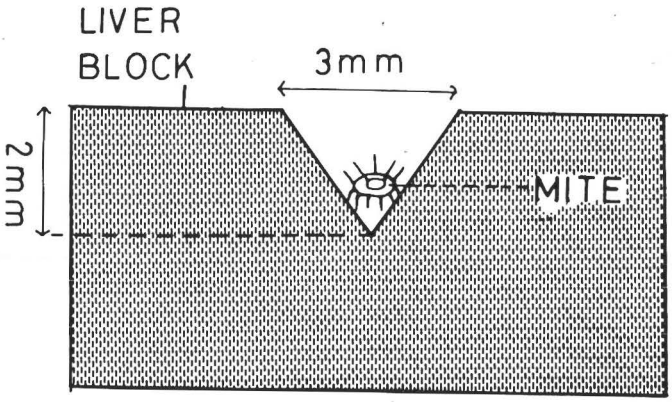


FIG. TC 1 : the mite mounted in the liver block.

The liver block was placed in a cavity block with exactly one drop of Meyer's albumin at the bottom to keep the liver block in position. The albumin, if added in excess, would invade and wet the grooves on the liver block. The embedding of the mite in the groove would then be difficult. The mites were placed in the groove carefully oriented with their anterior ends directed towards one end of the liver block and with their dorsum facing up. After placing the mites in the groove albumin was added, drop by drop, through a micropipette into the cavity block thus allowing the albumen to flow gently into the groove without dislodging the mites. When the groove and the cavity block were filled with albumin, the mites were safely located in the groove well oriented for cutting transverse sections.

■ *Dehydration :*

Alcohol 90 % was added, drop by drop, over the albumen away from the groove, to avoid the agitation of the albumen in the groove of the liver block. After half an hour, absolute alcohol was added to the cavity block in the same way as above. After another half an hour, the liver block carrying the mites covered by the dehydrated and coagulated albumin was carefully transferred, with a fine forceps, into a specimen tube (3″ × 1″) containing dioxan. Cellosolve over anhydrous calcium chloride, which has been freshly heated, may be used as the dehydrating agent. However, dioxan is preferred.

The liver block, after dehydration is immersed in paraffin in an oven at 37°C to allow the impregnation of wax. The liver block was then blocked in the wax in a cavity block in vacuo.

Sections were cut at 5.5, 6 and 7 microns thickness.

They were stained in Alcoholic eosin and Delafield Haematoxylin, and mounted in Canada balsam.

■ *Squash preparations :*

Specimens cleared in 50 % lactic acid for 24 hours, were pressed with the coverslip on a slide and the chelicerae and their allied arthrodial membranes and other structures were clearly prepared, suitable for study under the microscope.

KEY TO ILLUSTRATIONS

AC	arthrodial membrane
AK	acanthodion
AP_1	leg I
APC	apodeme of pedipalpal coxa
ARS	anterior rostral seta
AX	Sclerotised frame for the attachment of muscles of the pharyngeal pump in the immature stages
BJ	basal joint of chelicera
BW	body wall
CL	claw

CP sclerotised wall of pharynx
DB dorsal wall of basal joint of chelicera
DT deutosternum
DW dorsal wall of the gnathosoma
EN endite of pedipalp
FP femoral process of leg I
FR floor of rostrum
G salivary gland
GN gnathosoma
LB lateral wall of basal joint of chelicera
LM muscles of labrum
LR labrum
LW lateral wall of gnathosoma
MP origin of the muscles of the pharyngeal pump on the propodosoma
MP_1 insertion of the muscles of the pharyngeal pump
MS muscles of chelicera
MW median wall of labrum
O œsophagus
OO oral opening
OP opening of pharynx to œsophagus
PG pre-oral groove
PP palp of pedipalp
PRS posterior rostral seta
PX pharynx
S lateral wall of basal joint which has been removed to show the internal structure of the rostrum
SD salivary duct
SG stigmata
SL stylets
SLC stylets complex (stylets + sheath)
SLR sclerotised wall of the labrum
SR fulcrum for the attachment of the arthrodial membrane of the stylet
SS sub-cheliceral shelf
SSL sheath of stylets
STD distal segment of stylet
STP proximal segment of stylet
Ta tarsus of pedipalp
Ti tibia of pedipalp
TR trachea
VW ventral wall of gnathosoma
W wall of gnathosoma, cut to show the internal anatomy
WG wall of gnathosoma
WP wall of propodosoma

