Odonatologica 28(3): 257-271 *September 1, 1999*

MOUTHPART SENSILLA IN THE DRAGONFLY, *BRACHYTHEMIS CONTAMINATA* (FABRICIUS) (ANISOPTERA : LIBELLULIDAE)

S.M. WAZALWAR and D.B. TEMBHARE
Department of Zoology, Nagpur University Campus, Amaravati Road, Nagpur 440 010, India

Received May 5, 1998 / Revised and Accepted January 27, 1999

The mouthpart sensilla in *B. contaminata* comprise trichoid sensilla, acanthae, basiconic sensilla, campaniform sensilla, microtrichia, papillae, sensory pegs and spines. There are various types of trichoid sensilla: 8 labral, 7 mandibular, 14 hypopharyngeal, 8 maxillary and 17 labial. They differ in size and distribution from one another. The acanthae are of 2 types, the labral in the adult and the mandibular in the larva. The basiconic sensilla are found on the labrum of the adult only. The campaniform sensilla are present on the maxillae and labium of the adult and are lacking in the larva. There are 7 types of microtrichia evident on the labrum, hypopharynx and maxillae of the larva and on the hypopharynx and maxillae of the adult. The papillae are present on the inner surface of the labrum in both the larva and the adult. The sensory pegs are confined to the labium of the adult. The spines are located on the labium of the larva and are lacking in the adult. This study is based on SEM and neuro-anatomical staining techniques.

INTRODUCTION

The biting and chewing type of mouthparts of insects bear various types of sensilla: articulated sensory hairs or trichoid sensilla, campaniform sensilla, sensilla basiconica, sensilla ampullacea, coeloconic pegs, pores and pore-plates (SCHNEIDER & KAISSLING, 1957; ISMAIL,1962; DETHIER 1955, 1963; THOMAS, 1966; SLIFER, 1970; ARNOLD, 1974; McIVER, 1975; KUBRA, 1978; CARLINE et al. 1984). The literature indicates that these sensilla differ widely between phytophagous and carnivorous insects (CHAPMAN, 1982). They have been described in detail in Plecoptera (KAPOOR,1989); Orthoptera (LIU & LEO, 1960; THOMAS, 1966); Isoptera (RICHARDS, 1951) and Dictyoptera (PETRYSZAK, 1975).

In Odonata the cuticular processes on the mouthparts of the larva of *Aeshna* spp. (ZAWARZIN,1912), the larva and adults of *Aeshna interrupta lineata* (PRIT-

CHARD, 1965), the adults of *Libellula depressa* and *L. quadrimaculata* (PETRYSZAK,1977) and the larvae of *Coenagrion puella* and *Ischnura elegans* (BASSEMIR & HANSON,1980) have been studied with the help of light microscopic vital staining techniques.

The present work was undertaken to explore the various types of cuticular processes of the mouthparts of the last instar larva and adult of the anisopteran, *Brachythemis contaminata*, with the help of both light and scanning electron microscopy.

MATERIAL AND METHODS

The last instar larvae and the adults were collected from the Nagpur University Campus area during the months of July-February, 1993-1996.

LIGHT MICROSCOPY. – The mouthparts of the larvae and adults were dissected out gently, from the live insects, washed thoroughly in distilled water, boiled in 10% aqueous KOH solution for 15 minutes, dehydrated and kept in clove oil overnight and observed under the light microscope.

SEM STUDIES. – Dehydrated mouthparts were transferred to cold acetone, dried at room temperature and mounted on a stub. They were coated with gold palladium alloy in a Poloron Automatic Unit and observed under the stereoscan MK III Cambridge SEM at the Regional Sophisticated Instrumentation Centre of Nagpur University. The sensory nature of various cuticular processes was confirmed after staining with (i) Methylene blue vital stain method (GURR, 1962; ZACHARUK, 1962), (ii) Golgi's silver impregnation method (BLEST, 1980), (iii) Toluidine blue method (ALTMAN, 1980) and (iv) Miller's Dioxane method (HUMASON, 1962). The mouthpart sensilla were classified on the basis of cytomorphology, size and location.

RESULTS

With the help of light and scanning electron microscopy, various types of sensilla situated all-over the dorsal, ventral and marginal surfaces of the mouthparts of the last instar larva and adult *Brachythemis contaminata* were evident.

Table I

Mouthpart trichoid sensilla in the larva and adult *Brachythemis contaminata*

Type of trichoid sensilla	Size (μm)	Stage Larva	Stage Adult
Labral			
LT1	71.43 ± 43.90	-	+
LT2	80.57 ± 28.44	+	-
LT3	94.93 ± 23.90	-	+
LT4	131.57 ± 28.44	+	-
LT5	133.00 ± 43.90	-	+
LT6	159.00 ± 43.90	-	+
LT7	180.00 ± 31.92	-	+
LT8	200.00 ± 43.90	-	+
Mandibular			
MT1	46.87 ± 6.40	-	+
MT2	47.86 ± 3.63	-	+

LABRAL SENSILLA

Figures 1-8

The labrum is a subovoid sclerite, attached to the anteclypeus as an upper lip over the mouth and bears the membranous epipharynx midventrally. It is convex dorsally and flattened ventrally. The labrum measures 2.5 ± 0.71mm in length and 1.2 ± 0.42mm in width in the larva, while it measures 2.0 ± 0.69 mm in length and 1.0 ± 0.025mm in

width in the adult.

The labrum of the larva bears trichoid sensilla (Tab. I) on the margin (LT2) and all over the dorsal surface (LT4). Besides trichoid sensilla, two types of microtrichia (LM1) and (LM2) and papillae (LP1) are found around the epipharyngeal region on the ventral surface (Tab. II).

