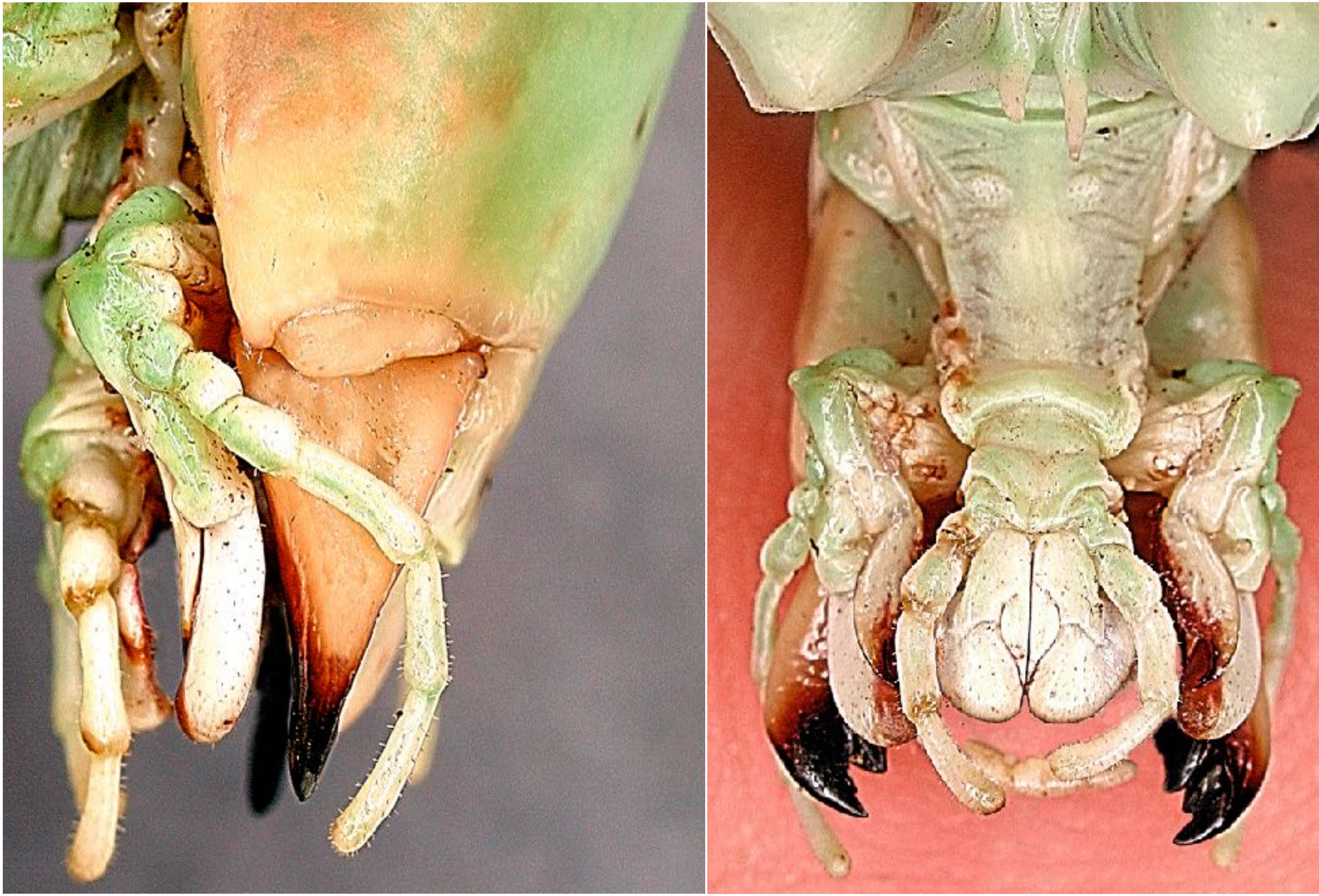


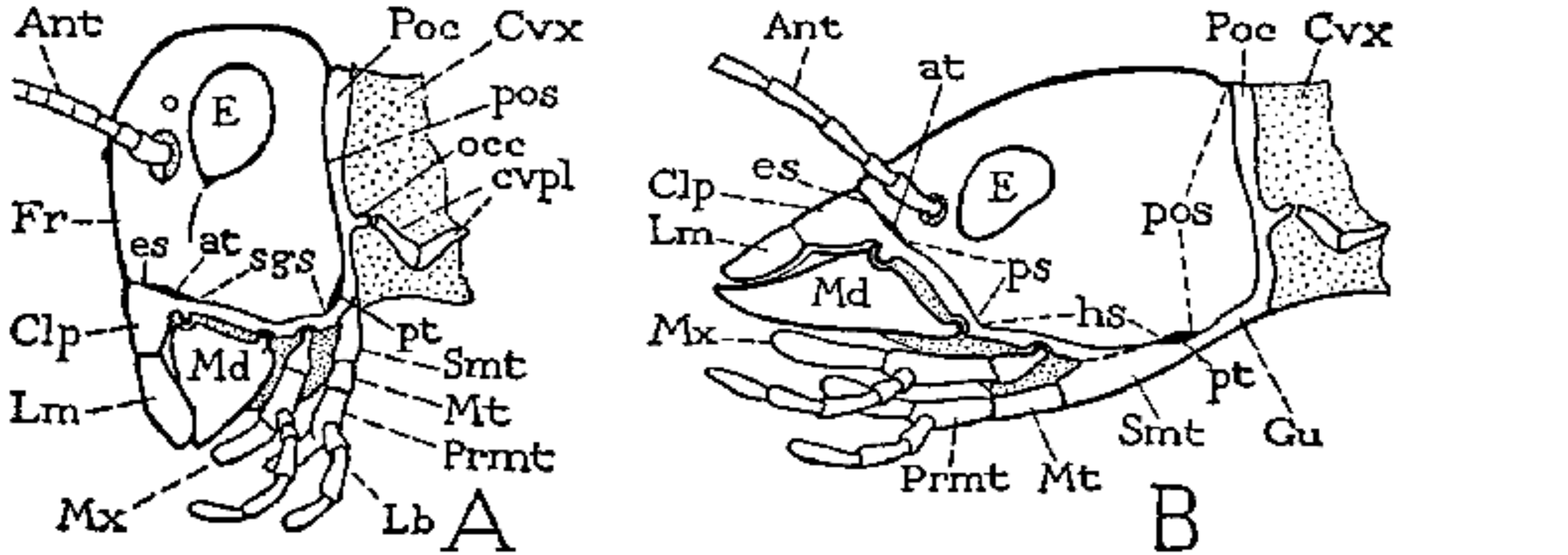
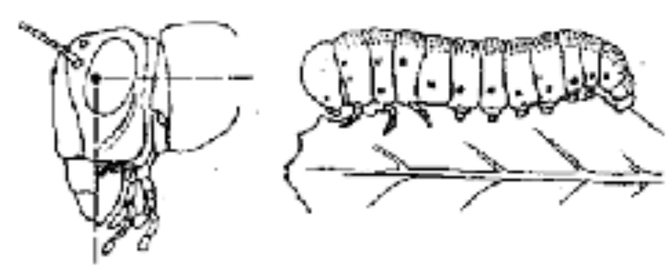


Fig. 66.—Diagrams illustrating the hypognathous (A) and prognathous (B) types of head structure.

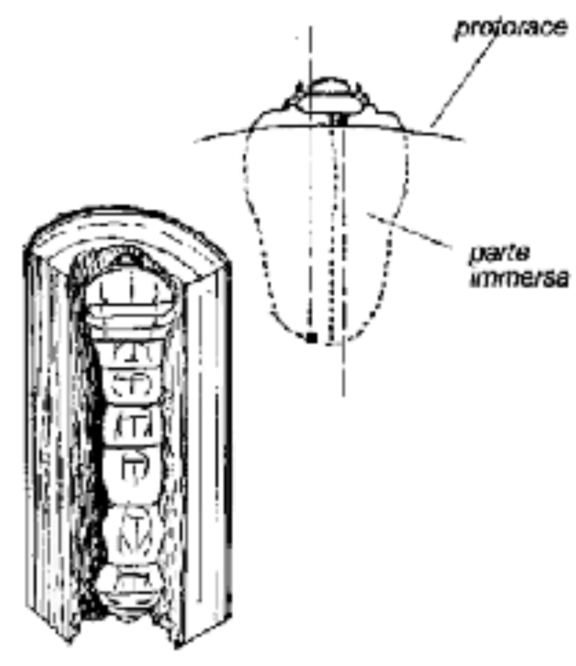
Figure 12.6 (Snodgrass, 1935)

▽ CAPO PROGNATO

▽ CAPO IPOGNATO



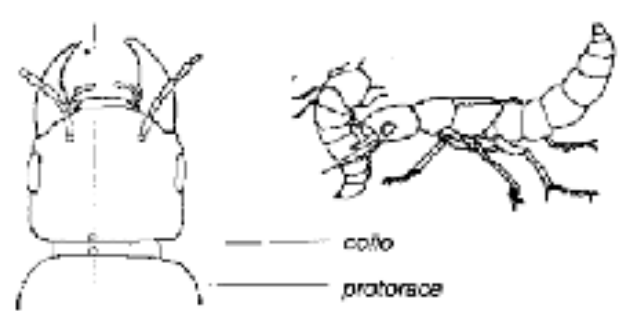
▽ CAPO IMMERSO NEL TORACE



▽ CAPO EPIGNATO

▽ CAPO METAGNATO

▽ CAPO LIBERO DAL TORACE

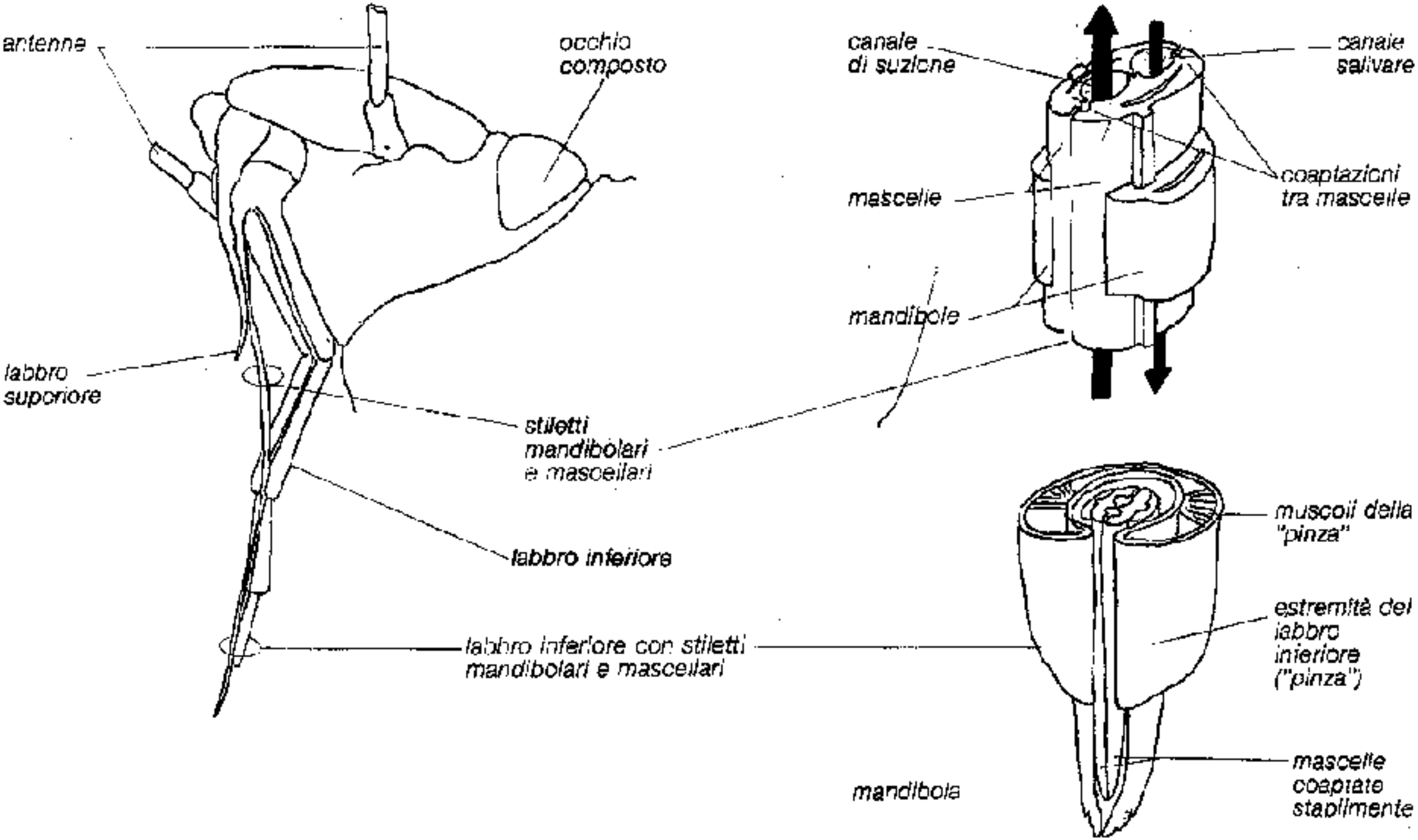


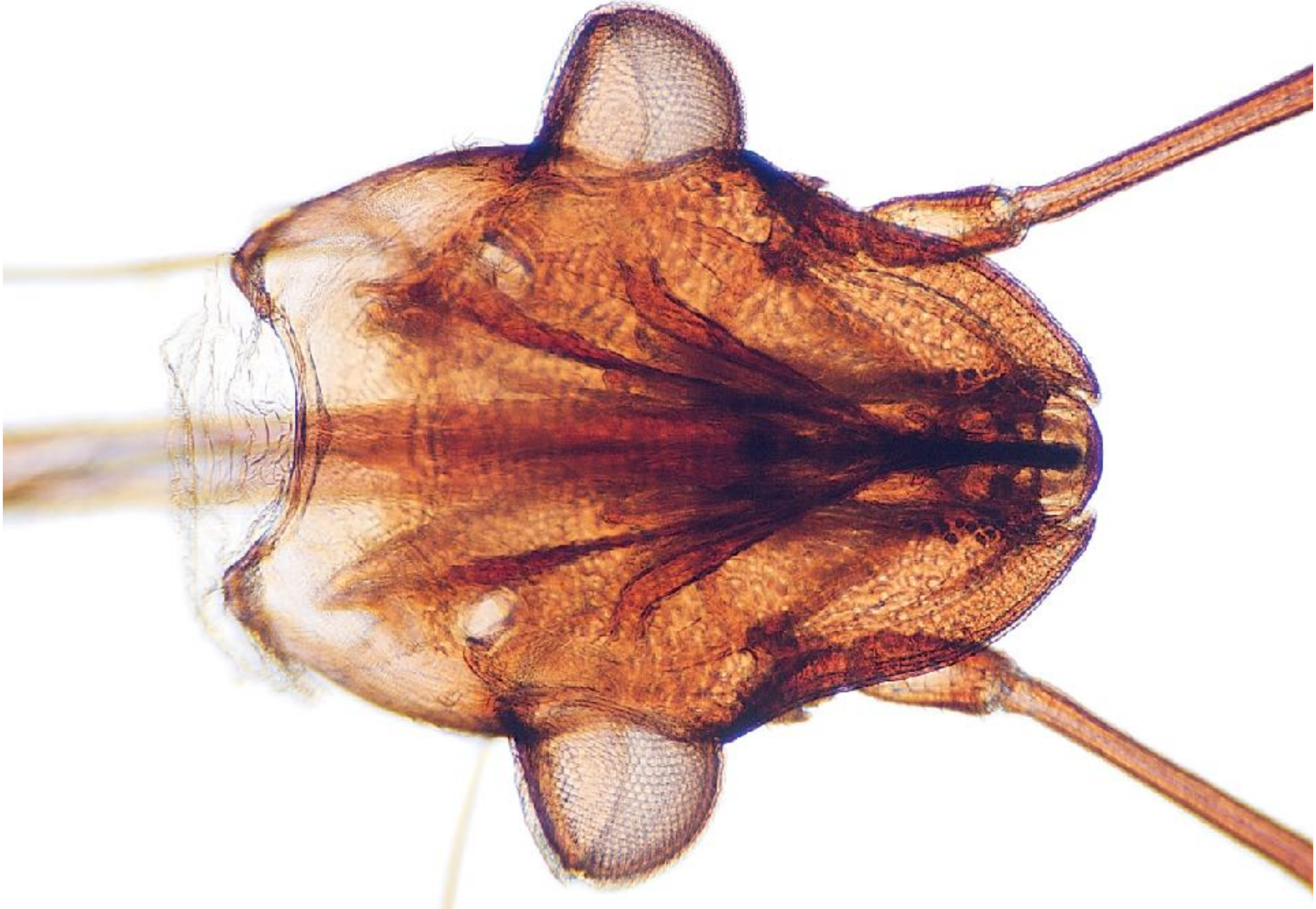
Bugs posses piercing, sucking mouthparts in the form of a long beak or rostrum. In heteropteran bugs, the rostrum arises from the front part of the head and can be hinged forward to point down or forwards, in front of the head. This allows much greater flexibility and a larger choice of food. In the Auchenorrhyncha and Sternorrhyncha, the rostrum, which arises from the posterior part of the head, or seemingly from between the front legs, is permanently directed backwards. With the exception of non-feeding male scale insects and the sexual forms of a few aphids, whose mouthparts are vestigial or lacking, the bug rostrum is similar throughout the order. The outer covering of the rostrum, the protective labium (with 1-4 segments), is grooved for most of its length and surrounds the slender, toughened feeding stylets.