MORPHOLOGY OF THE GNATHOSOMA

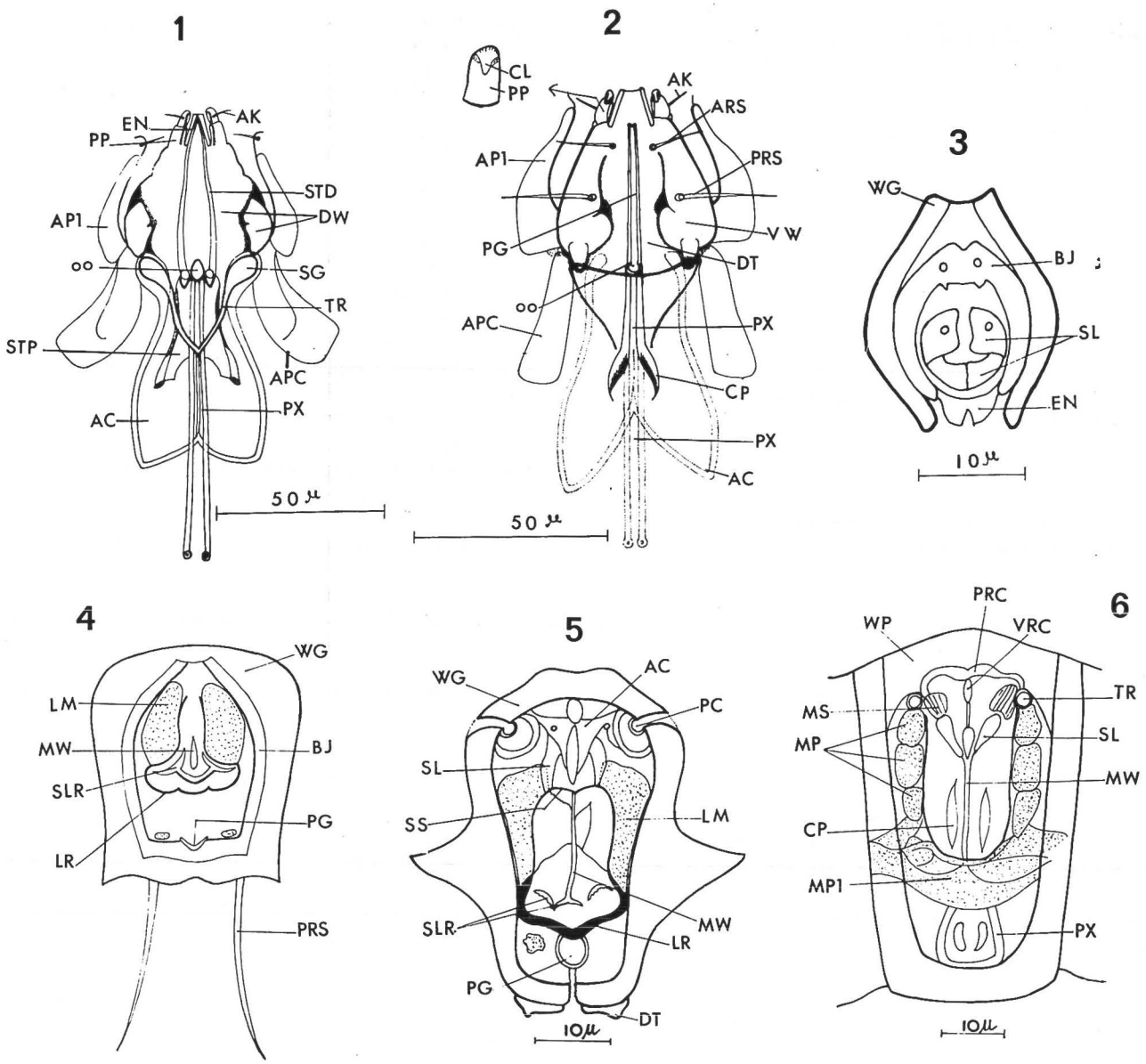
■ *External Features :*

The gnathosoma in all the stages of *M. musculi* (Figs. 1, 2, 13 and 14) is roughly conical in outline as seen dorsally and ventrally and is flanked by the highly specialised leg I (AP1) on either side. The gnathosoma in *Myobia* is presumably made of the tergites, the sternites and respective appendages of two segments viz, the cheliceral and the pedipalpal, with their associated arthrodial membranes and the musculature. The precheliceral segment has been lost. In the architecture of the gnathosoma, the tergites and the sternites and the endites of the pedipalps have fused completely and almost all traces of segmentation have been lost except for the trace of the deutosternum seen as a chitinous plate ventrally (Fig. 2, DT), between the coxae of the pedipalps. The external ramus of the pedipalp, which persists as a five-segmented palpus in the primitive acari, persists as a two-segmented appendage, the palpus, (PP) in the adults of *M. musculi*. The tibia is rudimentary and the tarsus bears a ventrally curved claw (CL). In the immature stages the palpus is either imperceptibly fused with the body of the gnathosoma or has been lost.