The adult labrum possesses different types of trichoid sensilla (Tab. I). LT1 and LT3 are found on the apical margin, LT5 and LT6 on the outer surface and LT7 and LT8 on the inner surface of the labrum. The acanthae (LA1) are present on the posterodorsal region of the labrum. Besides trichoid sensilla, the basiconic sensilla (BS) and papillae (LP2) are present on the inner side. The papillae encircle the epipharynx while basiconic sensilla are found on either side of the papillae in the form of a patch.

MANDIBULAR SENSILLA

Figures 9-14

The mandibles are unsegmented, strongly sclerotized, somewhat triangular appendages bearing strong teeth, basal mola and a distal group of incisors in both the last instar larva and the adult dragonfly. Each mandible in the larva measures 2.6 ± 0.72 mm in length and 1.5 ± 0.5mm in width, while in the adult it measures 1.1 ± 0.35 mm in length and 2.0 ± 0.69 mm in width.

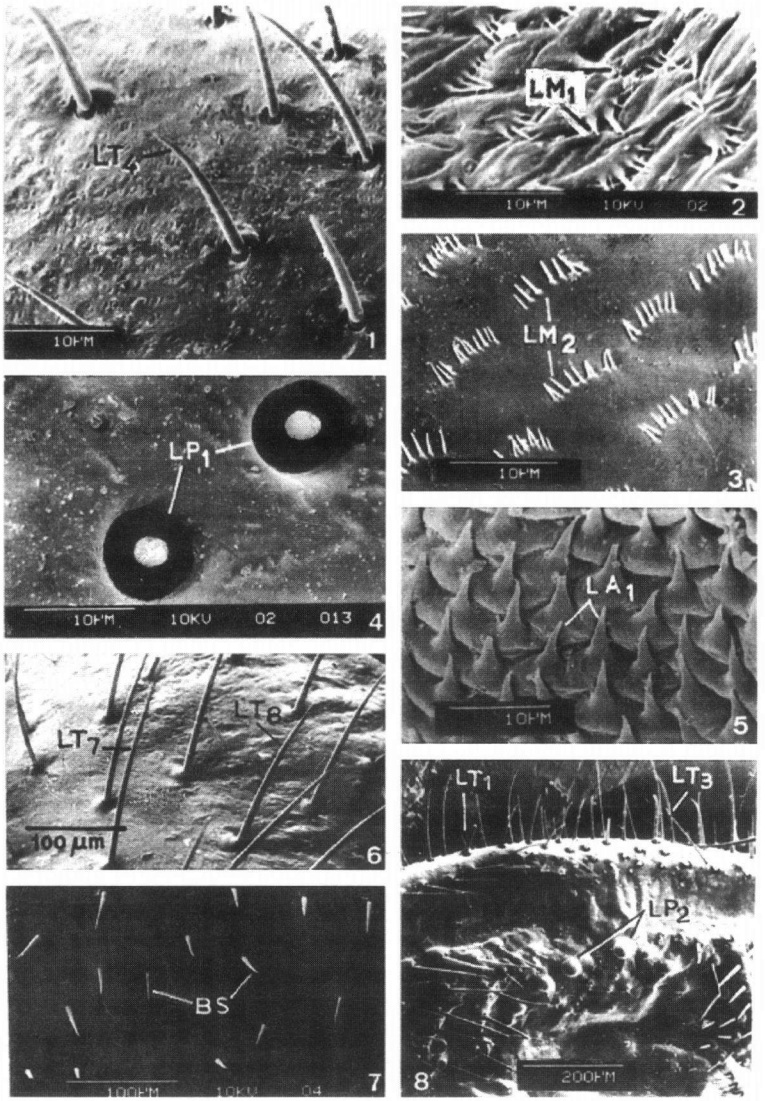
In the larva, the trichoid sensilla (MT7) are found on the lateral margin of the posterior region only (Tab. I) while the acanthae (MA1) are found predominently on the inner region,

Table I, continued

MT3	58.00 ± 2.82	-	+
MT4	69.22 ± 10.64	-	+
MT5	87.50 ± 20.38	-	+
MT6	135.10 ± 2.37	-	+
MT7	249.55 ± 70.13	+	-
Hypopharyngeal			
HT1	76.80 ± 29.49	+	-
HT2	83.00 ± 78.32	-	+
HT3	89.42 ± 50.20	-	+
HT4	91.75 ± 15.49	+	-
HT5	132.04 ± 17.29	-	+
HT6	132.28 ± 78.32	-	+
HT7	145.20 ± 43.49	+	-
HT8	150.00 ± 34.46	+	-
HT9	181.00 ± 44.76	-	+
HT10	220.00 ± 20.24	-	+
HT11	225.00 ± 27.37	-	+
HT12	254.00 ± 34.46	+	-
HT13	264.51 ± 27.37	-	+
HT14	309.00 ± 27.37	-	+
Maxillary			
MXT1	65.71 ± 17.09	-	+
MXT2	78.09 ± 11.36	-	+
MXT3	100.82 ± 26.36	+	-
MXT4	138.09 ± 28.17	-	+
MXT5	138.66 ± 10.87	+	-
MXT6	185.76 ± 97.99	-	+
MXT7	190.8 ± 97.99	-	+
MXT8	199.99 ± 28.59	-	+
Labial			
LbT1	34.28 ± 8.43	-	+
LbT2	57.77 ± 7.84	+	-
LbT3	96.43 ± 24.69	+	-
LbT4	309.09 ± 65.38	+	-
LbT5	490.00 ± 167.84	-	+
LbT6	490.90 ± 167.84	+	-
LbT7	615.48 ± 28.14	-	+
LbT8	654.54 ± 29	+	-
LbT9	727.27 ± 180.34	+	-
LbT10	863.63 ± 185.53	+	-
LbT11	1000.00 ± 230.53	+	-
LbT12	1272.72 ± 340.45	+	-
LbT13	1454.54 ± 651.49	+	-
LbT14	1466.66 ± 651.49	-	+
LbT15	1472.72 ± 651.49	+	-
LbT16	1527.27 ± 651.49	+	-
LbT17	2711.10 ± 907.80	+	-