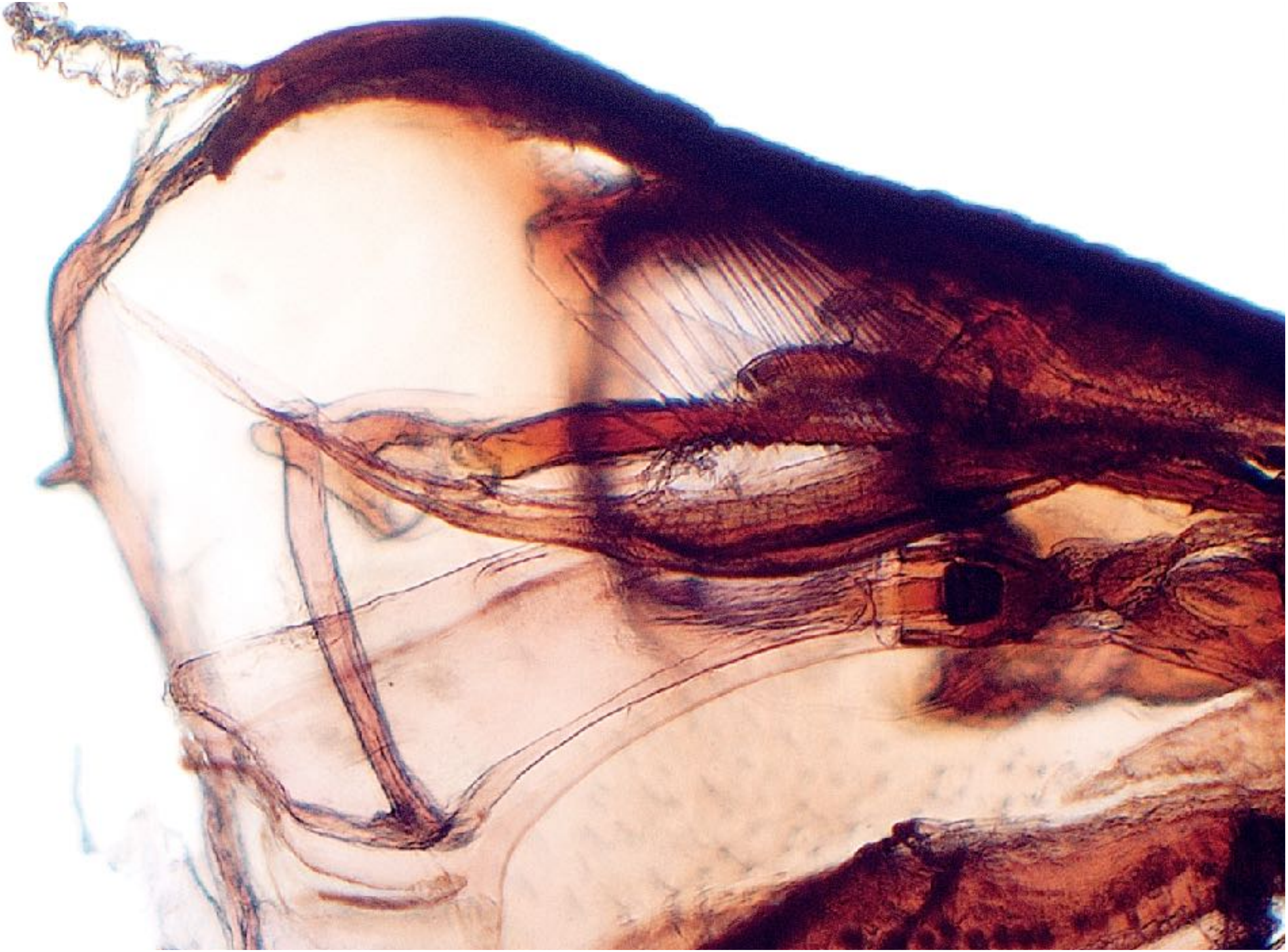
The stylet bundle is made up of a pair of mandibular and a pair of maxillary stylets. The mandibular stylets enclose the maxillary stylets and can be closely connected by means of longitudinal ridges and grooves on their surfaces fitting together like the seal of a zip-lock plastic bag. The two pairs of stylets can slide freely on each other but are difficult to pull apart. The mandibular stylets have saw-like serrations, teeth, and, sometimes, barbs to penetrate plant and animal tissues. Predacious bugs penetrate the cuticle of their prey through a weak spot and use their long stylets and saliva to macerate the internal tissues before they are sucked out. The inner surfaces of the maxillary stylets are folded into longitudinal ridges and grooves, which firmly unite the two and provide two very fine, parallel canals running along their entire length. The ventral canal is the salivary canal, which carries digestive enzymes from the salivary glands in the anterior part of the thorax, the other is the food canal.