The gnathosoma in the adults as well as the immature stages in the Myobiidae bears varying number of setae. In the adults of *M. musculi*, the palpus bears on its terminal segment, a special seta, presumably the acanthodion (Figs. 1 and 2, AK). Ventrally the gnathosoma in the adults bears two pairs of setae, a shorter anterior pair and a longer posterior pair designated respectively as anterior and posterior rostral seta (Fig. 2, ARS, and PRS). In the immature stages, the palpus is absent and hence the acanthodion too. Ventrally there is only one pair of setae. These are comparatively long and flexible and are presumably homologous with the anterior rostral setae of the adults and regarded as such (Fig. 14 ARS).

■ *Functional Anatomy :*

The gnathosoma in *M. musculi* essentially consists of a slcerotised body or capsule enclosing the



FIGS. 1-6 : *Myobia musculi*, gnathosoma of female, dorsum (1) ; ventrum (2) ; serial transverse sections : at the anterior end, anterior to the anterior rostral seta (3) ; at the level of the posterior rostral seta (4) ; at the level of the stigmata (5) ; at the level of the anterior end of the pharynx (6).

chelicerae and a sucking mechanism provided by the pharynx. The apodemes of the pedipalpal coxae (Figs 1, 2 and 13) running backwards strengthen the attachment of the gnathosoma to the propodosoma. The interpretation of the detailed functional anatomy of the gnathosoma follows. This original interpretation is based on the investigation of the whole mounts, serial cross sections and squash preparations of the gnathosoma of the female. This information on the female is used as a basis for the interpretation of the functional anatomy of the organ in the male as well as the immature stages. The body or the capsule of the gnathosoma (Figs. 3, 4 and 5, WG) in *Myobia* is roughly conical in outline as also seen externally (Figs 1 and 2). This applies to all

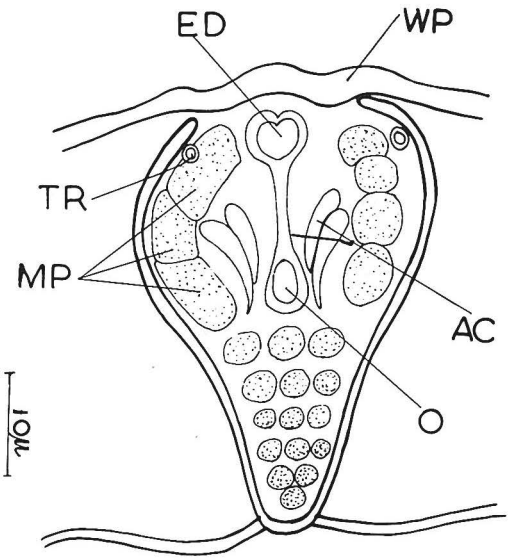
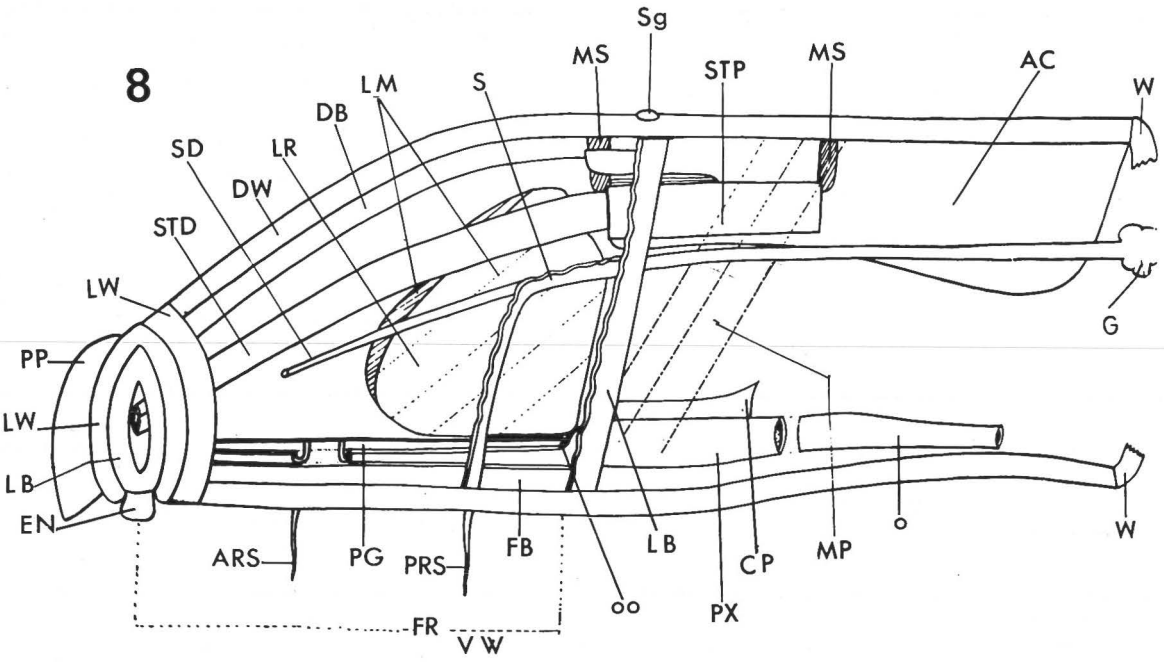
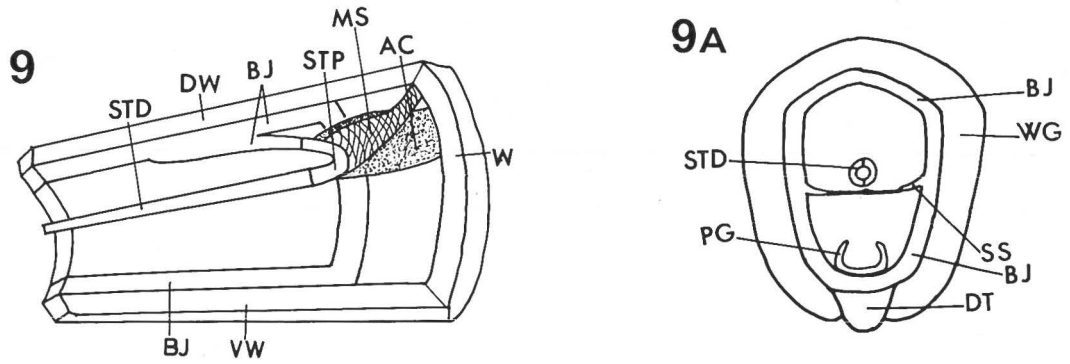