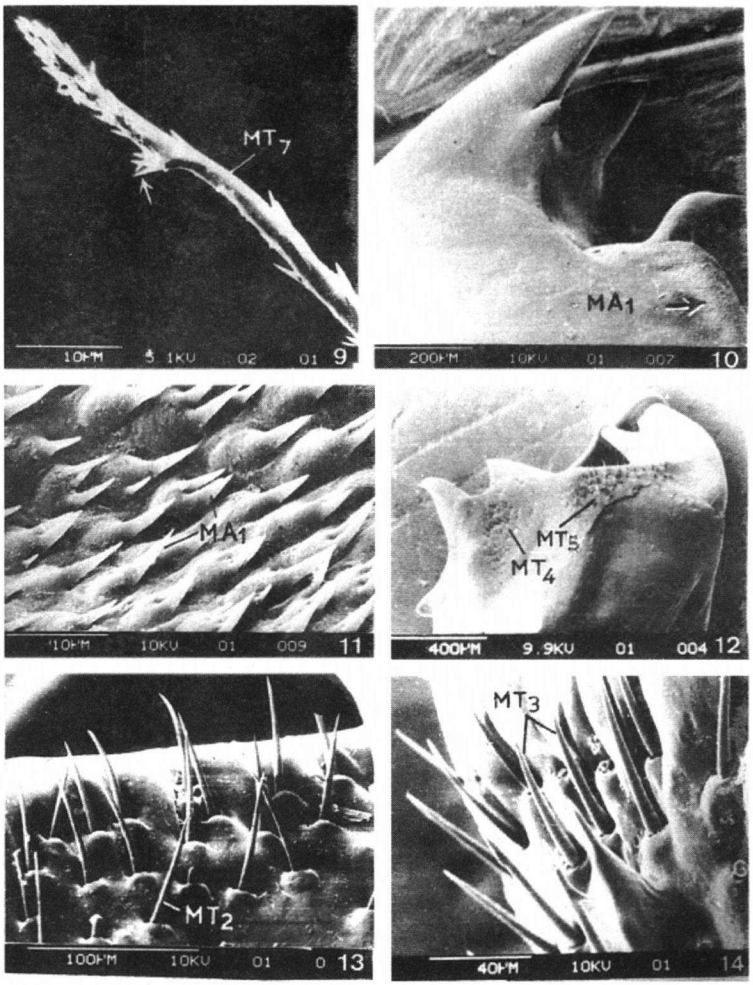
+ Present, - Absent, ± Standard error

(Tab. II). The acanthae are pointed terminally like the spines and are broad (dome--shaped) basally appearing as overlapping scale-like structures. There are nine strong teeth, four on the apical margin of one side, the remaining four on the distal margin of the other side and a single one in the submarginal region encircling the concave cavity.



Figs 1-8. Labral sensilla in the larva (Figs 1-4) and adults (Figs 5-8): (1) dorsal trichoid sensilla (LT4); – (2) ventral microtrichia (LM1); – (3) ventral microtrichia (LM2); – (4) ventral papillae (LP1); – (5) dorsal acanthae (LA1); – (6) dorsal trichoid sensilla (LT7, LT8); – (7) ventral basiconic sensilla (BS); – (8) ventral papillae (LP2).

In the adult dragonfly, the mandibles are adorned with trichoid sensilla of three types on both the outer and inner surfaces (Tab. I). Trichoid sensilla are present at the base of incisors (MT4) and parallel to the margin of the mola (MT2). On the lateral side of both the outer and inner surfaces a patch of trichoid sensilla (MT3) is present. On the inner side three types of trichoid sensilla (MT1, MT5, MT6) are found. There are seven teeth: three apical incisors and four distal molars. The incisors are pointed while the molars are flattened and have notched cusps.



Figs 9-14. Mandibular sensilla in the larva (Figs 9-11) and adult (Figs 12-14): (9) ventrolateral branched trichoid sensilla (MT7); – (10) arrow showing a patch of ventral acanthae (MA1); – (11) ventral acanthae (MA1), magnified; – (12) dorsal trichoid sensilla (MT4, MT5); – (13) ventral trichoid sensilla (MT2); – (14) ventral trichoid sensilla (MT3).

Table II

Heterogenous sensilla on the mouthparts of the larva and adult *Brachythemis contaminata*

Type of sensilla	Size (μm)	Location	Stage	
			Larva	Adult
Acanthae				
LA1	3.98 ± 0.538	labrum	-	+
MA1	5.94 ± 0.567	mandible	+	-
Basiconic sensilla				
BS	35.91 ± 5.68	labrum	-	+
Campaniform sensilla				
MXS	3.03 ± 11.28	maxilla	-	+
LbCS	2.13 ± 0.4971	labium	-	+
Microtrichia				
LM1	2.2 ± 0.16	labrum	+	-
LM2	3.48 ± 0.87	labrum	+	-
HM1	2.8 ± 0.357	hypopharynx	+	-
HM2	6.08 ± 0.8158	hypopharynx	-	+
HM3	4.08 ± 0.8158	hypopharynx	-	+
MM1	0.9166 ± 0.2356	maxillae	+	-
MM2	2.46 ± 0.5437	maxillae	-	+
Papillae				
LP1	3.59 ± 0.243	labrum	+	-
LP2	8.91 ± 1.70	labrum	-	+
Sensory pegs				
LbS	8.91 ± 1.70	labium	-	+
Spines				
LbS1	27.71 ± 8.00	labium	+	-
LbS2	35.71 ± 7.71	labium	+	-
LbS3	55.35 ± 15.36	labium	+	-
LbS4	89.86 ± 22.60	labium	+	-
LbS5	36.36 ± 7.00	labium	+	-