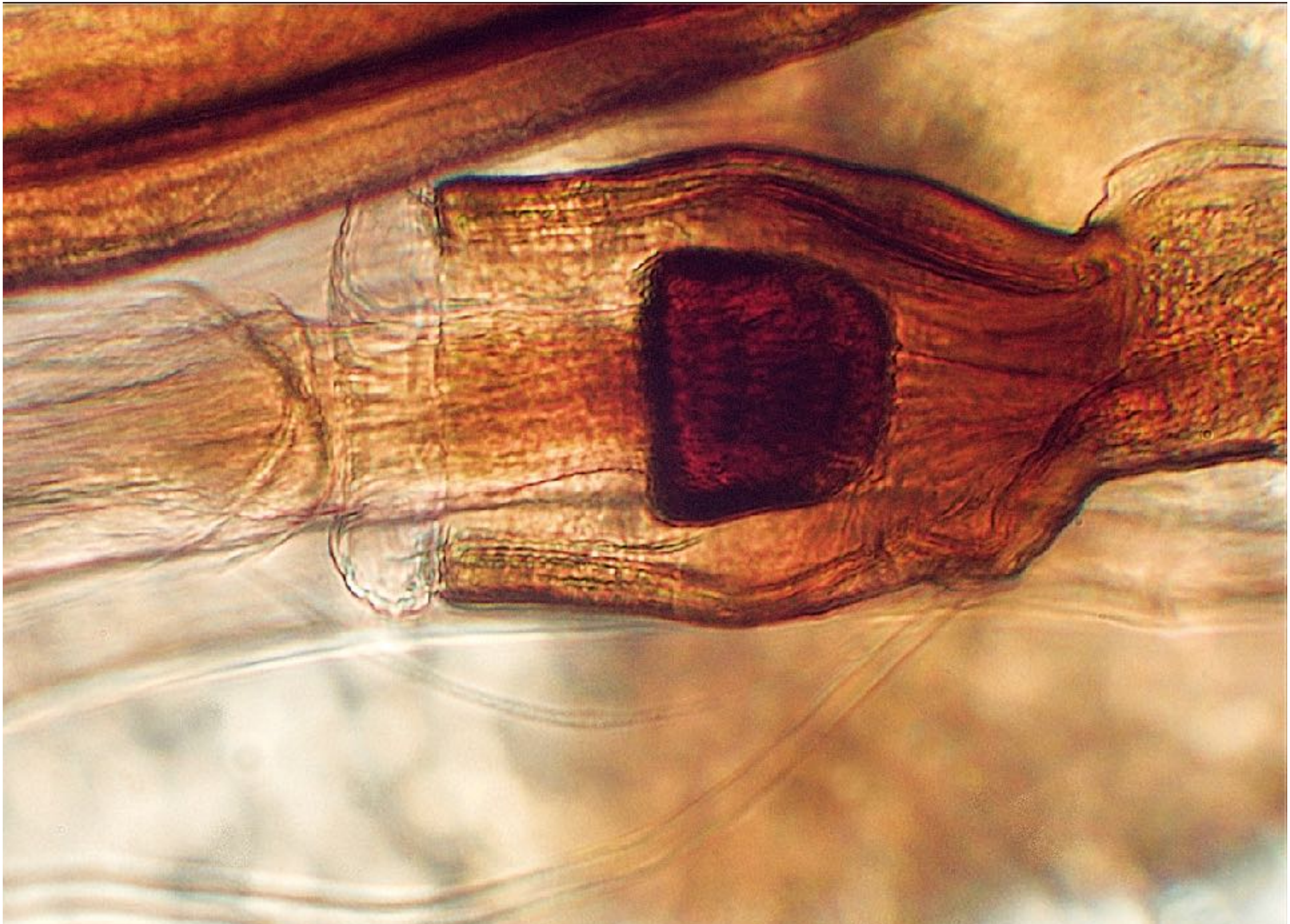
▽ CAPO CON PARTI BOCCALI

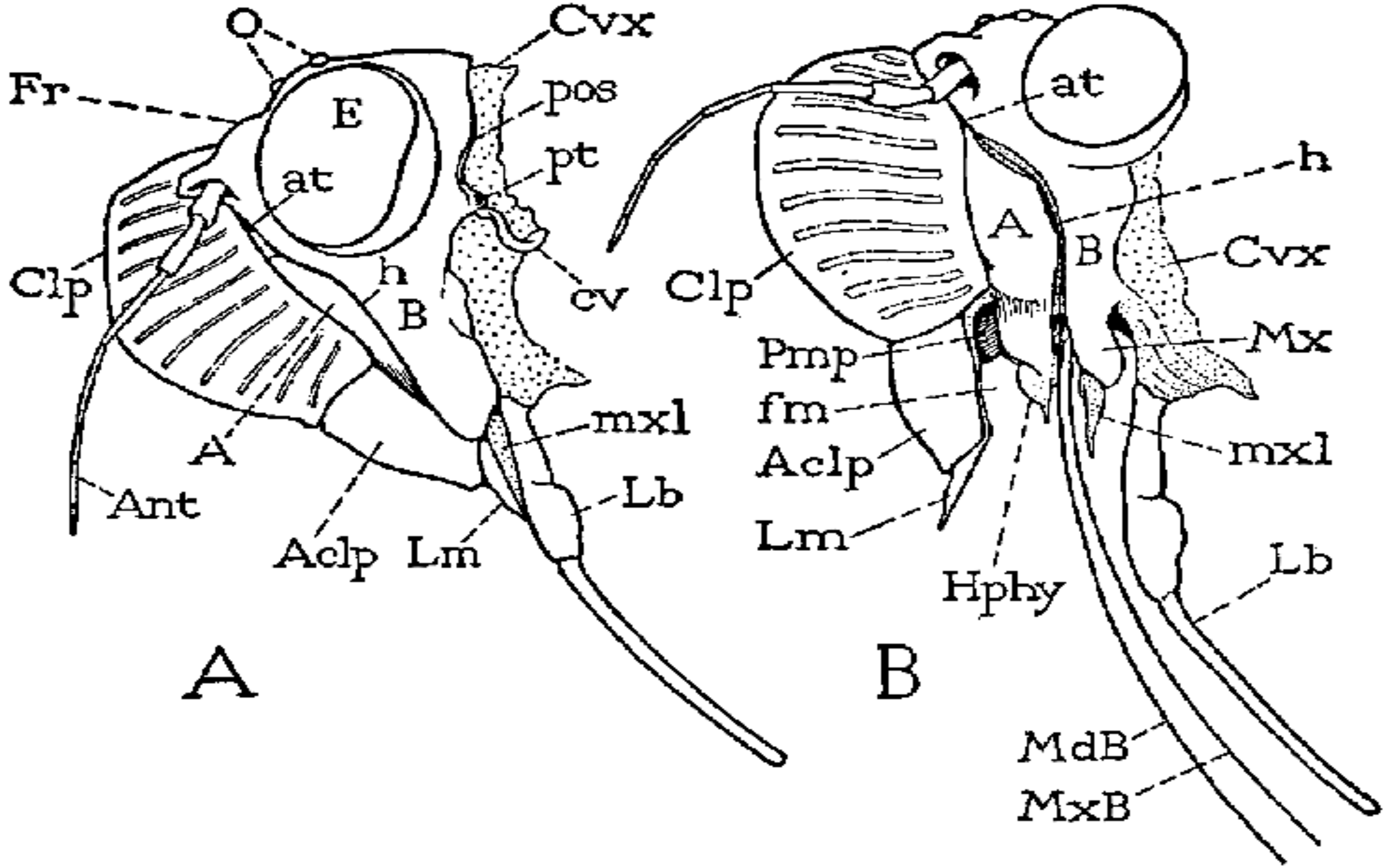
▽ SPACCATO DELLE PARTI BOCCALI A DIVERSO INGRANDIMENTO E LIVELLO



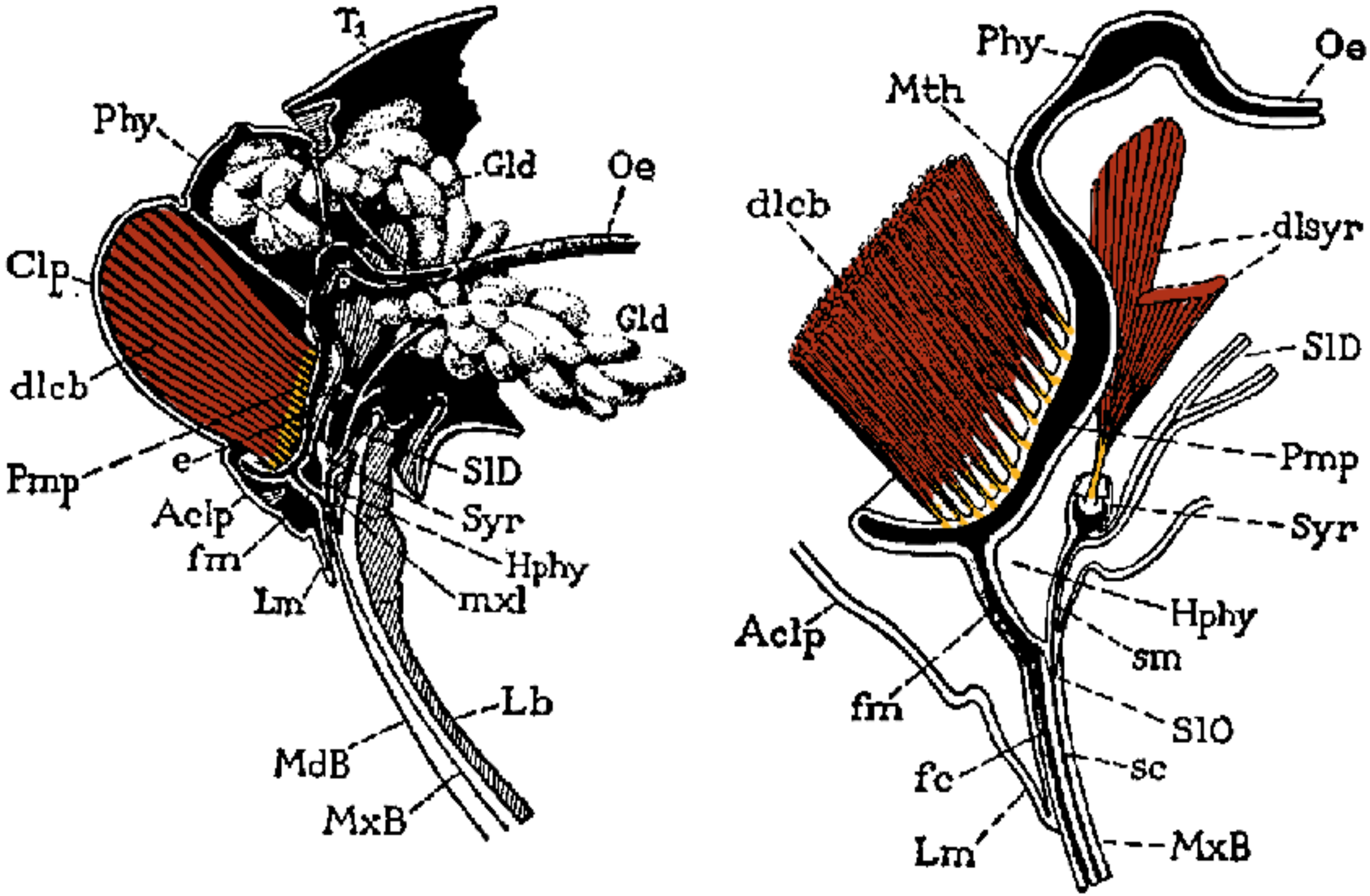




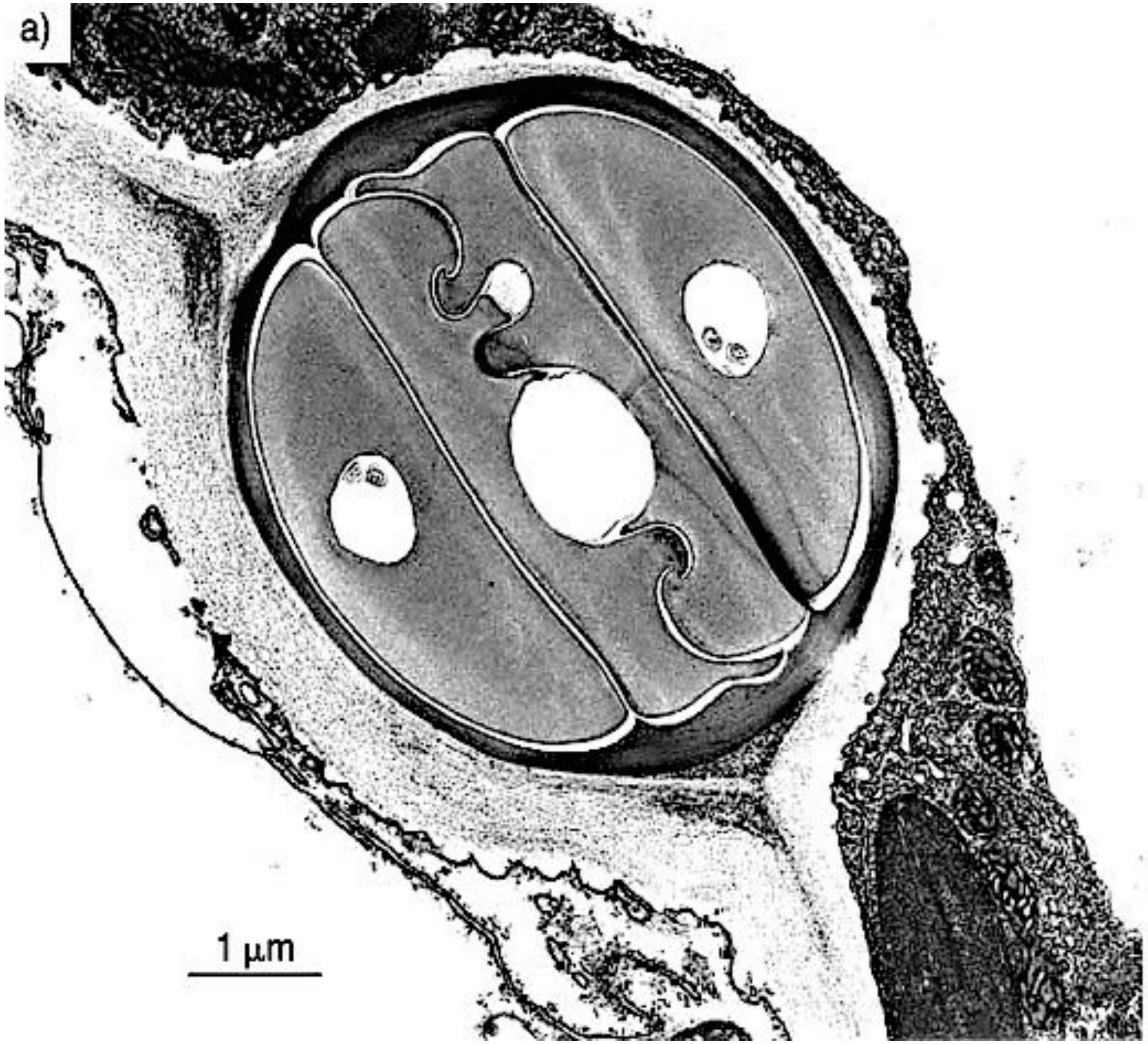


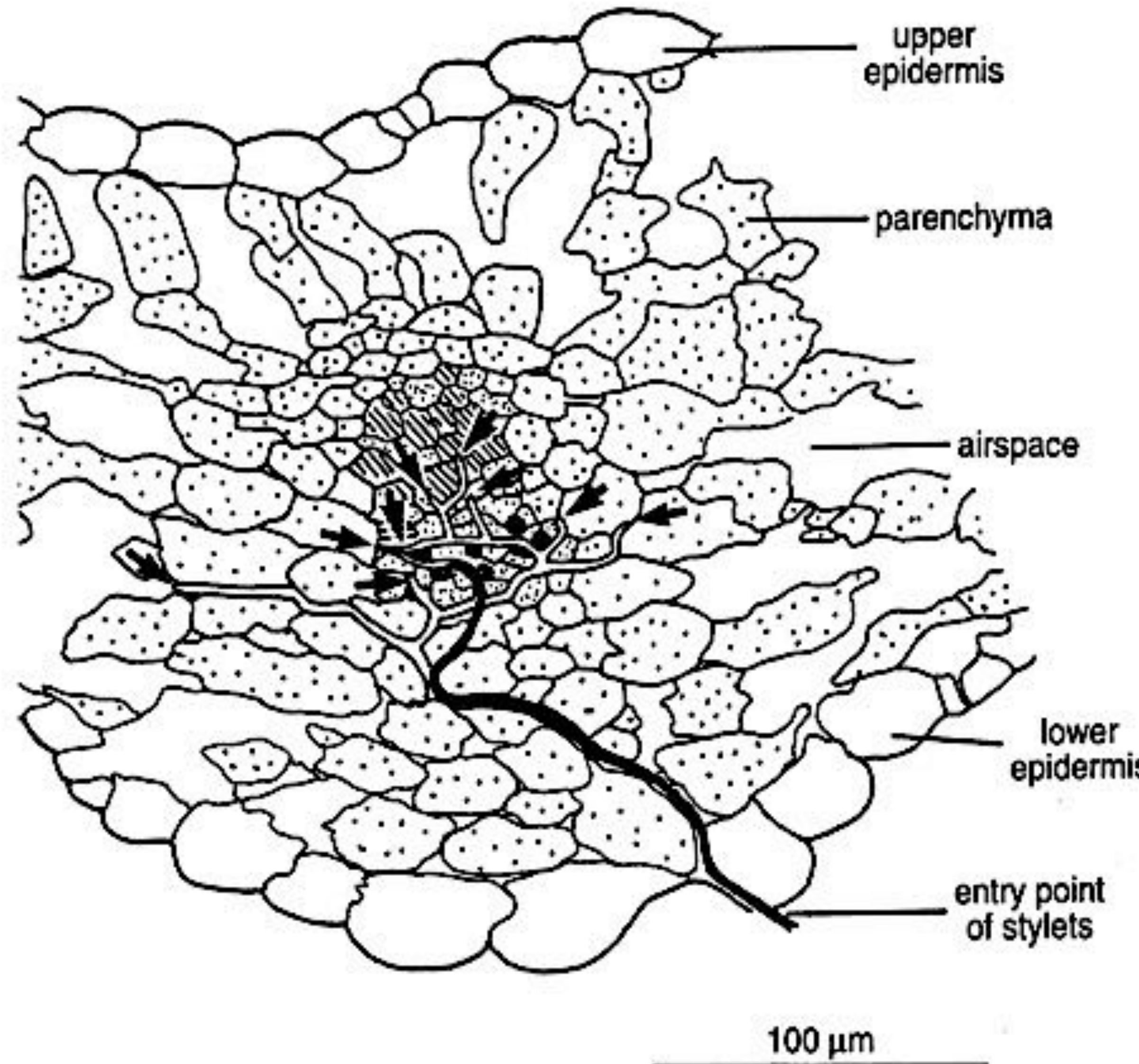

O
Cvx
Fr
E
pos
pt
at
Clp
h
B
cv
A
mxl
Ant
Lb
Aclp
Lm
at
h
A
B
Cvx
Clp
Mx
Pmp
fm
mxl
Aclp
Lm
Lb
Hphy
MdB
MxB

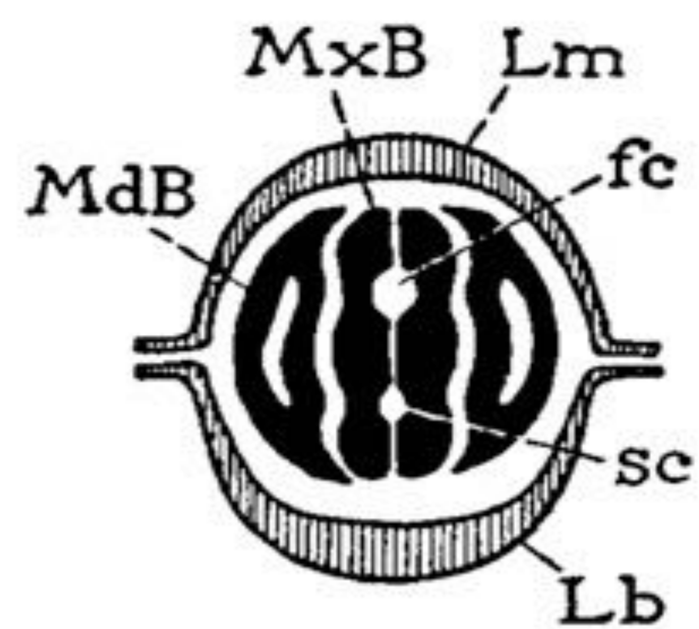
A B



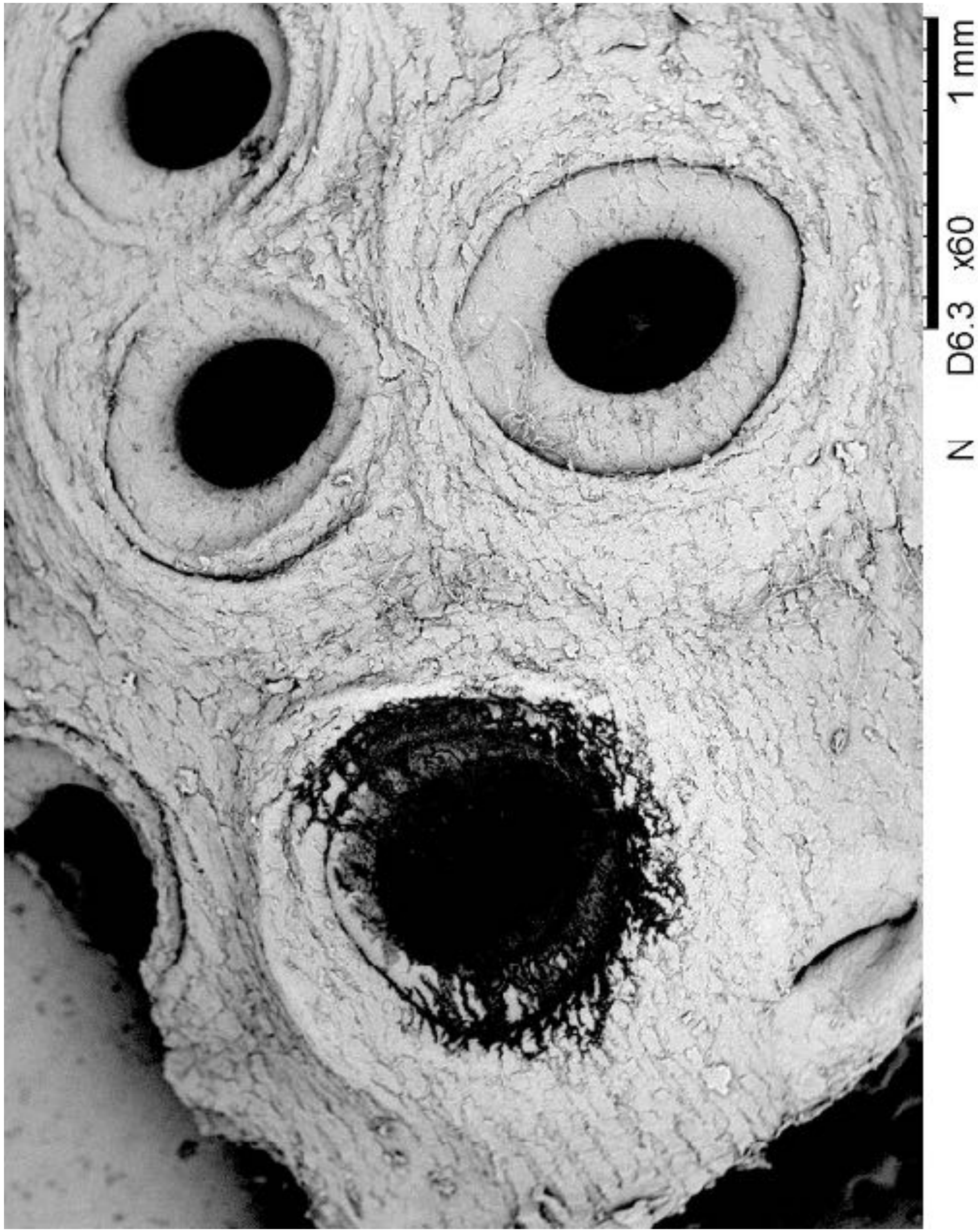
Bug saliva is a complex mixture of a number of different enzymes, toxins, lubricants, and other substances. Herbivorous bugs need enzymes, such as pectinases, to break down plant cell walls, while the saliva of carnivorous heteropteran bugs may contain powerful enzymes causing the instantaneous paralysis and death of prey. In plant sap feeding bugs, such as aphids, the site of the phloem vessels in the plant may be some distance from the surface, and the stylet bundle has to wander between the tough-walled cells of the plant's epidermis before reaching a feeding site. The stylets are protected by the formation of a proteinaceous sheath formed by the hardening of special salivary gland secretions, which are produced throughout the course of penetration. In the head, powerful muscles operating the sucking or cibarial pump draws the liquid or pre-dissolved food up the stylet bundle and passes it into the pharynx. Bugs feeding on the sap in phloem vessels do not require very strong cibarial pumps as their diet is under slight positive pressure.