FIG. 7 : *Myobia musculi*, gnathosoma of female, transverse section behind leg I at the level of the external vertical seta on the propodosoma to show the arthrodial membrane.

the other stages as well (figs. 13 and 14). This is confirmed by the respective serial cross sections. The dorsal wall (Figs. 1 and 8, DW) is formed by the tergites of the segments concerned which have intimately fused with the coxae, the endites (Figs. 2 and 3, EN) and the sternites of the pedipalpal segment to form the lateral wall and part of the ventral wall on either side of the midventral axis. The only visible trace of the sternal element is the deuto-sternum seen between the thick ventral halves of the posterior margin of the coxae (Figs. 2 and 5, DT). The protosternum of the cheliceral segment has invisibly fused with the other elements constituting the body of the gnathosoma. The basal joint (BJ) of the chelicerae are imperceptibly fused, except anteriorly (Figs. 3, 4, 5, 9 and 9A) to contribute to the inner dorsal and lateral walls (Fig. 8, DW, LB). The floor of the capsule is the rostrum (Fig. 8, FR), the equivalent of the hypostome of the mesostigmatid gnathosoma (HUGHES, 1958). The roof of the rostrum is obviously lined by the basal joints (BJ) of the chelicerae. The rostrum assumes the form of a trough with a well sclerotised canal, the pre-oral groove (Figs. 4, 5, 8 and 9A, PG) beginning anteriorly just behind the external opening of the gnathosoma, and opening posteriorly by the oral opening (Figs. 2 and 8, OO) into the pharynx (Figs. 1 and 6, PX). The pre-oral groove is formed by the extension dorsad of the fused ventral part of the basal joints reinforced by the endites of the pedipalp. The pre-oral groove is very shallow at its anterior end but becomes progressively deeper until it becomes almost tubular posteriorly (Figs. 2, 4 and 5, 8, and 9A, PG).

The paired chelicerae provide the essential piercing organ of the gnathosomal apparatus. Each chelicera is uniramous and three-segmented and consists of the one-segmented basal joint and two-segmented digitus mobilis (= stylets) (Figs. 3, 5, 6 and 8, SL (STP + STD)). The basal joint on either side has fused with the dorsal gnathosomal wall beginning at the anterior end and extending upto the posterior end of the gnathosoma and ventrally upto the rostrum (Figs. 4, BJ). The lateral wall of the basal joint (Figs. 3, 4, 5 and 9A, BJ) on either side sends mesially, half way between the floor of the rostrum (Fig. 8, FR) and the roof of the gnathosoma, two platelike extensions. Either of them fuses with its fellow in the centre cutting off a space dorsally above the rostrum and enclosing the digitus mobilis (Stylet) (SL) of the chelicera. The platelike part of the mesial extension of the basal joint forms the subcheliceral shelf (Figs. 5 and 9A SS). The stylet on either side consists of the shorter proximal segment and the longer distal segment (Figs. 1, 8 and 9, STP + STD) which forms the piercing part of the organ. The stylet lies above the rostrum dorsal to the sub-cheliceral shelf and on either side it is attached proximally to the ventral wall of its respective cheliceral plate (basal joint) (Figs 3 and 4, BJ), which in turn is fused with the dorsal wall of the gnathosoma (Fig. 8, DB). The attachment of the stylet (digitus mobilis) to the basal joint is effected by arthrodial membrane (Figs. 2, 5, 7, 8 and 9 AC) which is elastic and is capable of stretching forwards and far backwards to enable the stylet to be protruded and retracted when the cheliceral muscles go into action. These arthrodial membranes of the two sides fuse mid-ventrally and mesially behind the gnathosoma. Dorsally they are attached to the posterior dorsal wall of the gnathosoma and the anterior part of