+ Present, - Absent, ± Standard error

HYPOPHARYNGEAL SENSILLA

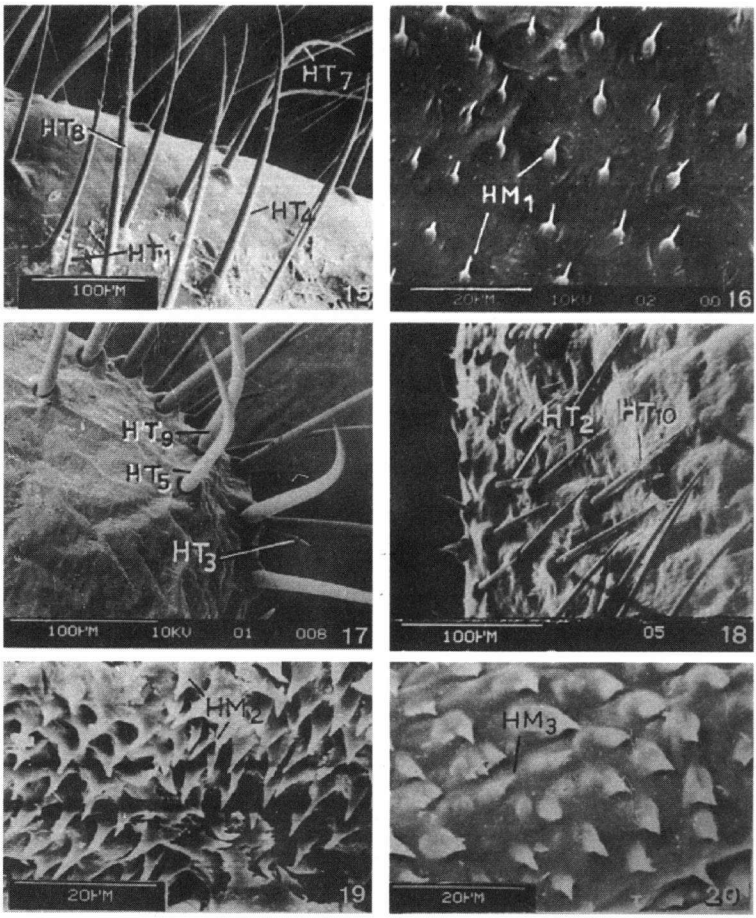
Figures 15-20

The hypopharynx is an unsegmented and lobulat structure in both the larva and the adult. It measures about 1.5 ± 0.3mm and 2 ± 0.63mm in length and 1.4 ± 0.46 mm and 2.1± 0.64 mm in width in the larva and adult, respectively. It is cushion--like and somewhat triangular in shape in the larva, while wedge-shaped in the adults.

The hypopharynx of the larva bears long trichoid sensilla all over the marginal (HT7, HT8, HT12) and sub-marginal (HT1, HT4) regions (Tab. I). The middle region is, however, devoid of sensilla. In the posteroventral region, small pointed microtrichia (HM1) are present (Tab. II). The marginal trichoid sensilla are longer

than the others. The microtrichia are short, fine, hair-like structures provided with large bulbus sockets. They are sparsely distributed.

In the case of the adult hypopharynx, the trichoid sensilla (HT2, HT3, HT5, HT6 and HT9) are present marginally, and HT10, HT11, HT13 and HT14 middorsally. Trichoid sensilla as well as two types of microtrichia (HM2, HM3) are present on the posterolateral region of the inner surface (Tab. II). The anterior microtrichia are elongate and blade-like, overlapping each other and without the sockets, whereas the posterior microtrichia are short, spine-like widely separated and possess bulbus sockets.

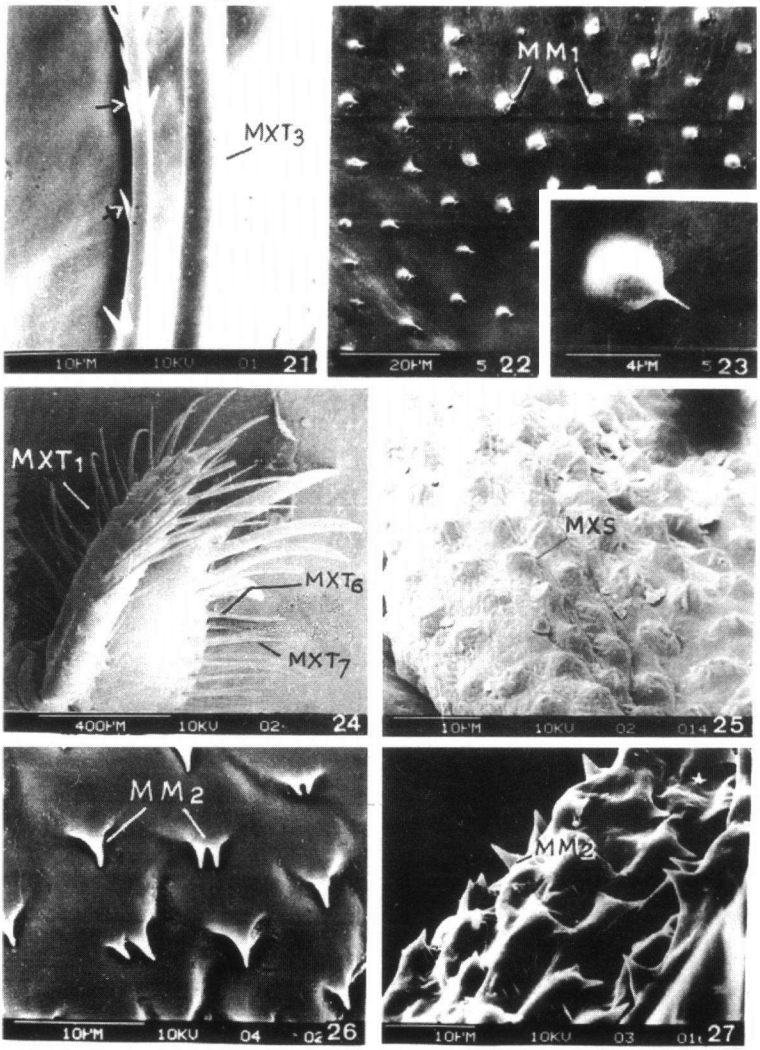


Figs 15-20. Hypopharyngeal sensilla in the larva (Figs 15-16) and adult (Figs 17-20): (15) ventral trichoid sensilla (HT1, HT4, HT7, HT8); – (16) ventral microtrichia (HM1); – (17) dorsal trichoid sensilla (HT3, HT5, HT9); – (18) dorsolateral trichoid sensilla (HT2, HT10); – (19) ventral microtrichia (HM2); – (20) ventral microtrichia (HM3).