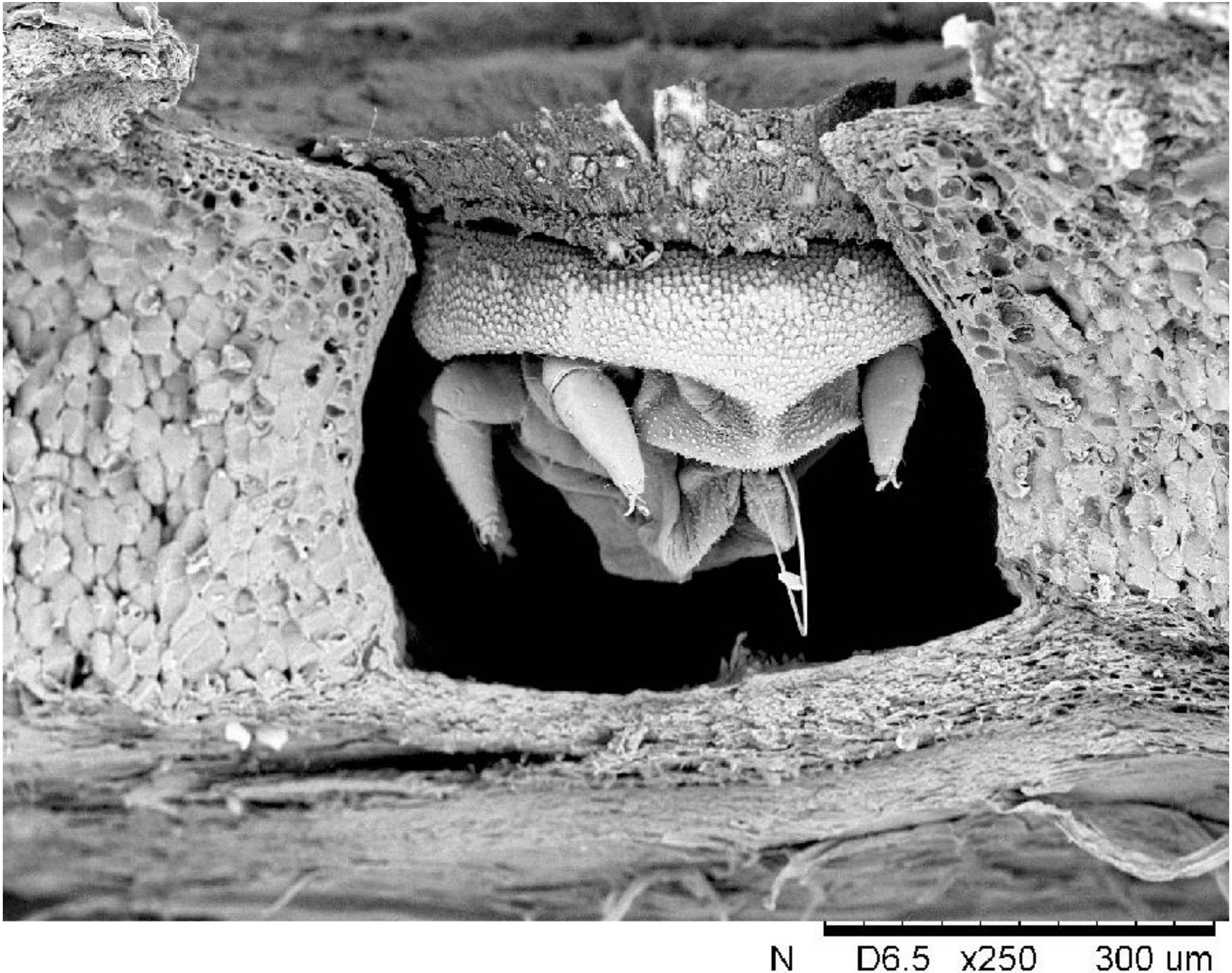


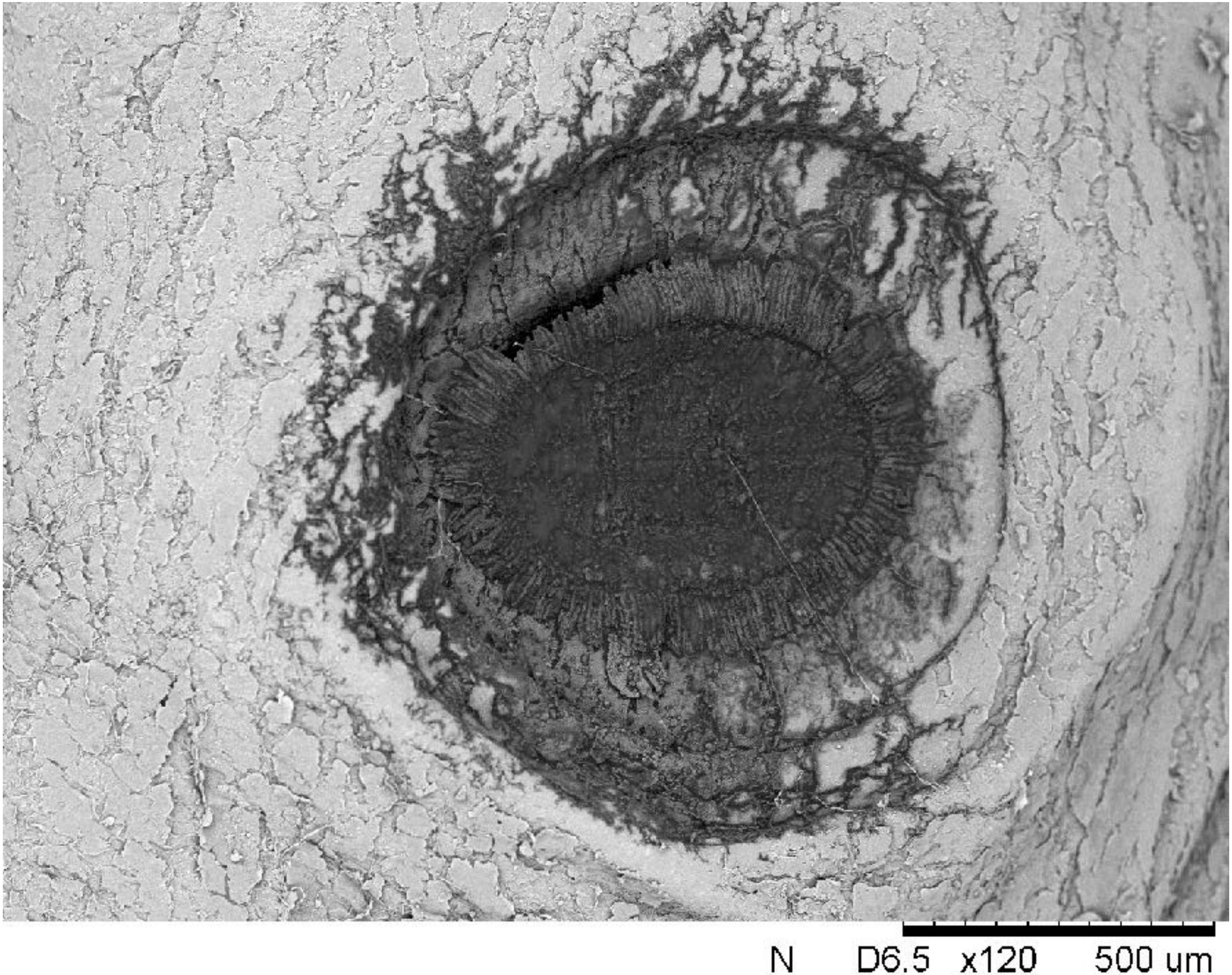


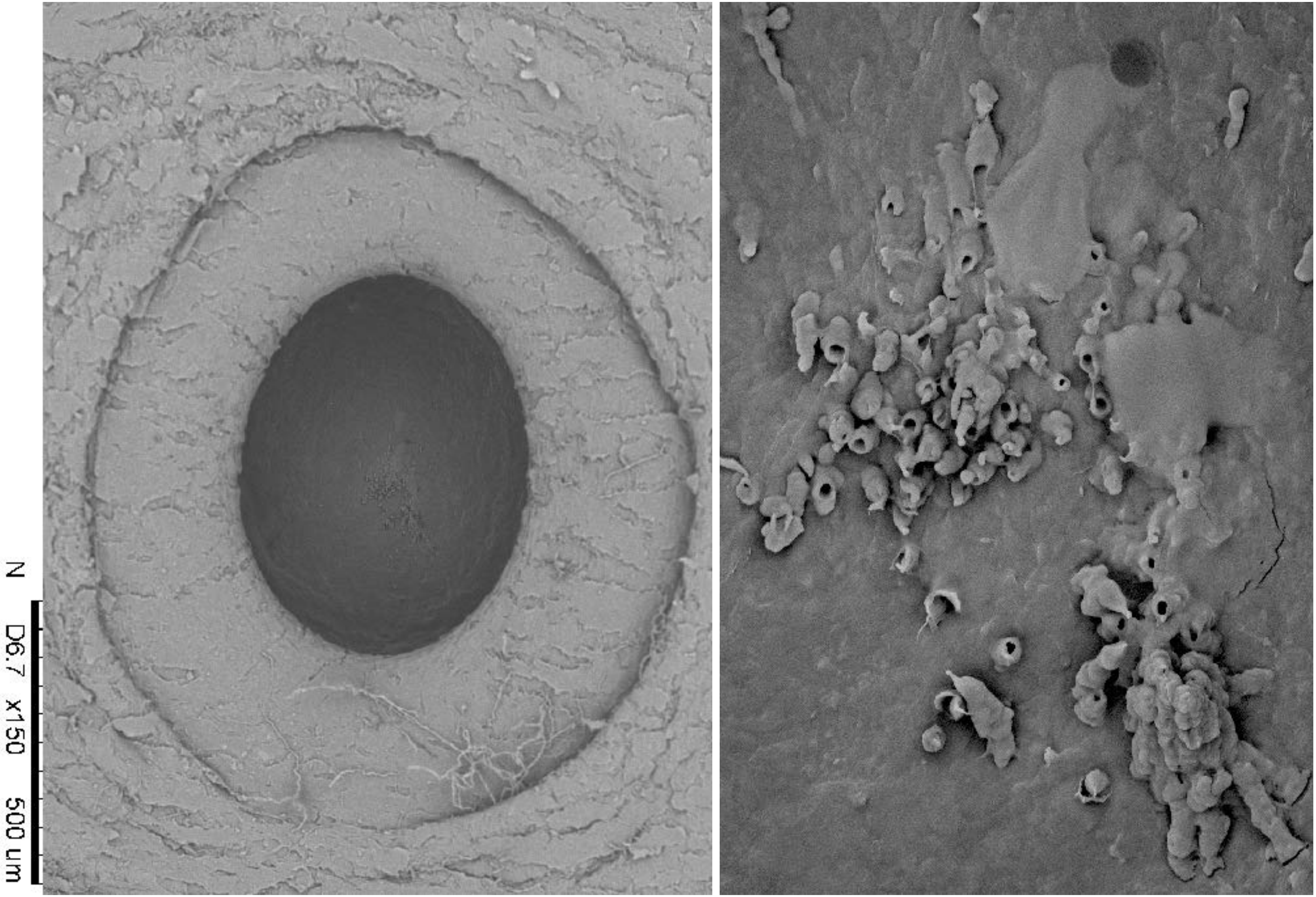


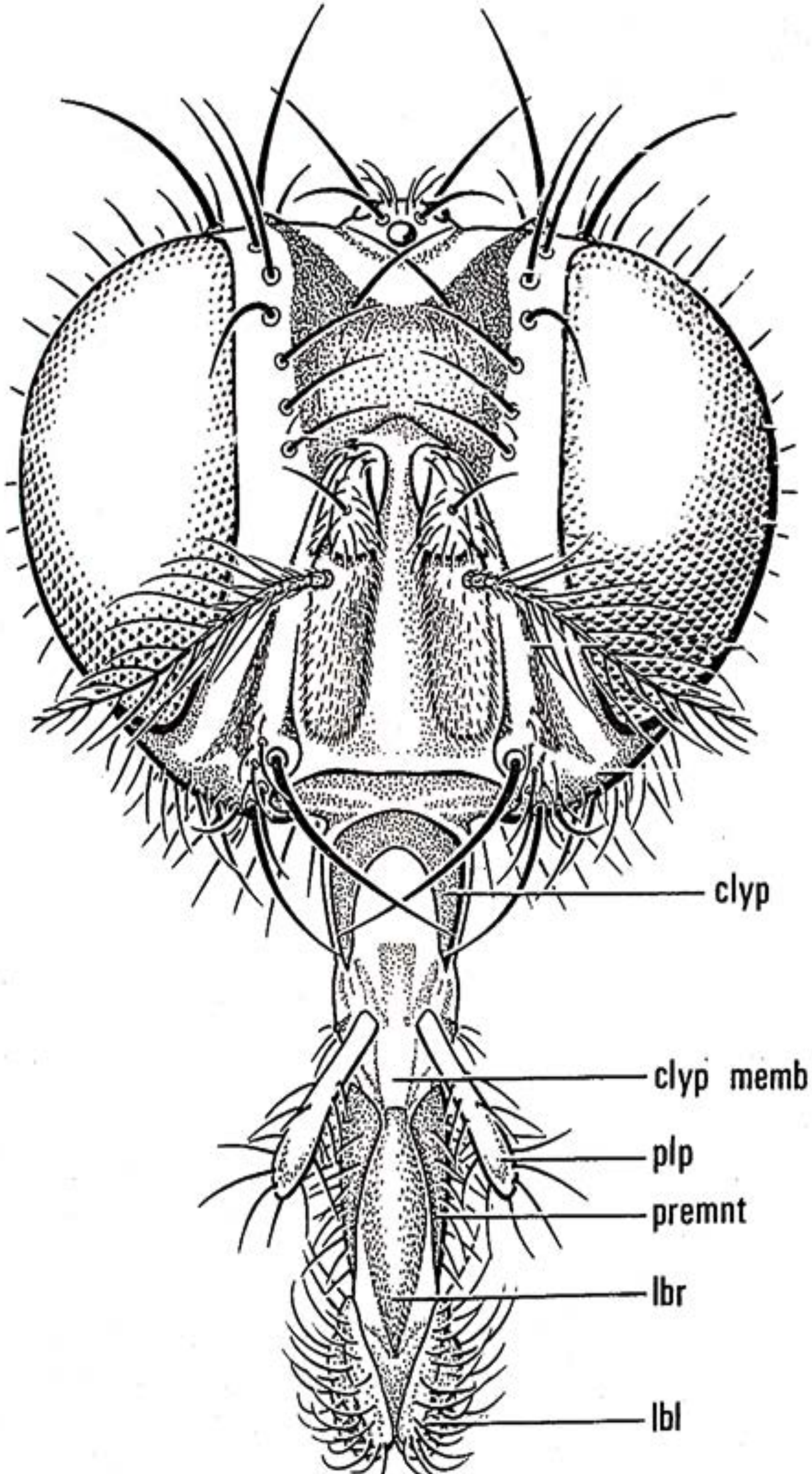
Feeding by an aphid (after Tjallingii & Esch, 1993). (a) Transverse section through the stylets and salivary sheath in a leaf. The maxillary stylets interlock to form the food canal (center) and the salivary canal (above). Each mandibular stylet has a narrow lumen, an extension of the hemocoel, containing mechanoreceptor neurons. The dark ring surrounding the stylets is the salivary sheath. Outside it, the pale fibrous material is plant cell wall. Notice that the stylets are contained within the cell wall; they do not enter the surrounding cytoplasm. (b) Pathways taken by the stylets of an aphid at the start of feeding. Abortive pathways are shown white with the ends of the paths indicated by arrows. The final pathway, reaching the phloem, is shown black. Phloem sieve tubes, black; xylem, cross-hatched; parenchyma, stippled.