FIGS. 8-9 : *Myobia musculi*, stereogram of the sagittal half of the gnathosoma, a reconstruction based on the serial sections — figs. 3-7 (8) ; A simplified diagram of the stereogram in fig. 8 (9) ; A simplified diagram of the cross section in fig. 9 (9A).

the propodosoma (Figs. 5, 7, 8 and 9, AC). The stylets are protruded by the action of the chelicera muscles but are presumably withdrawn by the elasticity of the arthrodial membranes as has been observed in squash preparations of the adults as well as the immature stages (Figs. 21 and 22, AC). This has been suggested by HUGHES (1958) with respect to the trombidiform families Erythraeidae, Tetranychidae and Cheyletidae. The anatomical features of the gnathosoma in *Myobia* as revealed in transverse sections and squash preparations also suggest that the stylets are withdrawn by the elasticity of the arthrodial membranes, as shown above (Figs. 21 and 22).

The sucking mechanism associated with the feeding activity is provided by the pharynx and its accessory structures. Posteriorly, the pre-oral groove of the rostrum opens into the pharynx through the oral opening (Figs. 1, 2 and 8, OO). The pharynx (PX) has a sclerotised wall. Laterally

two sclerotised plates (CP) arising from the ventral wall (endites) of the capsule and extending dorsad reinforce the pharyngeal wall (Figs. 2, 6 and 8). The anterior part of the pharynx forms a suctorial pump, which shows a diversity of form in the different groups of Acari. The working of the pharyngeal pump in *Myobia* is closely dependent on the structure and the function of the labrum as these two organs function conjointly. The labrum (Figs. 4, 5 and 8, LR) is a prolongation of the roof of the oral opening extending obliquely anteriad and directed towards and extending nearly to the anterior end of the pre-oral groove in the rostrum. The labrum is a hollow structure attached to the lateral wall of the gnathosoma and sclerotised dorsally as well as laterally (Figs. 4 and 5, LR). The labrum is continued backwards into the propodosoma as a median plate (Figs. 4, 5 and 6, MW) and is fused dorsally with the sub-cheliceral shelf. The dorsal median plate is connected to the labrum by two lateral plates (Figs. 4 and 5, SLR).

The stylets, the labrum and the pharyngeal pump are operated by the co-ordinated action of a system of muscles. There are two sets of well-developed muscles, one on either side, originating dorso-laterally on the sub-cheliceral shelf, running obliquely forwards and ventrad and inserted on the labrum (Figs. 4 and 5, LM). The alternate contraction and relaxation of the muscles move the labrum up and down obliquely backwards and forwards towards the pre-oral groove, thereby rhythmically closing and opening the oral opening. Bands of muscles originating (MP) from the dorsal wall of the propodosoma (WP) run obliquely forwards and are inserted (MP_1) on the dorsal wall of the pharynx. By the contraction and relaxation of these muscles the pharynx acts as a diaphragm pump (Figs. 6, 7 and 8). Cheliceral muscles originating on the dorso-lateral wall of the gnathosoma are inserted on the proximal segment (STP) of the digitus mobilis (stylets) which are protruded by the action of the muscles (Figs. 6 and 8, MS).

The complex systems of muscles described above are responsible for the essential functional activity of the gnathosoma. The two halves of the stylets of the chelicera, with a groove in the proximal part of each facing mesially close on each other to form the stylet tube (Fig. 8, SL = STP and STD). By the action of the stylet muscles (MS) the stylets are protruded into the skin and ultimatery pierce the sebaceous glands of the hosts. The fluid food from the host ascends the stylet tube a little due to capillarity. This is followed by a contraction of the muscles of the labrum and thus, the labrum opens the oral opening. This process is immediately followed by the contraction of the muscles of the pharyngeal pump. The action of the pharynx sucks the fluid up the pre-oral groove and then into the pharynx. HUGHES (1959) suggested, with reference to the gnathosoma of Eleutherengona in general, that if the contraction and relaxation of the muscles of the labrum were slightly in advance of those operating the pharyngeal pump, a valved diaphragm pump would result capable of pumping fluid food from the oral opening along the pharynx into the œsophagus. In *M. musculi* the labrum presumably should work as described above.