MAXILLARY SENSILLA

Figures 21- 27

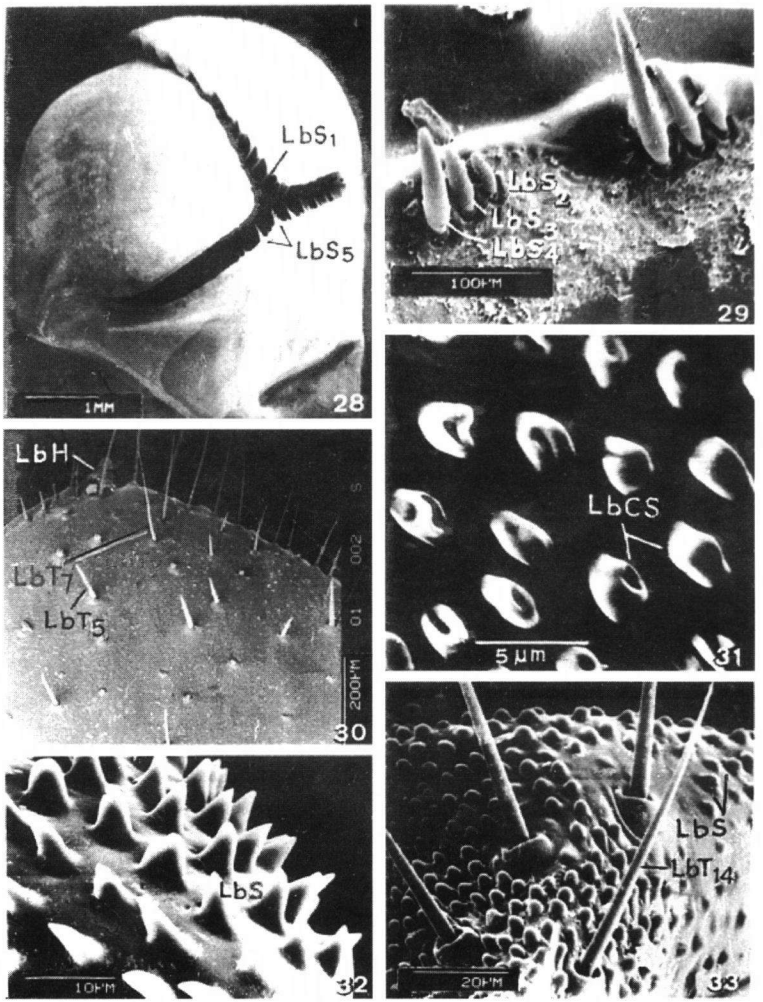
The maxillae of the larva and adult dragonfly are composed of various parts, viz. cardo, stipes, inner lobe and outer lobe. The cardo is elongate, whereas the stipes is large, elongate and rectangular. The inner and outer lobes are freely movable proc-



Figs 21-27. Maxillary sensilla in the larva (Figs 21-23) and adult (Figs 24-27): (21) dorsolateral branched trichoid sensillum on inner lobe (MXT3); – (22) ventral microtrichia (MM1); – (23) magnified MM1; – (24) dorsal trichoid sensilla (MXT1, MXT6, MXT7); – (25) ventral campaniform sensilla (MXS); – (26) ventral microtrichia (MM2); – (27) ventrolateral view of MM2.

esses. The inner lobe is formed by the fusion of the lacinia and galea, whereas the outer lobe represents the palpus. The larval maxillae are 2 ± 0.63 mm long and 0.7 ± 0.02 mm broad, while the adult maxillae measure 1 ± 0.33mm in width and 2.6 ± 0.86mm in length.

In the larval maxillae, the apical end of the inner lobe bears a group of seven spines. The trichoid sensilla are present on the outer as well as on the inner surface of the inner lobe (MXT3) and palps (MXT5, MXT6). The microtrichia (MM1) are



Figs 28-33. Labial spines and sensilla in the larva (Figs 28-29) and adult (Figs 30-33): (28) labial spines (LbS1, LbS5); – (29) palpal spines (LbS2-LbS4); – (30) dorsal trichoid sensilla (LbT5, LbT7) and hoof of palp (LbH); – (31) dorsal campaniform sensilla (LbCS); – (32) ventral sensory pegs (LbS); – (33) ventral trichoid sensilla (LbT14) and sensory pegs (LbS).

found on the posteroventral region of the stipes (Tab. II). They are short, fine structures and are widespread in distribution. At some places they form star-like clusters. They are devoid of sockets.

In the adult maxillae, the inner lobe bears six teeth apically. The trichoid sensilla are found on the outer and inner surfaces of the inner lobe (MXT1). The trichoid sensilla of the inner margin (MXT4, MXT8) are elongated and prominent. Trichoid sensilla are also found on the stipes (MXT2) (Tab. II). On the inner surface, in the region of the stipes, the campaniform (MXS) sensilla are present in the middle region, whereas the microtrichia (MM2) are found in the posterior region. The campaniform sensilla are present on the ventral surface of the middle region of the stipes. They are dome-shaped and closely situated. The microtrichia are small, pointed and nipple-like single, double or quadrate cuticular processes. The microtrichia bearing basal region of the stipes is folded repeatedly and thus differentiated distinctly.