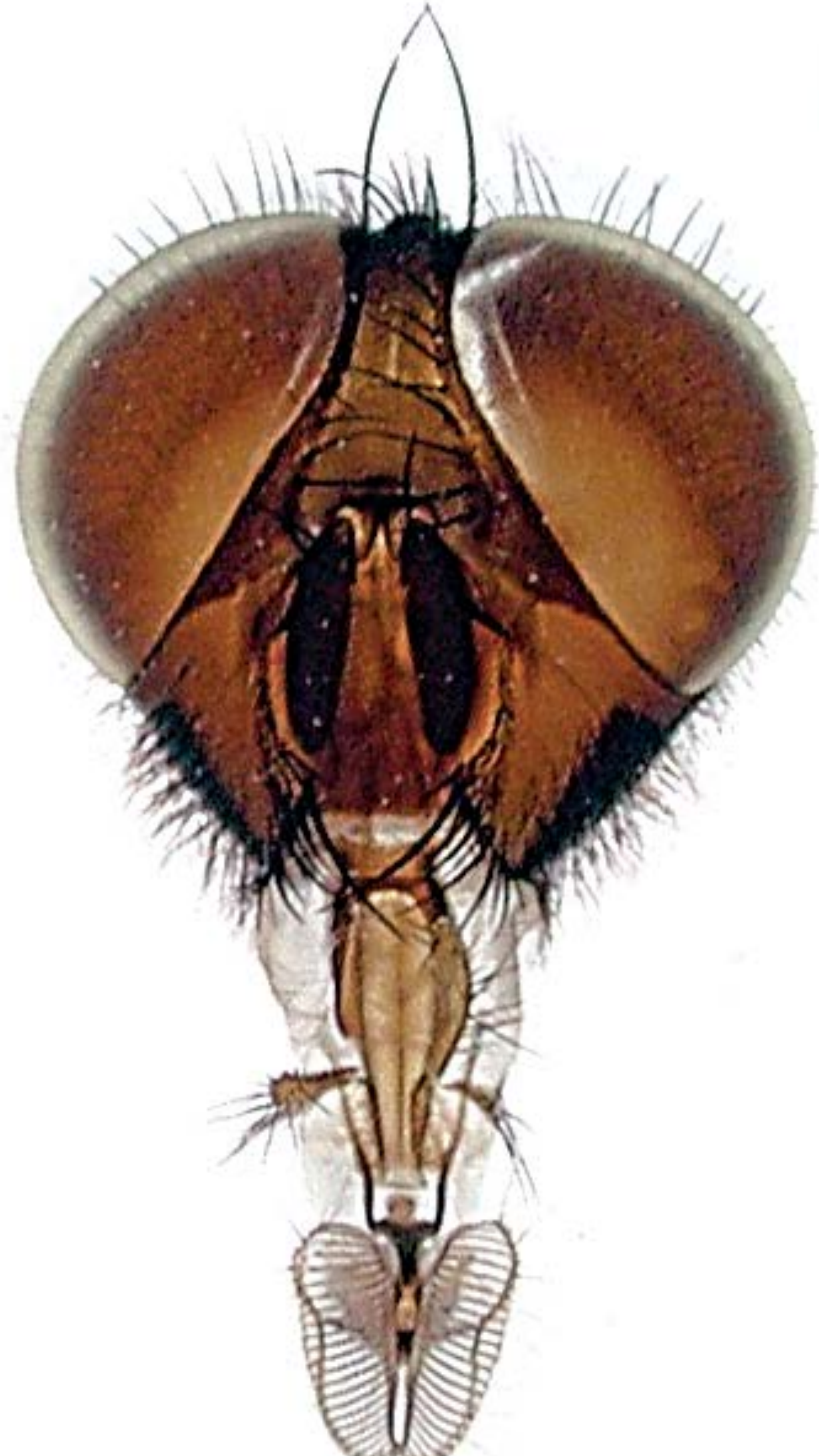

N D6.3 x60 1 mm

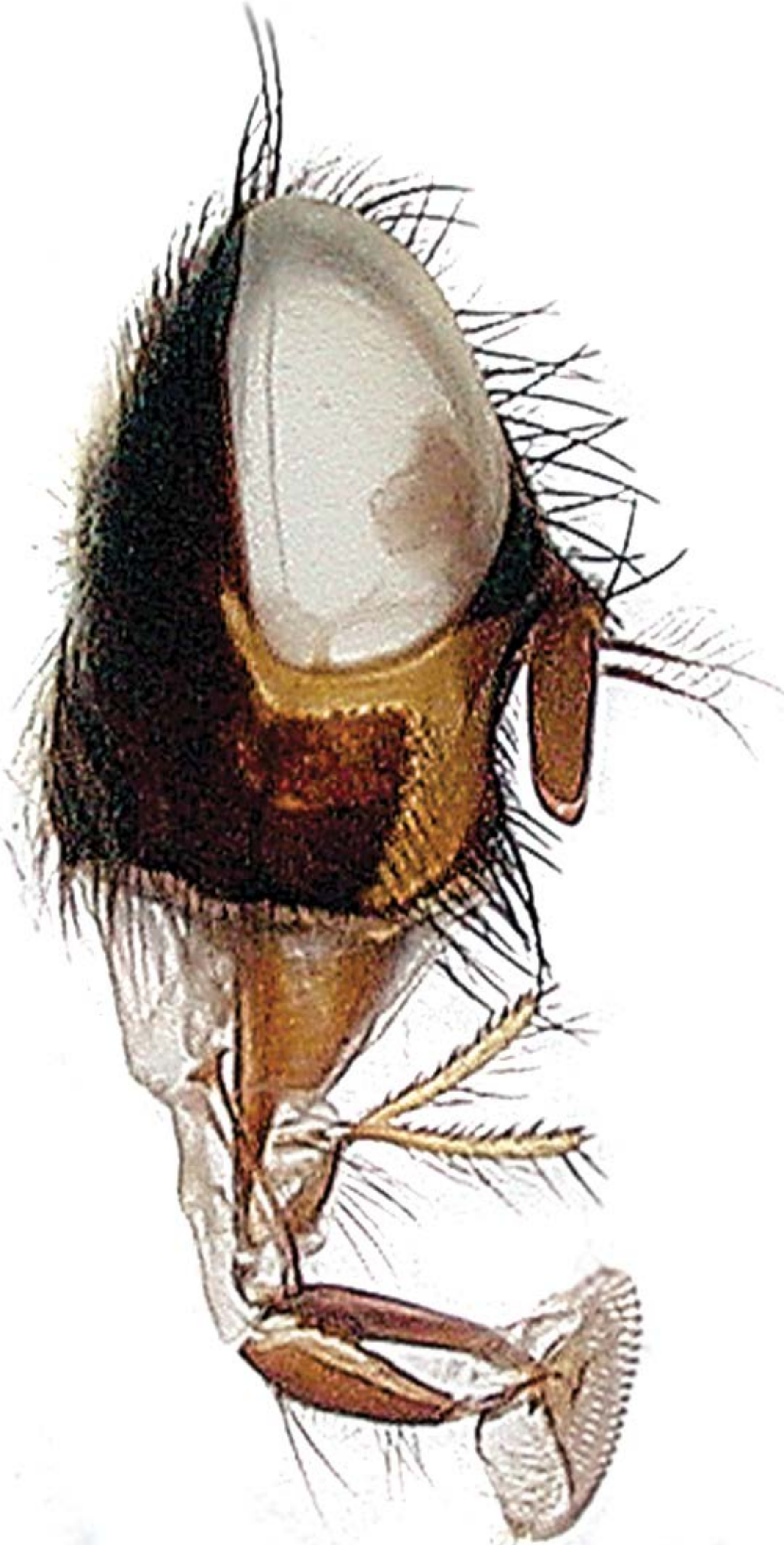

N D6.5 x250 300 um

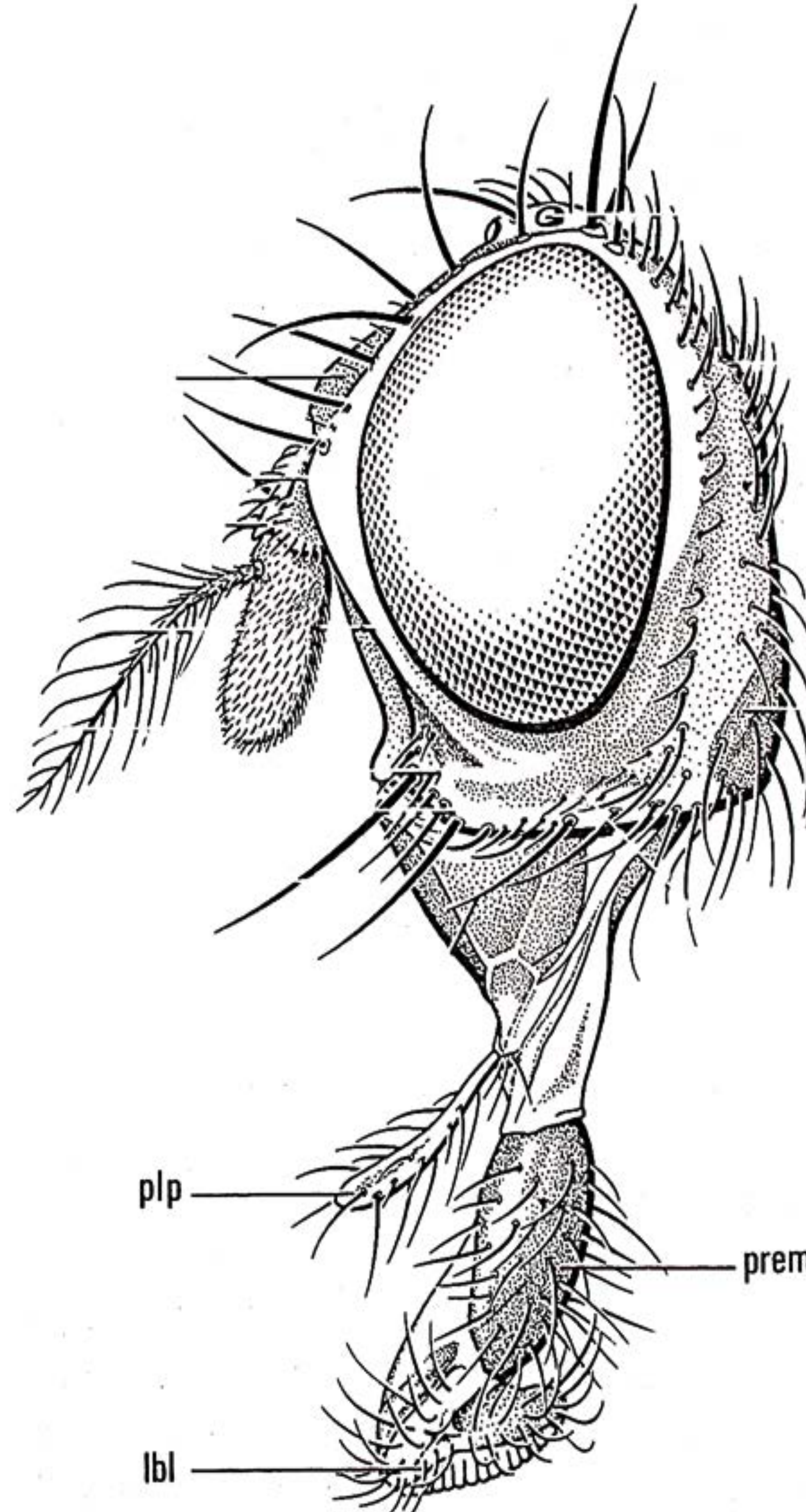

N D6.5 x120 500 um

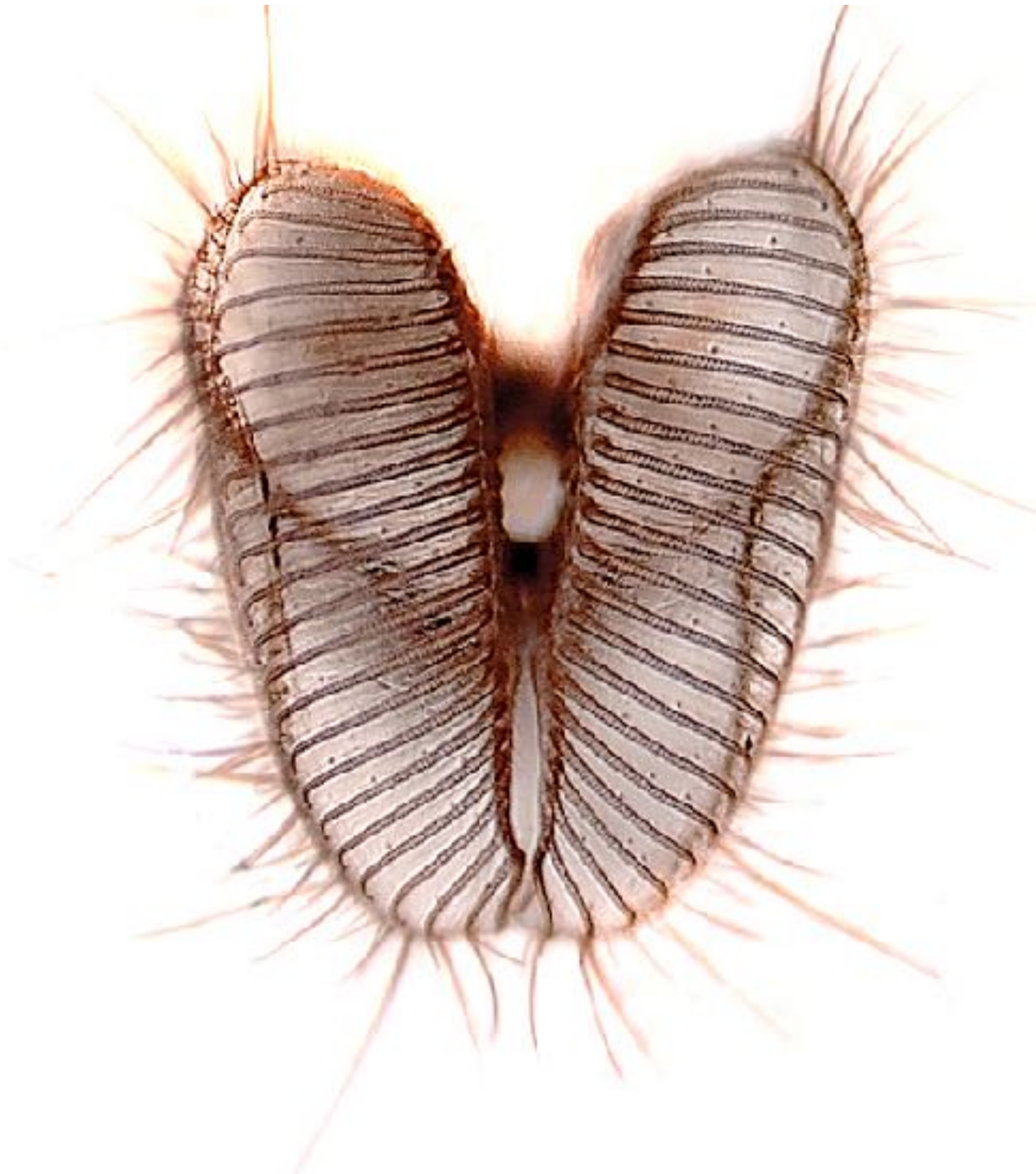

N D6.7 x150 500 um


clyp
clyp memb
plp
premnt
lbr
lbl

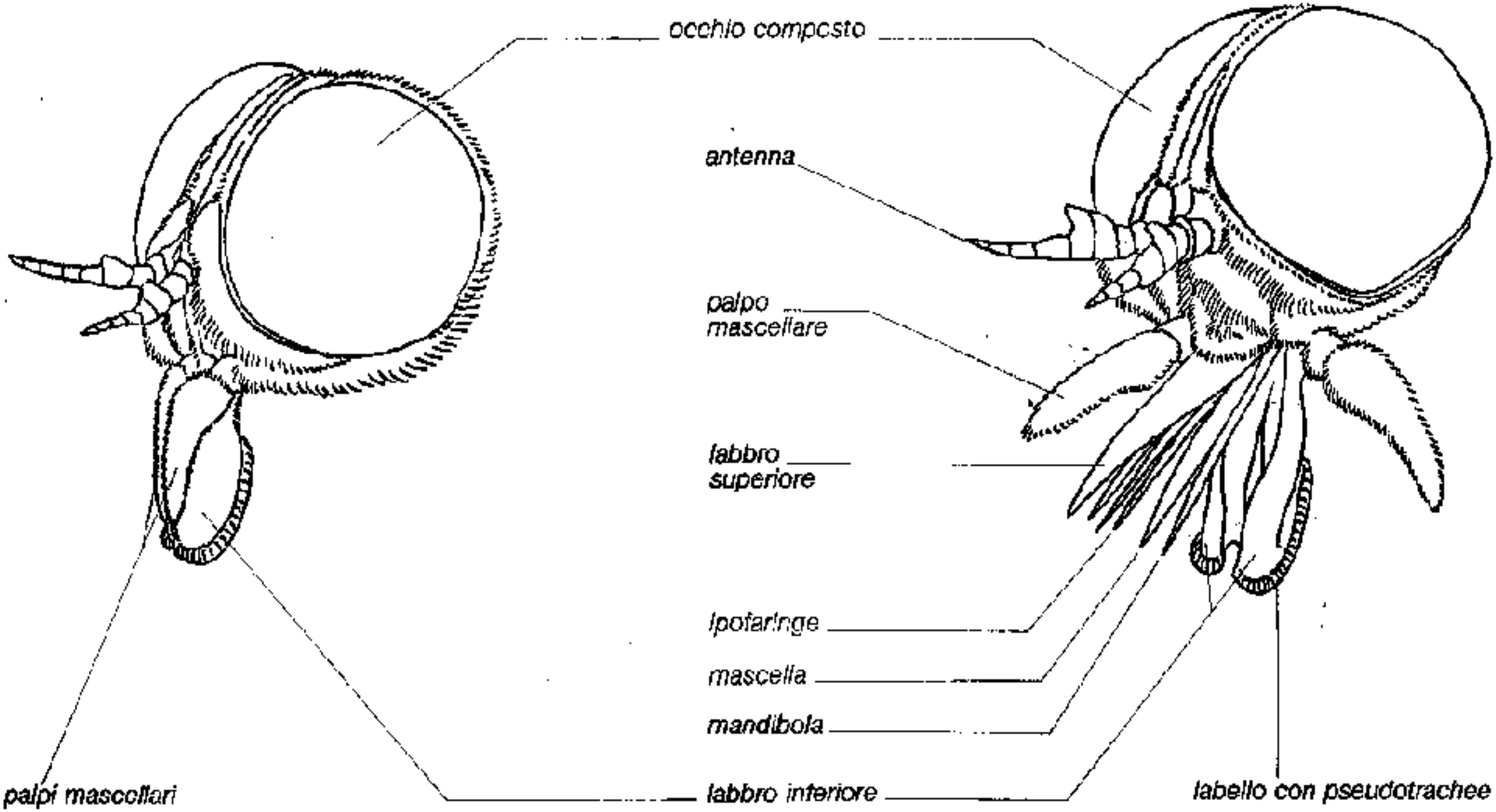




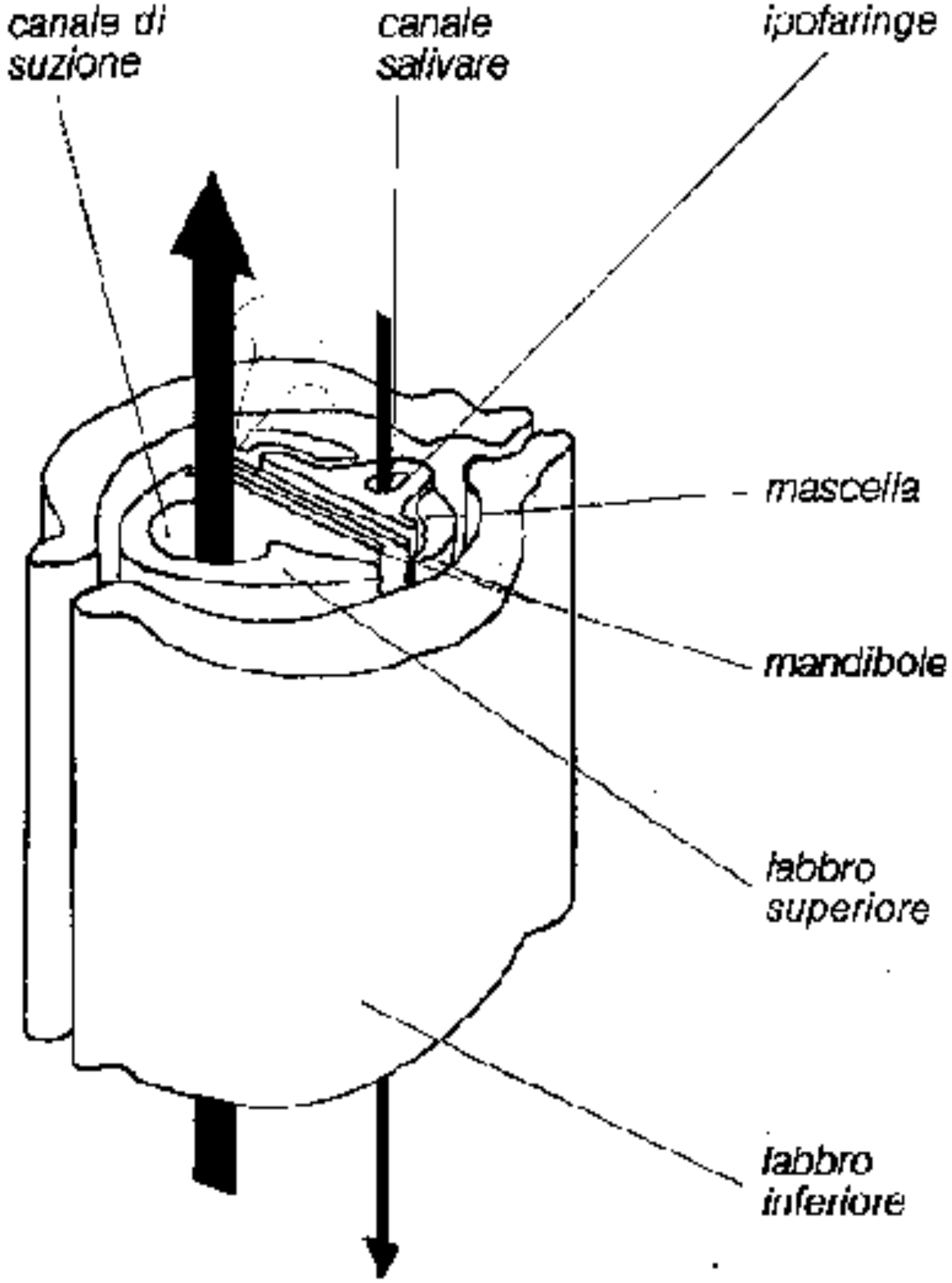

plp
premnt
lbl