Male (Figs. 10, 11 and 12). Even though all the essential elements of the gnathosoma wall are present, as seen in whole mounts, histological preparations reveal several abnormalities in the structure and an obvious degeneracy in function. Sections show distortion of the general structure of

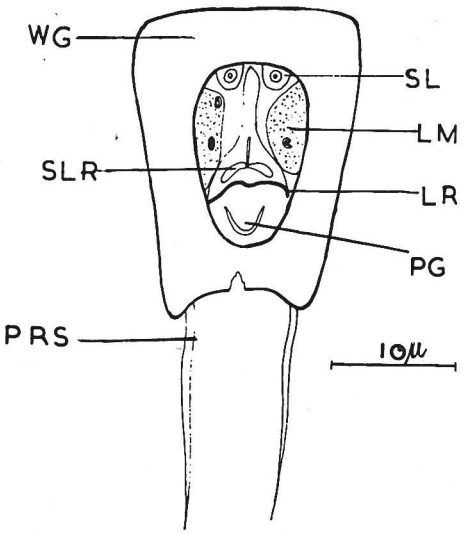
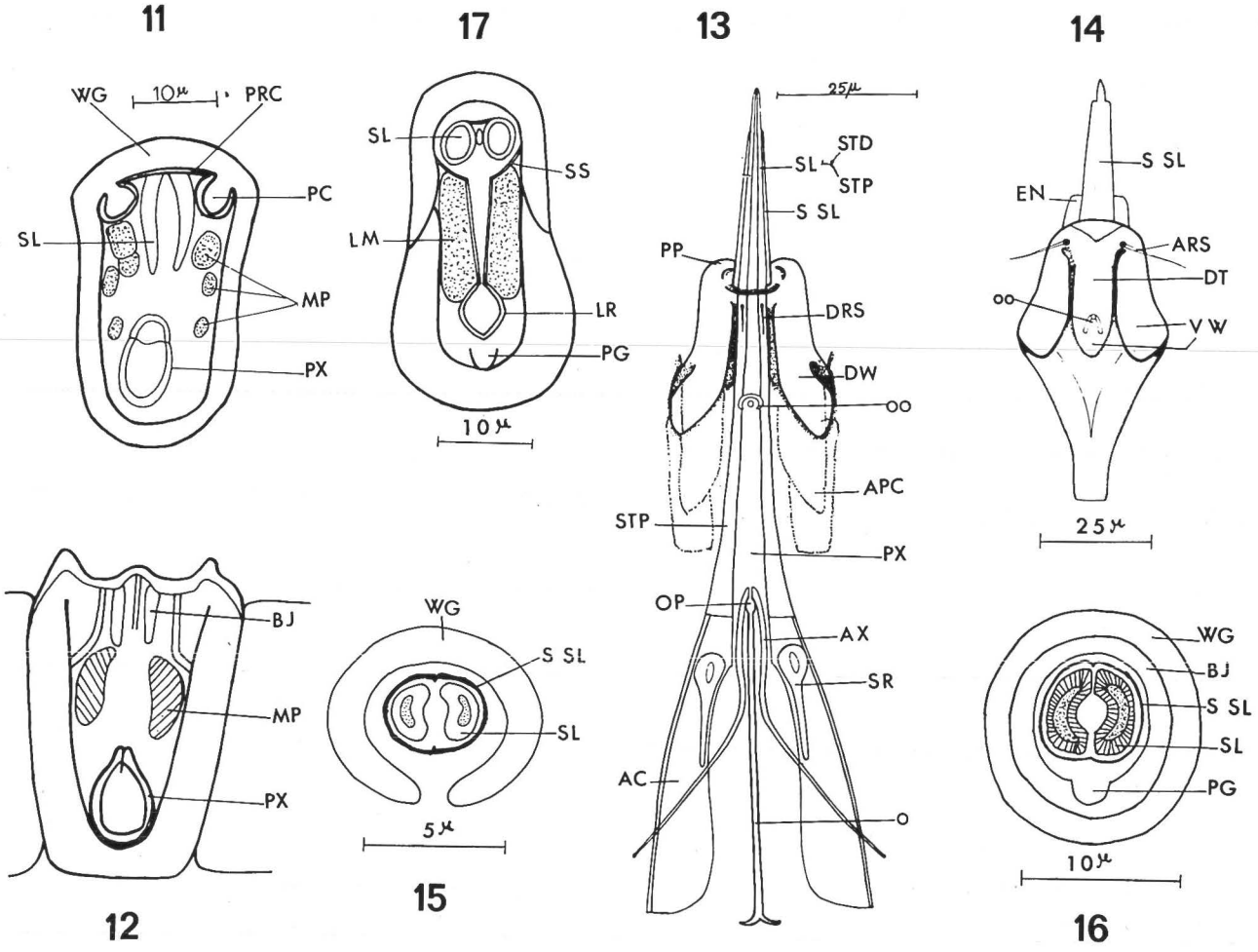


FIG. 10 : *Myobia musculi*, gnathosoma of male, transverse section at the level of the posterior rostral seta.