LABIAL SENSILLA

Figures 28-33

The labium consists of the postmentum, prementum, squames, middle lobe and lateral lobes. The labium acts as a prehensile organ in the larva. The prementum is 7.9 ± 2.63mm long and 5.3 ± 1.72mm broad. Both the palps are attached to the prementum, each measuring 4.5 ± 0.96mm in length and 3 ± 0.10mm in width. In the adult dragonfly, the median lobe is large and oval in shape. The squames are fused with the palps.

The sensilla are absent on the outer surface in the larva. On the inner surface, the prementum bears 2+2 small mid-posterior trichoid sensilla (LbT4, LbT13, LbT15, LbT16). Similarly, 4+4 trichoid sensilla (LbT6, LbT8) are present on the outer margin of the prementum beneath the base of the palpus (Tab. I). The distal margin of the palp has crenations, each bearing a group of three spines in ascending order (LbS2, LbS3, LbS4). The inner margin of the palp consists of linearly arranged five spines, opposing the lateral spines of the distal margin of the prementum. On the inner surface of the palp a row of eight elongated trichoid sensilla (Lb17) is found on the outer margin. A group of 15 fine trichoid sensilla (LbT2, LbT3) is situated at the site of the articulation of the palp with the prementum. Each palpus bears a long, slender movable hook. Very fine spines (LbS1, LbS5) are present on the distal margin of the median premental lobe. On the inner margin, very fine spines are arranged along the margin. The apical end of each palp bears a long, slender hook (LbH) measuring 0.53mm in length. The hooks of the palps of either side cross over each other.

On the adult labium, the trichoid sensilla are present all over the outer and the inner surface and also on the apical, inner and outer margins of the palps. There are trichoid sensilla on the dorsal surface of the middle lobe (LbT1, LbT5), the squames

(LbT7) and submentum (LbT14) (Tab. I). The middle lobe and the squames bear a group of campaniform sensilla (LbCS) dorsally. They are horse-shoe shaped. The sensory pegs (LbS) are present ventrally on the middle lobe and also on the submentum. They are arranged in parallel rows, so closely that at times they appear overlapping one another. The apical margin of each palp bears a short curved spine, measuring 0.11 mm in length.

DISCUSSION

The mouthparts of the larva and adult of dragonflies are primarily of the biting and chewing type and are adapted secondarily for carnivorous feeding habit (TILLYARD,1917; CORBET, 1983; RICHARDS & DAVIES, 1984).

The earlier light microscopic studies reveal that the labium is modified as a prehensile organ and the mouthparts are equipped with mechano- and chemoreceptors in the larva (ZAWARZIN, 1912; PRITCHARD, 1965; PETRYSZAK, 1977; BASSEMIR & HANSEN, 1980), while no information on that of the adult dragonflies is available.

Neuroanatomical studies reveal innervation of the trichoid sensilla, microtrichia, basiconic sensilla and papillae of the labrum, mandible, hypopharynx, maxillae and labium. Innervation of the teeth of the mandibles and maxillae is also evident (WAZALWAR, 1996).

The labrum of *Brachythemis contaminata* consists of trichoid sensilla and papillae in both the larva and adults, while the basiconic sensilla and acanthae are confined to the adults and the microtrichia to the larva. CHAO (1953) described a round, sclerotized area in the centre on the ventral side of the labrum (epipharynx), surrounded by a group of small circular tubercles and hairs in *"Onychogomphus ardens"* (= *Lamelligomphus camelus* [Martin]). During the present study it has been noticed that the epipharynx consists of a group of well defined papillae, encircled by the microtrichia in the larva and basiconic sensilla in the adults of *B. contaminata*. The labral trichoid sensilla are generally considered as the mechanoreceptors, responding to the sense of touch, while the basiconic sensilla and the papillae can be considered as the chemoreceptors (DETHIER, 1963; CHAPMAN, 1982). It was earlier thought that all the sensilla on the mounthparts, including the labrum, are mechanoreceptors and even those reported earlier in *Aeshna* spp. (ZAWARZIN, 1912; PRITCHARD, 1965) as chemoreceptors were later considered as campaniform sensilla and pressure receptors (CHAPMAN, 1982).

PETRYSZAK (1977) reported the presence of hair-like sensilla, mostly representing mechanoreceptors and papillae-like sensilla, as chemoreceptors, on the inside of the labrum of the *Libellula*. She recorded for the first time the chemoreceptors on the dragonfly labrum. In *B. contaminata,* the labral chemoreceptors are represented by the basiconic sensilla as well as the papillae.

The presence of acanthae in the posterodorsal region of the labrum of adult *B.*

contaminata is described for the first time. Although they do not possess basal sockets, they are provided with basal, scale-like structures, overlapping each other and might be facilitating movement to the acanthae in order to grasp or grind the soft bodied prey, as suggested earlier in Mecoptera and Siphonaptera (RICHARDS & RICHARDS,1979). The neuroanatomical studies confirm their true sensory nature, as they are innervated by bipolar neurons (WAZALWAR, 1996). A cluster of microtrichia has also been described on the inner side of the labrum of the gryllid, *Acheta domestica* (ROHR, 1982).