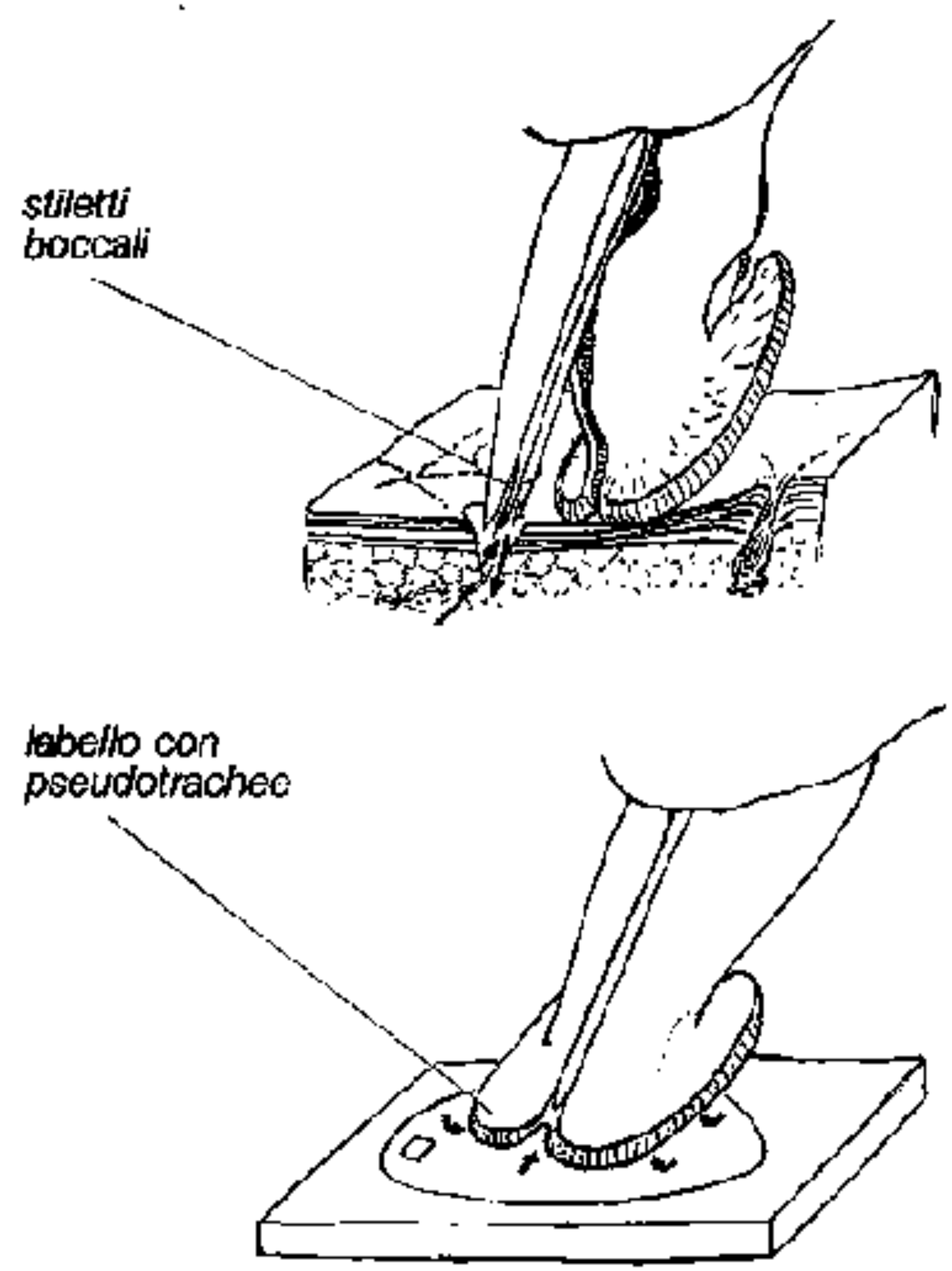
▽ CAPO VISTO SUBFRONTALMFNTE CON PARTI BOCCALI RACCOLTE (A SINISTRA) E SEPARATE ARTIFICIALMENTE (A DESTRA)



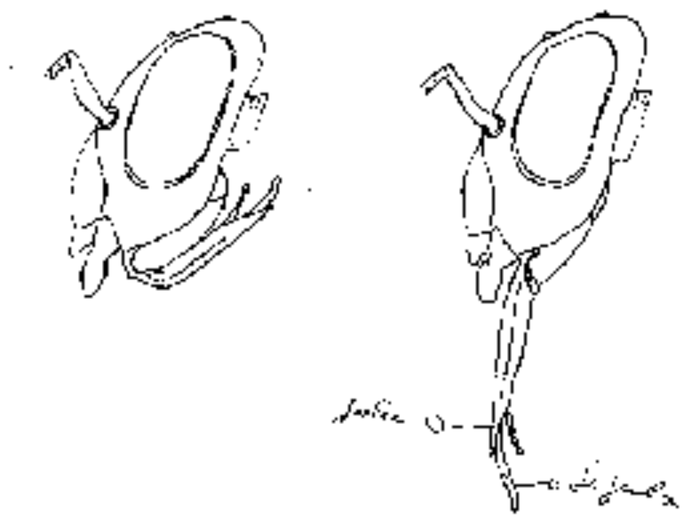
▽ SPACCATO DISTALE DELLE PARTI BOCCALI



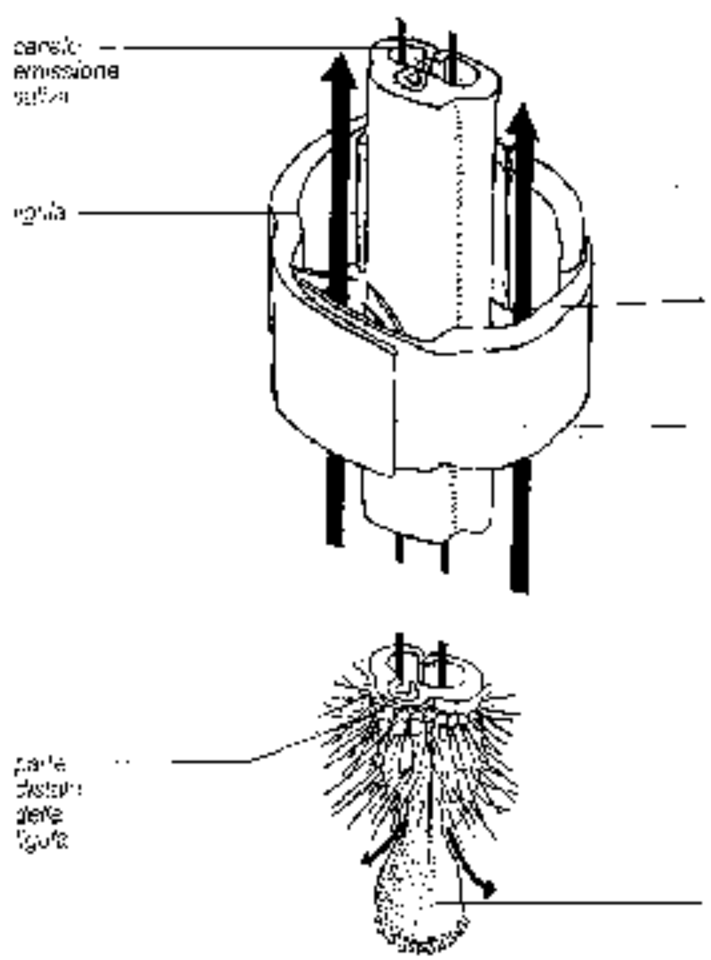
▽ DIFFERENTI MODALITÀ DI NUTRIZIONE: PUNGENTE - SUCCHIANTE (IN ALTO) E LAMBENTE - SUCCHIANTE (IN BASSO)