FIGS. 11-17 : *Myobia musculi*, gnathosoma.

Gnathosoma of male, transverse sections : at the level of the stigmata (11) ; at the level of the internal vertical seta (12) ; gnathosoma of deutonymph. dorsum (13) ; ventrum (14) ; serial transverse sections at the tip (15) ; behind the tip (16) ; far behind the anterior rostral seta (17).

the gnathosoma (Figs. 10 and 11, WG) due to comparatively weak sclerotisation of the gnathosomal elements especially those constituting the wall. The muscles of the pharyngeal pump (MP), the muscles of the labrum (LM), the labrum and its parts (LR and SLR), the sclerotised frame of the pharynx (PX), and the pre-oral groove (PG), show signs of degeneration compared to those of the female. The basal joint and the stylet on either side appear to have been fused to form a stump (Figs 11, SL and 12, BJ) hanging from the roof of the capsule. The cheliceral muscles are lacking (Figs. 11 and 12). Hence the male does not presumably feed at all. In many mites the males have only a reproductive function and the feeding and digestive organs are consequently degenerate to various degrees. In the male of *M. musculi* this degeneration is clearly seen in the histological preparation of the gnathosoma as well as the gut. In the sections through the middle of the body, a reduced stomach and a blunt excretory duct with guanine crystals, probably carried over from the previous instar, have been observed. The closure of the excretory duct is correlated to the absence of uropore in the male, (PARAN, 1979).

Immature Stages. Externally the gnathosoma in the larva and nymphs (Figs. 13 and 14) is clo-

sely similar, as all these stages are homeomorphic. The following account of the functional anatomy is based on the whole amounts, serial transverse sections and squash preparations of the deutonymph and the larva. The protonymph is presumably similar to the other two stages. Basically, the gnathosoma in the immature stages is formed of the same homologous elements integrated more or less in the same way as in the female. These stages differ from the female only in the details of the assembly of the various gnathosomal elements. The anterior end is blunt, the palpus is absent (Figs. 13 and 14).

As seen in serial transverse sections, the gnathosoma of the deutonymph and the larva show the following features. The wall (Figs. 13, 14 and 15, DT, DW, VW and WG) is formed in the same way as in the female. The basal joint of the chelicera (BJ) shows its contour distinctly lining the capsule (Figs. 16 and 19) internally. In the larva the fusion of these elements leaves a line of demarcation on the lateral wall (WG) (Fig. 17). The pre-oral groove (PG) is formed in the same way as in the female (Figs. 16, 17, 19 and 20). The muscles (LM) of the labrum and those (MP) of the pharynx (PX) appear to differ from those of the corresponding mechanisms in the female. The labrum (LR) is relatively narrow but is provided with well-developed muscles. These muscles originate on the mesial extension of the basal

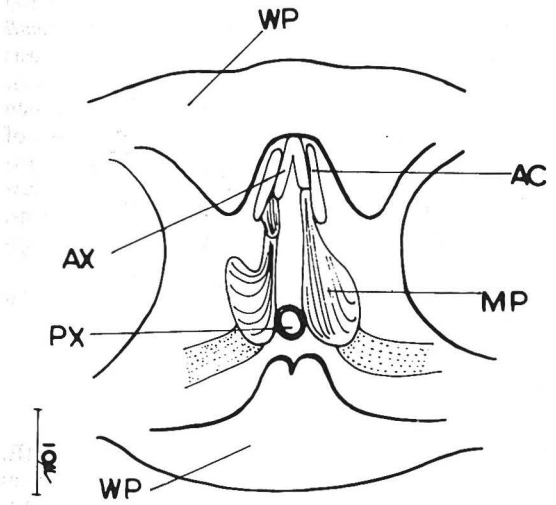
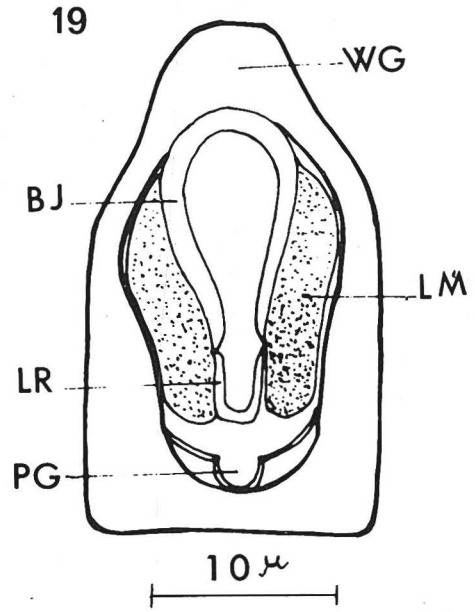
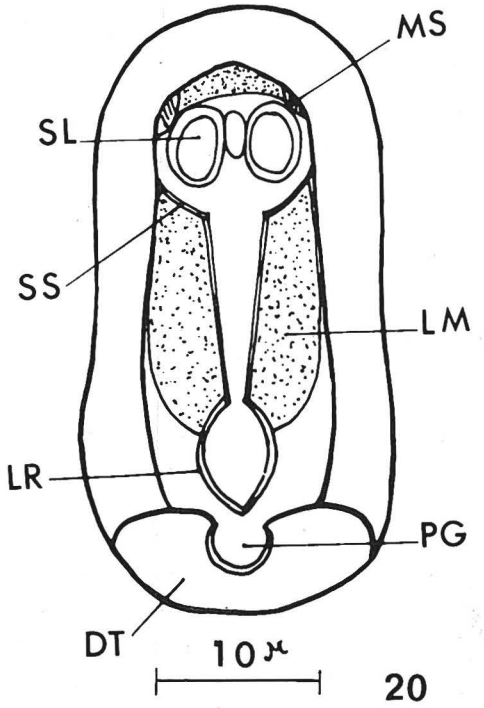