In *B. contaminata* the larval mandibles contain a linear fringe of trichoid sensilla on the outer lateral margin, while acanthae are found below the lower teeth. The mandibles of the adult contain dense trichoid sensilla, distributed all over the outer as well as the inner surface. CHAO (1953) reported the presence of tuberculate and hairy areas at the base of the incisors and parallel to the margin of the mola on the adoral side and also on the aboral side in the adult *"Onychogomphus ardens"*. PETRYSZAK (1977) reported the presence of papillae on the mandibles in *Libellula* and considered them as chemoreceptors. In *B. contaminata* the acanthae might be homologous with the so called papillae of PETRYSZAK (1977). The trichoid sensilla, as well as the acanthae, are innervated by neurons, suggesting their sensory nature. CORBIERE-TICHANE (1971) noticed the pressure receptors in the mandibles of the larva *Speophyes lucidulus* (Coleoptera). PETRYSZAK (1977) considered all hair-like sensilla as mechanoreceptors, and acanthae (papillae) as chemoreceptors. A similar role for the mandibular sensilla of *B. contaminata* can be suggested. The trichoid sensilla found on the mandibles of *B. contaminata* are, however, ultrastructurally identical to that of the larval stonefly *Paragnetina media* (KAPOOR,1989).

There are about nine teeth in the larva, which are also of the incisor type, while in the adult there are seven teeth. Of the latter, the three apical teeth are incisors and the posterior four teeth are molars in *B. contaminata*, suggesting species-specific modification of the mandibles in accordance with the feeding habit. These teeth are innervated by the methylene blue stained neurons.

The hypopharynx in larval and adult *B. contaminata* resembles morphologically that of *Anax junius* larva (SNODGRASS, 1954) and *"Onychogomphus ardens"* adult (CHAO, 1953). The whole surface of the nymph is covered with long trichoid sensilla varying in length, and with a patch of microtrichia in the posteroventral region. Similarly, the hypopharynx of the adult is also provided with five types of dorsal trichoid sensilla and four types of ventral trichoid sensilla, besides the posterolateral region being occupied by two types of microtrichia. The microtrichia function as chemoreceptors (PETRYSZAK, 1977). The presence of microtrichia on the hypopharynx has also been reported in several species of plecopteran larvae (HYNES, 1941; KAPOOR, 1989) .

The maxillae in larval and adult *B. contaminata* consist of cardo, stipes and inner and outer lobes. The inner lobe according to SNODGRASS (1935) represents lacinia. However, according to CHAO (1953), it represents the lacinia and galea, and the

outer lobe represents the palp. The inner lobe bears seven maxillary teeth in the larva and six in the adult in order to facilitate predation. The trichoid sensilla are present on the inner lobe, stipes and palps, while the microtrichia are present in the posteroventral region of the stipes as the fine structures in the larva. In adult dragonflies, the inner lobe and palps, as well as the stipes, possess trichoid sensilla, but the stipes contain campaniform sensilla on the middle region and microtrichia on the posterior region on the inner surface also. The presence of campaniform sensilla in different regions of the maxillae has been reported in *Aeshna* (ZAWARZIN, 1912), *Aeshna interrupta lineata* (PRITCHARD, 1965), *Ischnura elegans*, *Coenagrion puella* (BASSEMIR & HANSEN, 1980), *Libellula depressa* and *L. quadrimaculata* (PETRYSZAK, 1977). They are probably the chemoreceptors (CHAPMAN, 1982). They are also reported on the maxillary palps of the stonefly *Paragnetina media* (KAPOOR. 1989). The function of the maxillary microtrichia in stoneflies has been suggested in osmoregulation (KAPOOR & ZACHARIAH, 1973; KAPOOR, 1978, 1980), whereas in odonate larvae KOMNICK (1977) was unable to demonstrate this function.

The trichoid sensilla are present on the palps and prementum in the larva and also on the palps, middle lobe, squames and submentum in the adult *B. contaminata.* In the adult dragonfly, besides the trichoid sensilla, the campaniform sensilla and sensory pegs are found on the squames and the middle lobe, respectively. The sensory pegs, campaniform sensilla and trichoid sensilla are reported on the labium of the larva of the stonefly *Paragnetina media*, and pegs are considered as chemoreceptors (KAPOOR, 1989). A similar function might be attributed to the pegs observed on the inner surface of the median lobe of the labium of the adult *B. contaminata.*

In the larva as well as in the adult dragonfly, the labium is evolved as a prehensile organ adapted for catching, grinding and swallowing the prey (CORBET, 1983; GUPTA et al.,1991). The presence of a single apical hook and ten groups of spines along the distal margin of the palp, and thirty-six spines on the distal margin of the median premental lobe in the larva seems to be a species-specific character of *B. contaminata.*

The labium of the adult bears a single, short, curved spine on the apical margin of each palp, opposing the contralateral one. These cuticular structures, no doubt, are basically adapted to facilitate a prehensile function. They are innervated by the dendrites of the bipolar neurons and their axonal fibres form the lateral axonal tract, suggesting their secondary sensory function (WAZALWAR, 1996).

REFERENCES

ALTMAN, J.S. 1980. Toluidine blue as a rapid stain for nerve cell bodies in intact ganglia. *In*: N.J. Strausfeld & T.A. Miller, [Eds], Neuroanatomical techniques. Insect nervous system Springer, New York.

ARNOLD, J.W., 1974. Adaptive features on the tarsi of cockroaches (Insecta: Dictyoptera). *Int. J. Insect Morphol. Embryol.* 3: 317-334.

BASSEMIR, U. & K. HANSEN, 1980. Single-pore sensilla of damselfly larvae: representatives of phyllogenetically old contact chemoreceptors ? *Cell - Tiss. Res.* 207: 307-320.

BLEST, A.S., 1980. Reduced silver impregnation of the ungewitter type. *In*: N.J. Strausfeld & T.A. Millder, [Eds], Neuroanatomical techniques. Insect nervous system Springer, New York.

CARLINE, T., K. KUBRA, V.K. BROWN & R. BECK, 1984. Comparison of the distribution and nervous innervation of the sensilla on the labrum of Gryllus bimaculatus (De Geer) and Acheta domesticus (L.) (Orthoptera: Gryllidae) and an account of their development in A. domesticus. *Int. J. Insect Morphol. Embryol.* 13: 81-103.