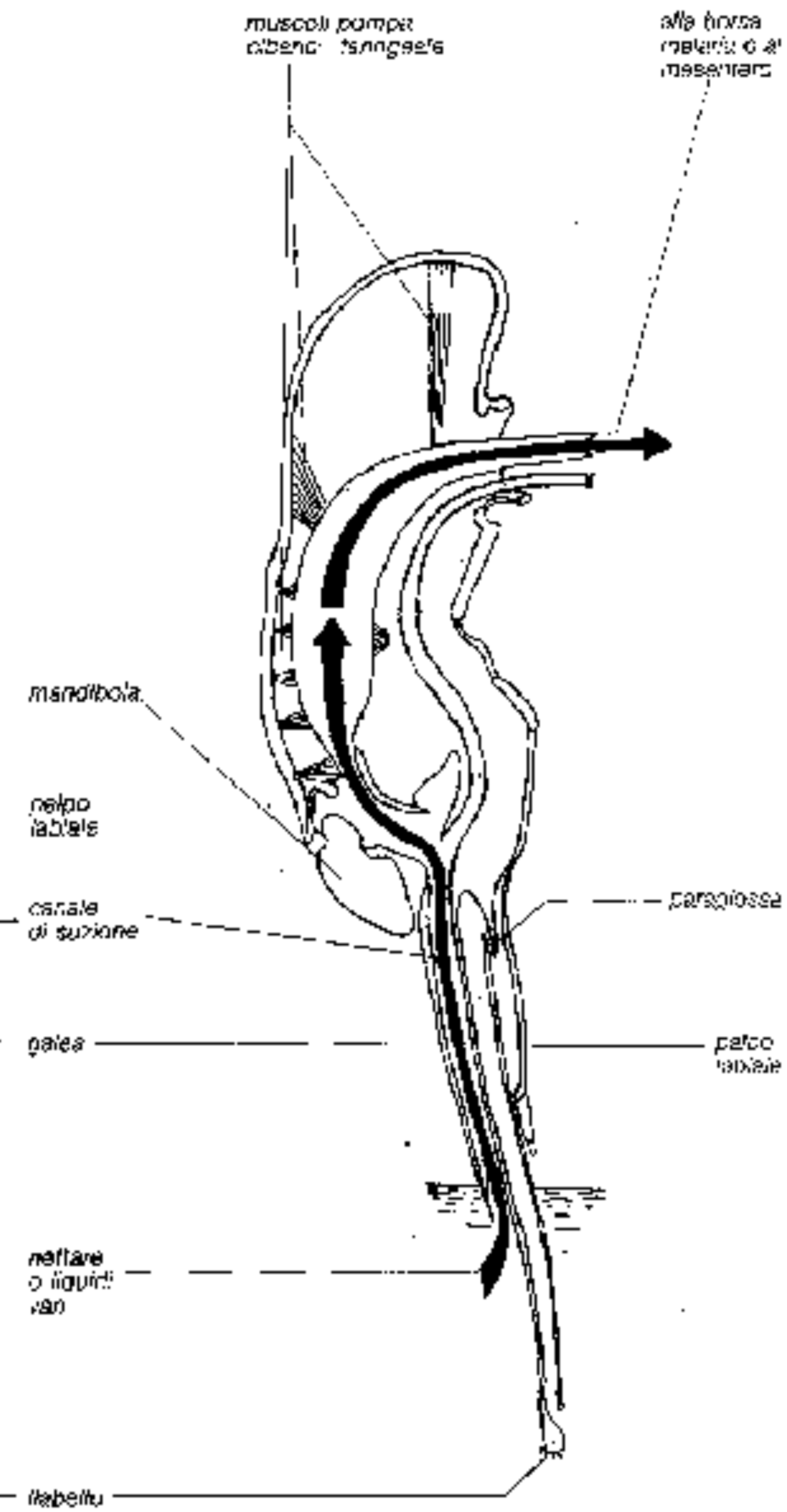
▽ PROBOSCIDE IN POSIZIONE RACCOLTA E DISTESA PER L'ATTIVITÀ TROFICA

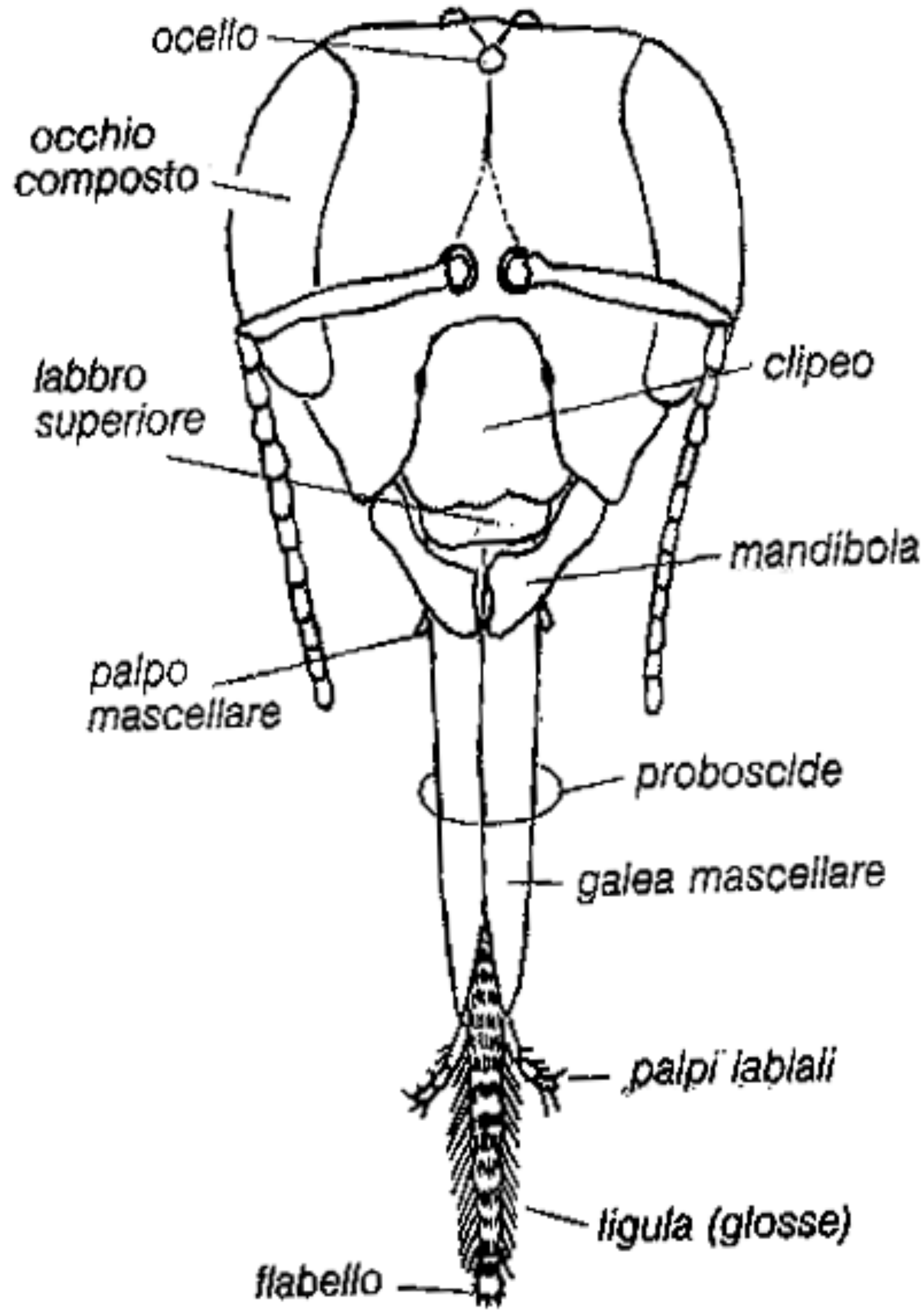


▽ SPACCATO DELLA PROBOSCIDE (IN ALTO) E DELLA LIGULA (IN BASSO) VISTI SUBANTERIORMENTE, CON CANALE DI SUZIONE DEL CIBO E DI EMISSIONE DELLA SALIVA



▽ SEZIONE LONGITUDINALE - MEDIALE E MODALITÀ DI SUZIONE AD OPERA DEL CANALE TEMPORANEO FORMATO DA GALEE E PALPI LABIALI ATTORNO ALLA LIGULA

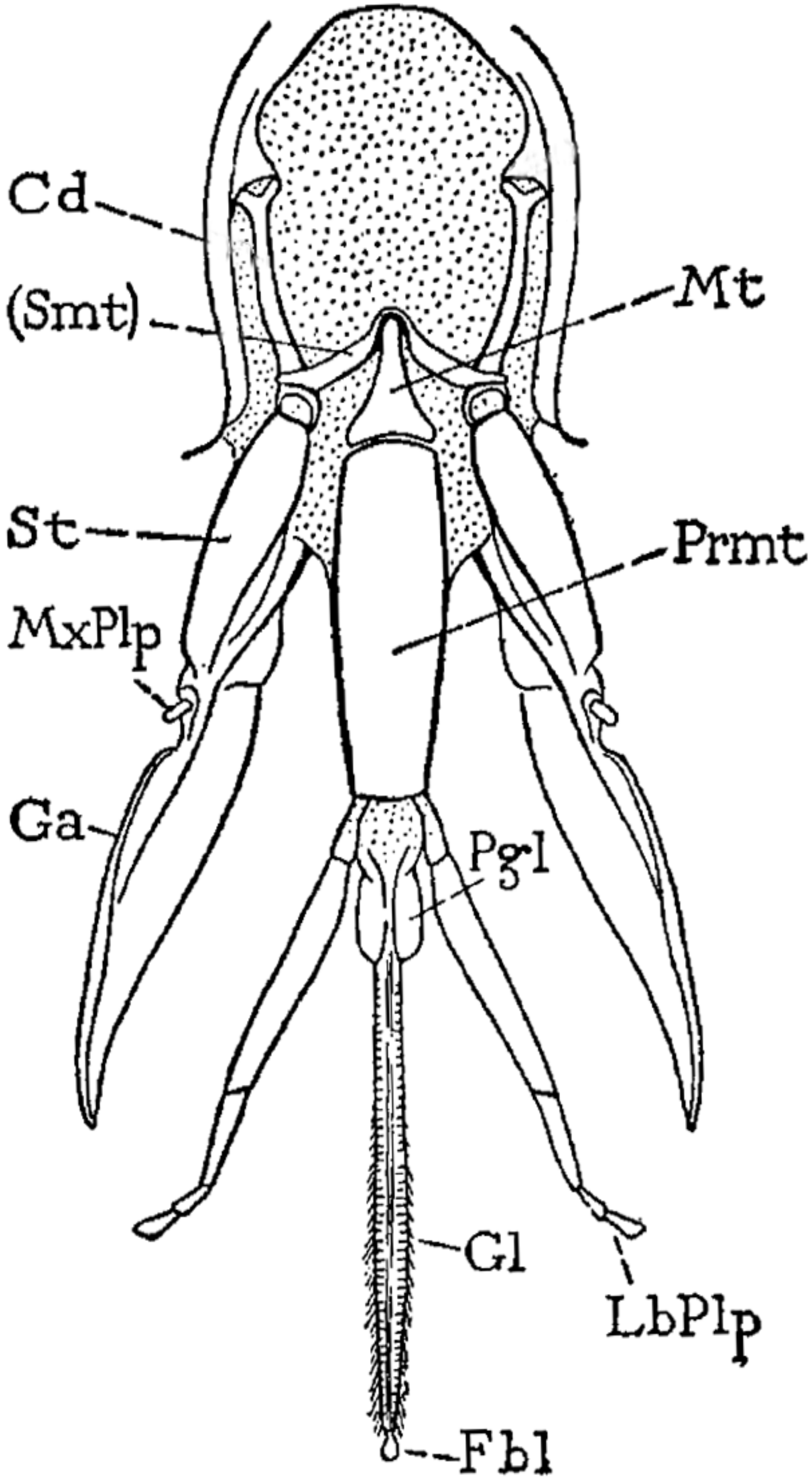


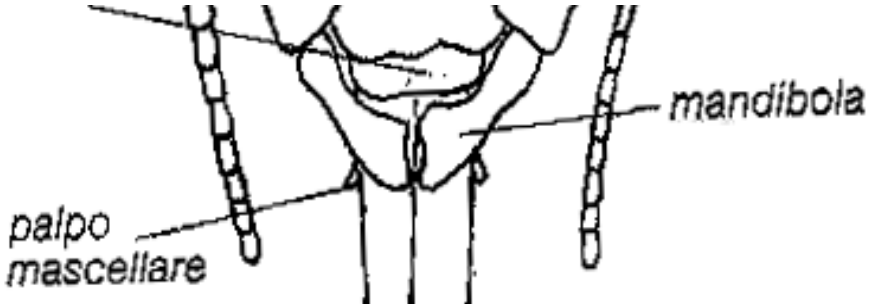

ocello
occhio composto
labbro superiore
palpo mascellare
clipeo
mandibola
proboscide
galea mascellare
palpi labiali
ligula (glosse)
flabello

a) le appendici possono accostarsi mosse da muscoli, incastrarsi in modo provvisorio o permanente grazie a **<u>strutture specializzate</u>**;

b) in tutti i casi sono le **<u>caratteristiche superficiali di bagnabilità</u>** che danno il tocco essenziale al funzionamento dell'apparato boccale;

c) il complesso maxillo-labiale si **<u>specializza spesso in modo fondamentale</u>** rispetto alla dieta.




mandibola
palpo
mascellare

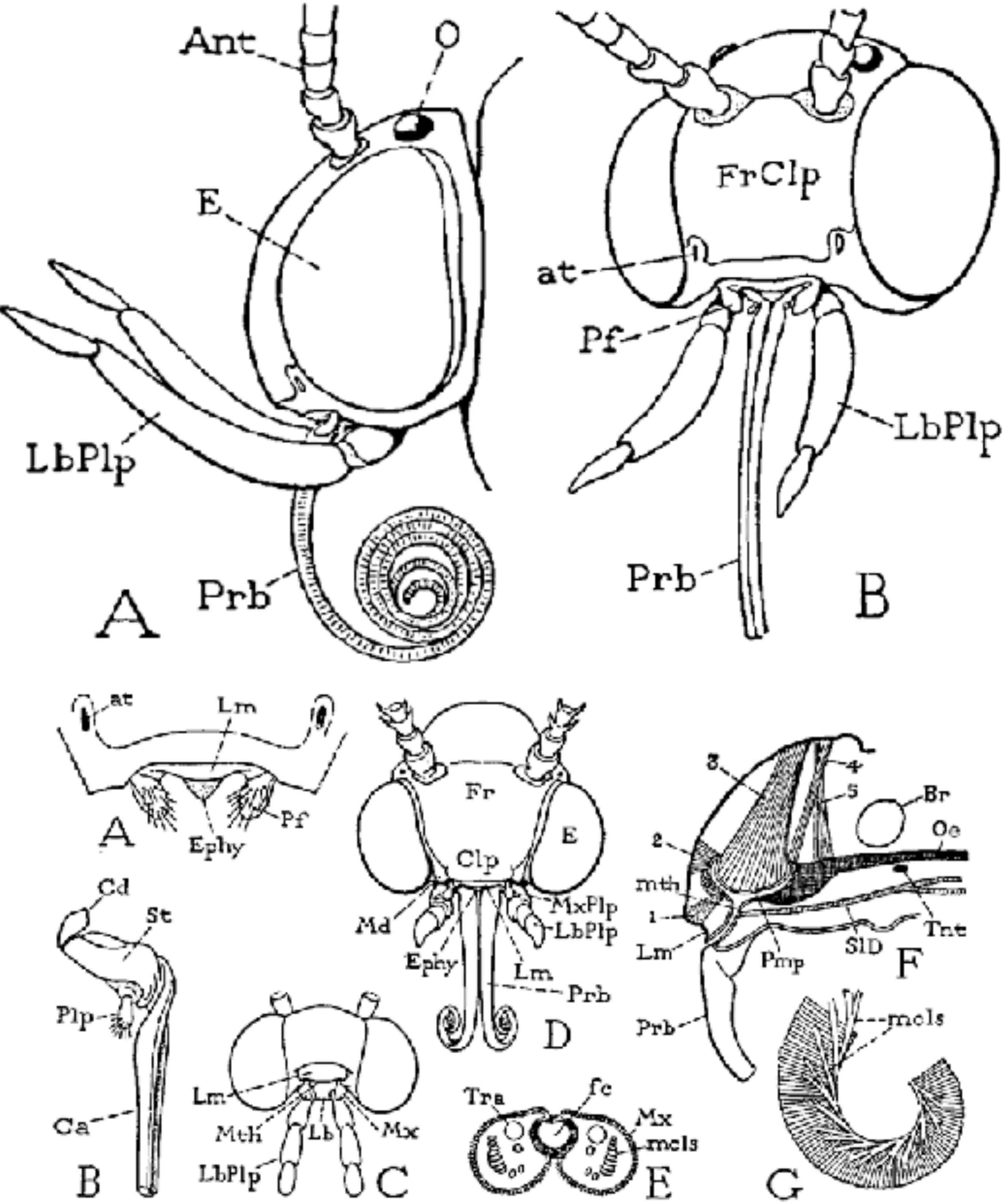
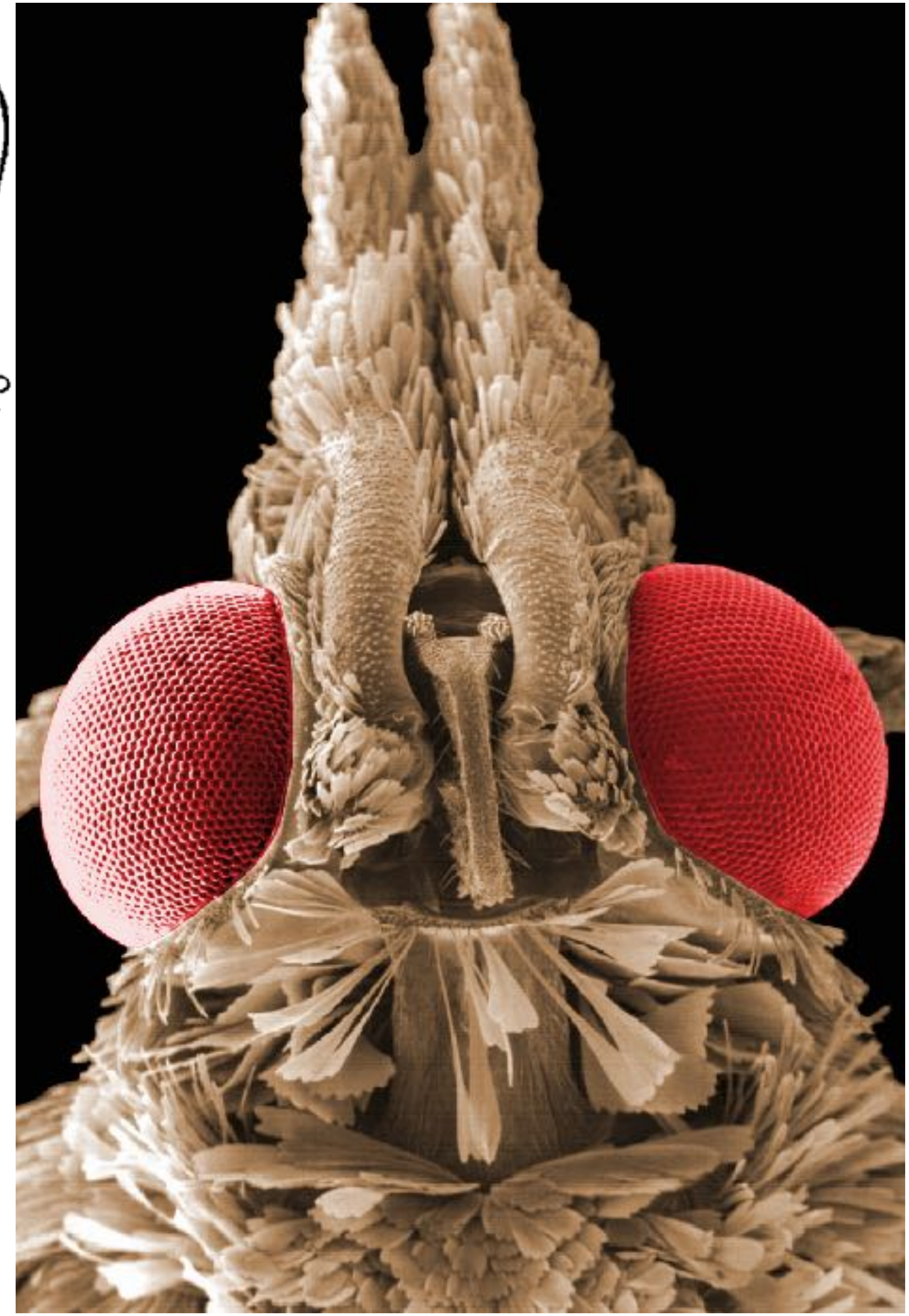
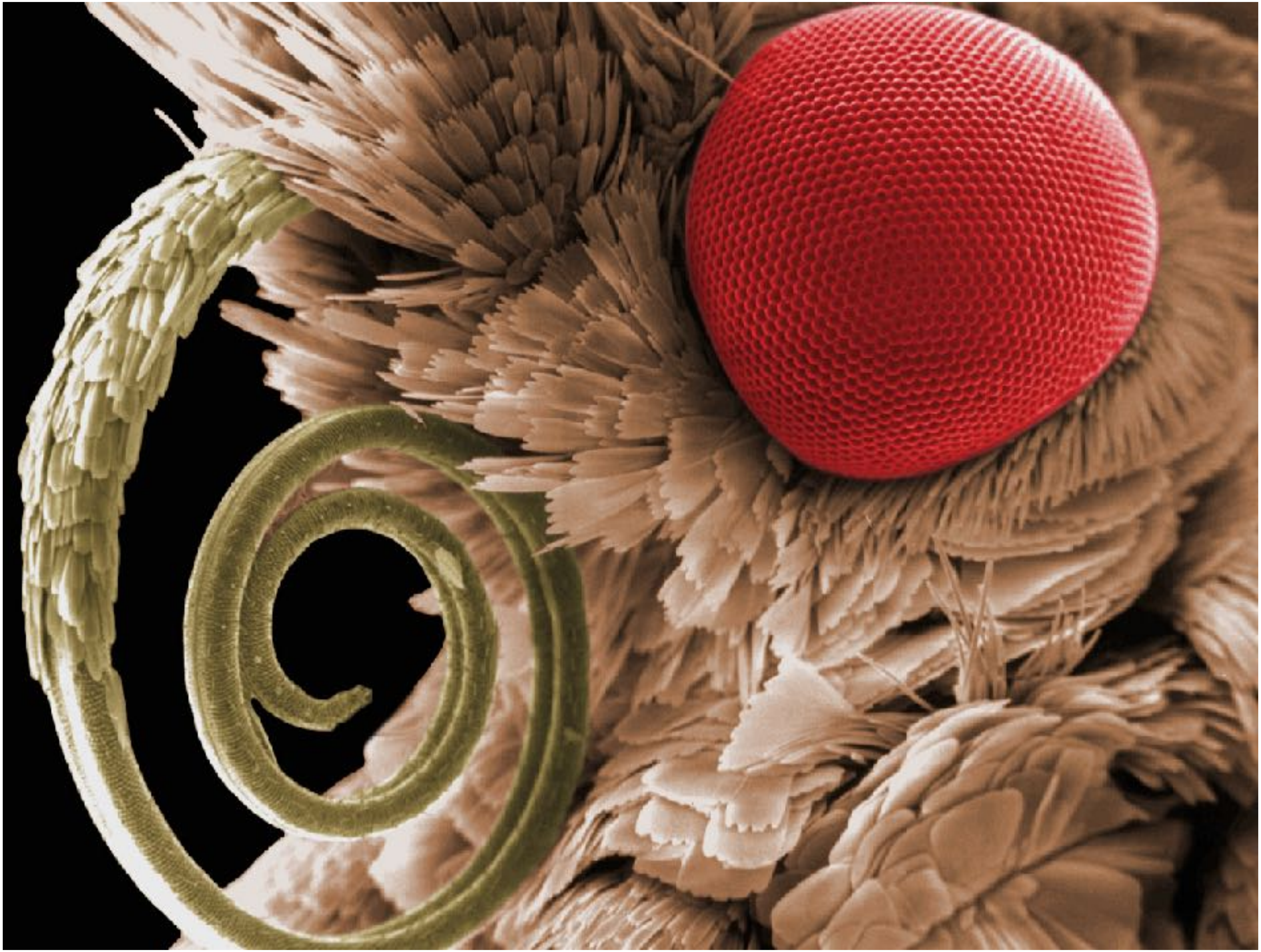
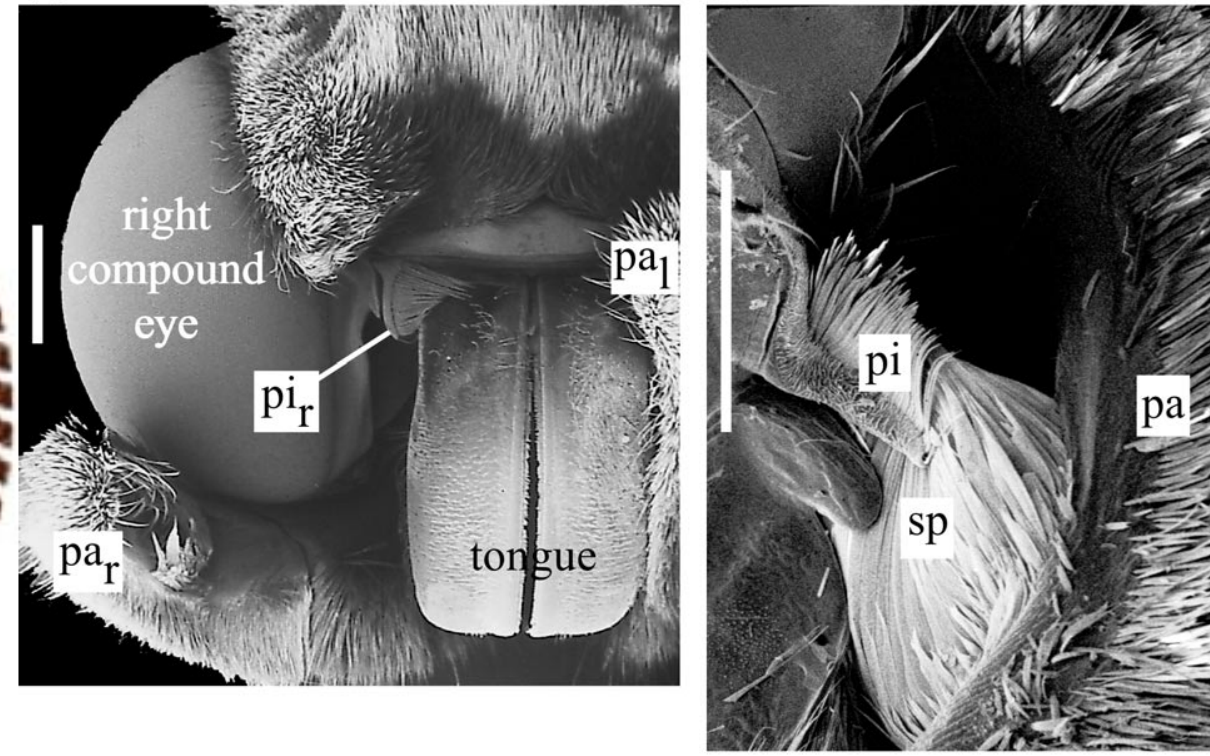