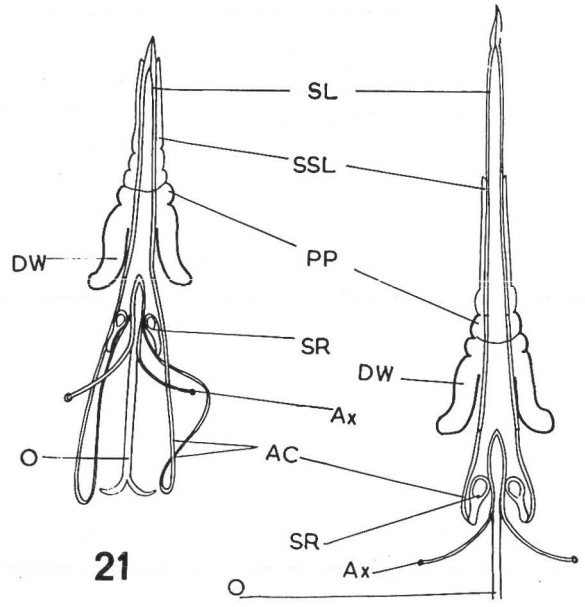
FIG. 18 : *Myobia musculi*, gnathosoma of deutonymph, transverse section through the propodosoma behind leg I.





FIGS. 19-20 : *Myobia musculi*, gnathosoma of larva, serial transverse sections just behind the rostral seta (19) ; far behind the rostral seta (20).

joint, the sub cheliceral shelf (SS), dorsal to the roof of the rostrum. They are inserted on the labrum (LR) (Figs. 17, 19, 20). The close relationship of these muscles, the basal joint and the labrum is essentially similar to that in the female. The pharynx (PX) does not show sclerotised reinforcement as strong as in the female. The muscles (MP) of the pharynx originate on a special sclerotised framework (AX). They are inserted on the phrarynx (PX) dorsally (Figs. 13 and 18). The arthrodial membranes (AC) of the



FIGS. 21-22 : *Radfordia affinis* Poppe, 1908, gnathosoma of the deutonymph, squash preparations : the stylets in situ (21) ; the stylets protruded (22).

stylets (SL) lie in close association (Figs. 13 and 18) with the two key-shaped processes (SR) on the propodosoma (WP). These processes act as a fulcrum around which the arthodial membranes (AC) move protruced (Figs. 13, 18, 21 and 22). These processes (SR) are presumably the derivatives of the basal joint. Each chelicera is three-segmented, formed of the basal joint (digitus flexus) (BJ), and digitus mobilis (Stylets) which is made of two pieces, the proximal (STP) and the distal (STD). The latter terminates in a lancet (Figs. 13, 15, 16, 17 and 20). The chelicerae are presumably operated by the conjoint action of the muscles as well as by the elasticity of the arthrodial membranes (AC) (Figs. 13, 18, 21 and 22), basically as in the female. One special feature of the gnathosoma of the immature stages is the presence of the stylet complex consisting of the stylets (SL) and the stylet sheath (SSL) (Fig. 13). The stylets sheath is presumably made of the endites of the pedipalps (Figs. 14, 15, 16, 21 and 22, EN and SSL).

CONCLUSION

From the above study, all the stages of the myobiid appear to be adapted for piercing and sucking mode of feeding. This aspect is under further investigation (PARAN, in preparation). However, more information on the functional anatomy of the gnathosoma in the various stages of myobiids of the different taxonomic groups of the hosts should be desirable for phylogenetic studies of the family. The studies of the gnathosoma and its associated parts like the pharyngeal pump by electron-microscopic and the contents of the gut by histo-chemical techniques would presumably provide a sound clue to the mode of feeding in the mite.

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