CHAO, H.F., 1953. The external morphology of the dragonfly Onychogomphus ardens Needham. *Smithson. misc. Colln* 122: 1-56.

CHAPMAN, R.F., 1982. Chemoreception: the significance of receptor numbers. *Adv. Insect Physiol.* 16: 247-356.

CORBET, P.S., 1983. *A biology of dragonflies.* Classey, Faringdon.

CORBIERE-TICHANE, G., 1971. Ultrastructre de l'équipement sensorial de la mandibule chez la larve du Speophyes lucidulus Delar (Coleoptera cavernicole de la sous famille des Bathysciinae). *Z. Zellf.* 112: 129-138.

DETHIER, V.G., 1955. The physiology and histology of the contact chemoreceptors of the blowfly. *Q. Rev. Biol.* 30: 348-371.

DETHIER, V.G., 1963. *The physiology of insect senses.* Methuen., London.

GUPTA, A., S. DEY & S. GUPTA, 1991. Cuticular structures on the labium of the larva of Crocothemis servilia (Drury) (Anisoptera: Libellulidae). *Odonatologica* 21: 7-10.

GURR, E., 1962. *Staining animal tissues, practical and theorotical.* Leonard Hill, London.

HUMASON, G.L., 1962. *Animal tissue techniques.* Freeman, San Fransisco-London.

HYNES, H.B.N.,1941. The taxonomy and ecology of the nymphs of British Plecoptera with notes on the adults and eggs. *Trans R. ent. Soc. Lond.* 91: 459-557.

ISMAIL, I.A.H., 1962. Sense organs on the antennae of Anopheles maculipennis atroparvus (V.Thiel) and their possible function in relation to the attraction of femal mosquitoes to man. *Acta. trop.* 19: 1-58.

KAPOOR, N.N., 1978. Effect of salinity on the osmoregulatory cells in the tracheal gill of stone fly nymph, Paragnetina media (Plecoptera: Peridae). *Can. J. Zool.* 56: 2608-2613.

KAPOOR, N.N., 1980. Relationship between gill Na, K-activate ATPase activity and osmotic stress in the plecopteran nymph. *J. exp. Zool.* 213: 213-218.

KAPOOR, N.N., 1989. Distribution and innervation of sensilla on the mouthparts of the carnivorous stonefly nymph, Paragnetina media (Walkar) (Plecoptera: Perlidae). *Can. J. Zool.* 67: 831--838.

KOMNICK, H., 1977. Chloride cells and chloride epithelia of aquatic insects. *Int. Rev. Cytol.* 49: 285-329.

KUBRA, K.T., 1978. The functional morphology of Acheta domesticus (L.). Ph.D. thesis, Univ. London.

LIU, Y.S. & P.L. LEO, 1960. Histological studies on the sense organs and the appendages on the oriental migratory locust, Locusta migratoria. *Acta. ent. sin.* 10: 243-272.

McIVER, S.B.,1975. Structure of cuticular mechanoreceptors of arthropods. *Annu. Rev. Ent.* 20: 381--397.

PETRYSZAK, A., 1975. The sensory peripheric nervous system of the cockroach Periplaneta americana (L) (Blattoidea), 1. Mouth parts. *Zesz. nauk, Uniw. jagiellonsk.* (Zool.) 20: 41-84.

PETRYSZAK, A., 1977. The sense organs of the mouthparts in Libellula depressa L. and Libellula quadrimaculata L. (Odonata). *Acta. biol. cracov.* (Zool.) 20: 80-100.

PRITCHARD, G., 1965. Sense organs in the labium of Aeshna interrupta lineata Walker (Odonata:

Anisoptera). *Can. J. Zool.* 43: 333-336.

RICHARDS, A.G., 1951. *The integument of arthropods.* Univ. Minnesota Press, Minneapolis,

RICHARDS, A.G. & P.A. RICHARDS, 1979. The cuticular protuberences in insects. *Int. J. Insect Morphol. Embryol.* 8: 143-157.

RICHARDS, O.W. & R.G. DAVIES, 1984. *Imm's general textbook of entomology*, 10th edn, Chapman & Hill, London.

ROHR, W., 1982. Bau und Verteilung der Sensillen auf der Innenseite des Clypeolabrum von Acheta domesticus L. (Insecta : Ensifera) während der postembryonalen Entwicklung. *Braunschweig. naturk. Schr.* 1: 513-531.

SCHNEIDER, D. & K.E. KAISSLING, 1957. Der Bau der Antenne des Seidenspinners Bombyx mori. L.1: Architektur und Bewegungsapparat der Antenne sowie Strucktur der Cuticula. *Zool. Jb.* (Anat.) 75: 287-310.

SLIFER, E.H., 1970. The structure of arthropod chemoreceptors. *Annu. Rev. Ent.* 15: 121-142.

SNODGRASS, R.E.,1935. *Principles of insect morphology.* McGraw-Hill, New York-London.

SNODGRASS, R.E., 1954. The dragonfly larva. *Smithson. misc. Colln* 123: 1-38.

THOMAS, J.G., 1966. The sense organs on the mouthparts of the desert locust (Schistocerca gregaria). *J. Zool.* 148: 420-448.

TILLYARD, R.J., 1917. *Biology of dragonflies.* Cambridge Univ. Press, London.

WAZALWAR, S.M., 1996. *Studies on the mouthparts and digestive system with special reference to the cuticular modifications in the anisopteran odonate.* Ph.D. thesis, Nagpur Univ., Nagpur.

ZACHARUK, R.Y., 1962. Sense organs on the head of larvae of some Elateridae (Coleoptera): their distribution, structure and innervation *J. Morphol.* 101: 359-397.

ZAWARZIN, A., 1912. Histologische studien über Insekten. 2. Das sensible Nervensystem der Aeschna-larven *Z. wiss. Zool* (A) 100: 245-286.