FIG. 169.—Mouth parts and sucking apparatus of adult Lepidoptera. A, *Synanthedon exitiosa*, labrum, epipharynx, and pilifers. B, same, base of maxilla. C, *Malacosoma americana*, showing rudimentary maxillae. D, *Hyphantria cunea*, head and proboscis. E, cross section of proboscis of *Danais archippus*. (*From Burgess*, 1880.) F, section of head of sphinx moth, showing sucking pump, diagrammatic. G, diagram of part of proboscis and its muscles.



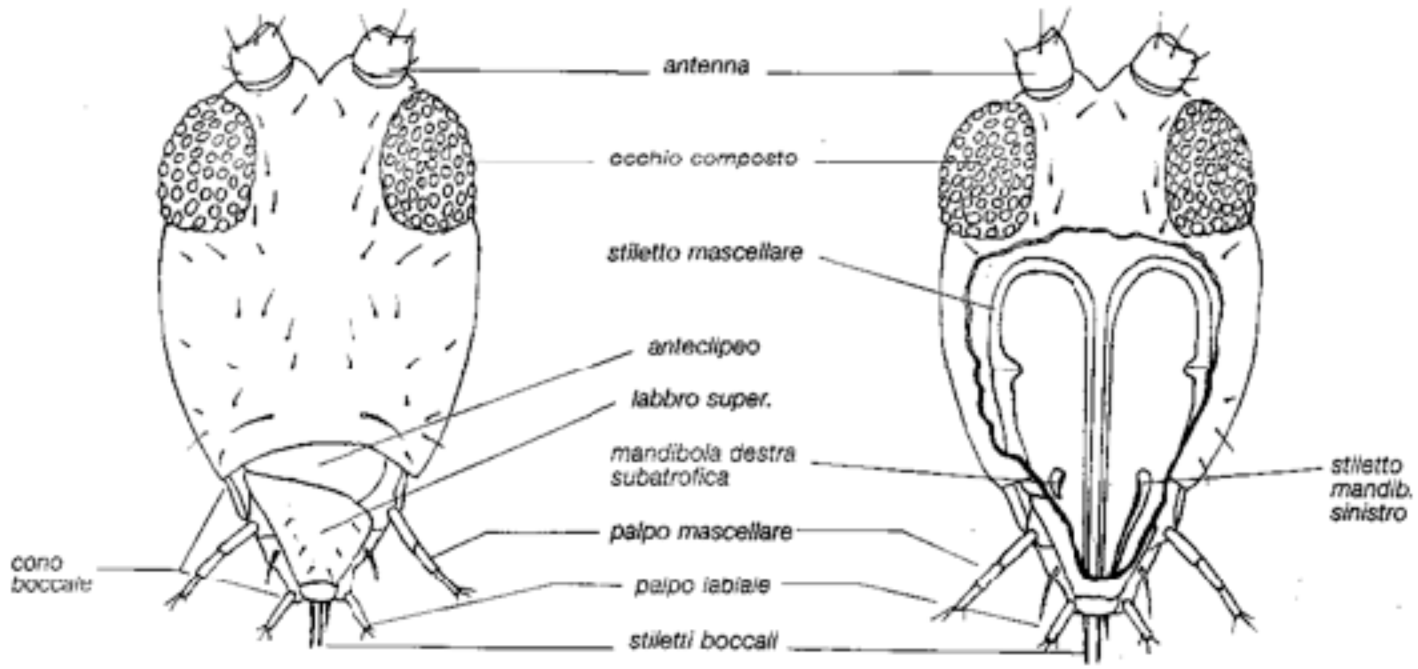




Anatomy of pilifer–palp hearing organs in hawkmoths. (a) Head of the hearing acherontiine species A. atropos (frontodorsal view). The left labial palp (pal) is in its natural, adducted position, completely concealing the left pilifer. The right palp (par) has been deflected from the head, thus exposing the right pilifer (pir). (b) Contact between the palp (pa) and pilifer (pi) in A. atropos. A characteristic feature of hearing Acherontiina is the pilifer in close contact with the scale-plate (sp) of the palp. Scale bars, 1 mm.

▽ CAPO CON PARTI BOCCALI VISIBILI DALL'ESTERNO

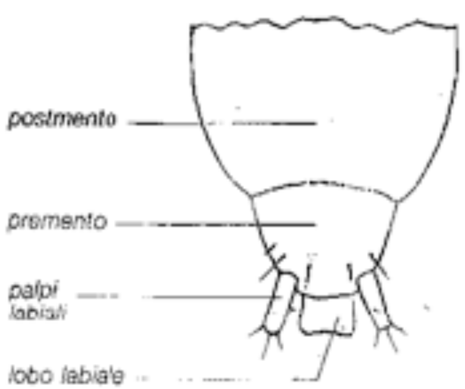
▽ CAPO APERTO AD ARTE PER MOSTRARE LE APPENDICI BOCCALI ENTOGNATE



▽ PARTI BOCCALI

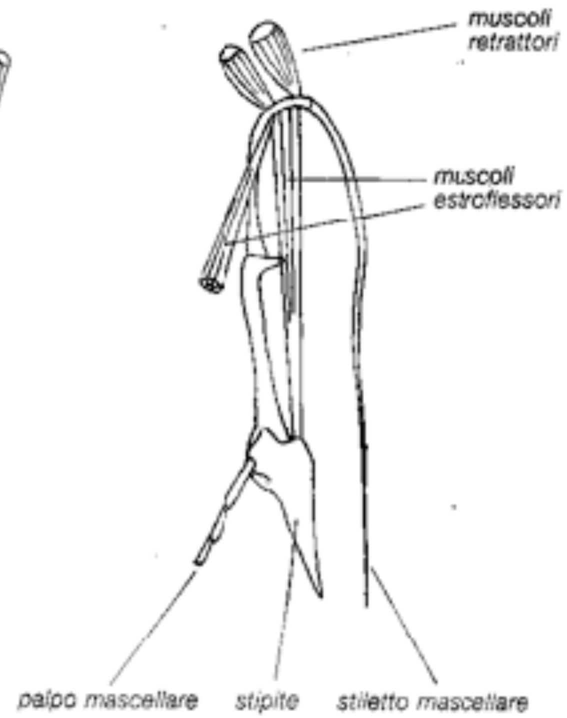
▽ labbro superiore

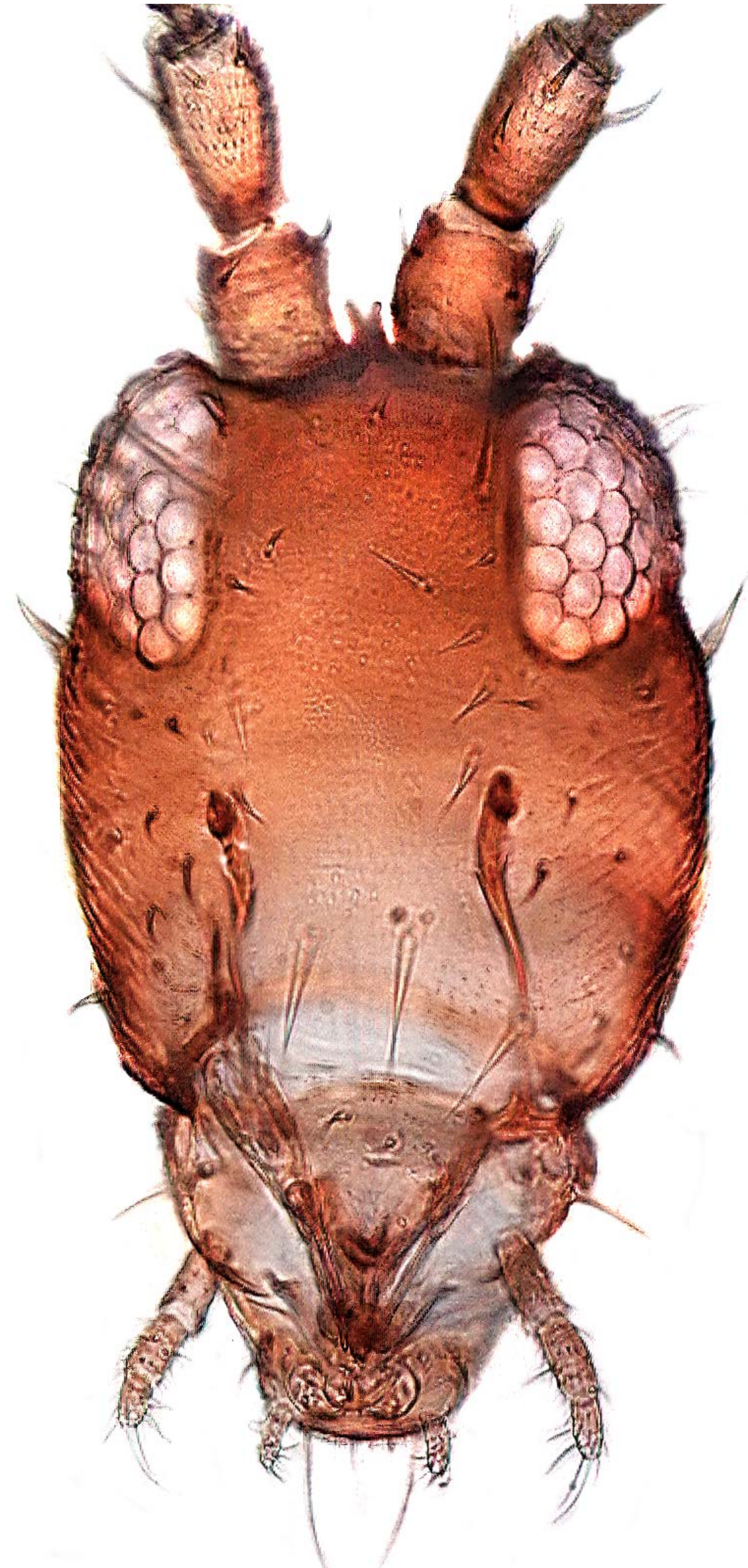
▽ labbro inferiore

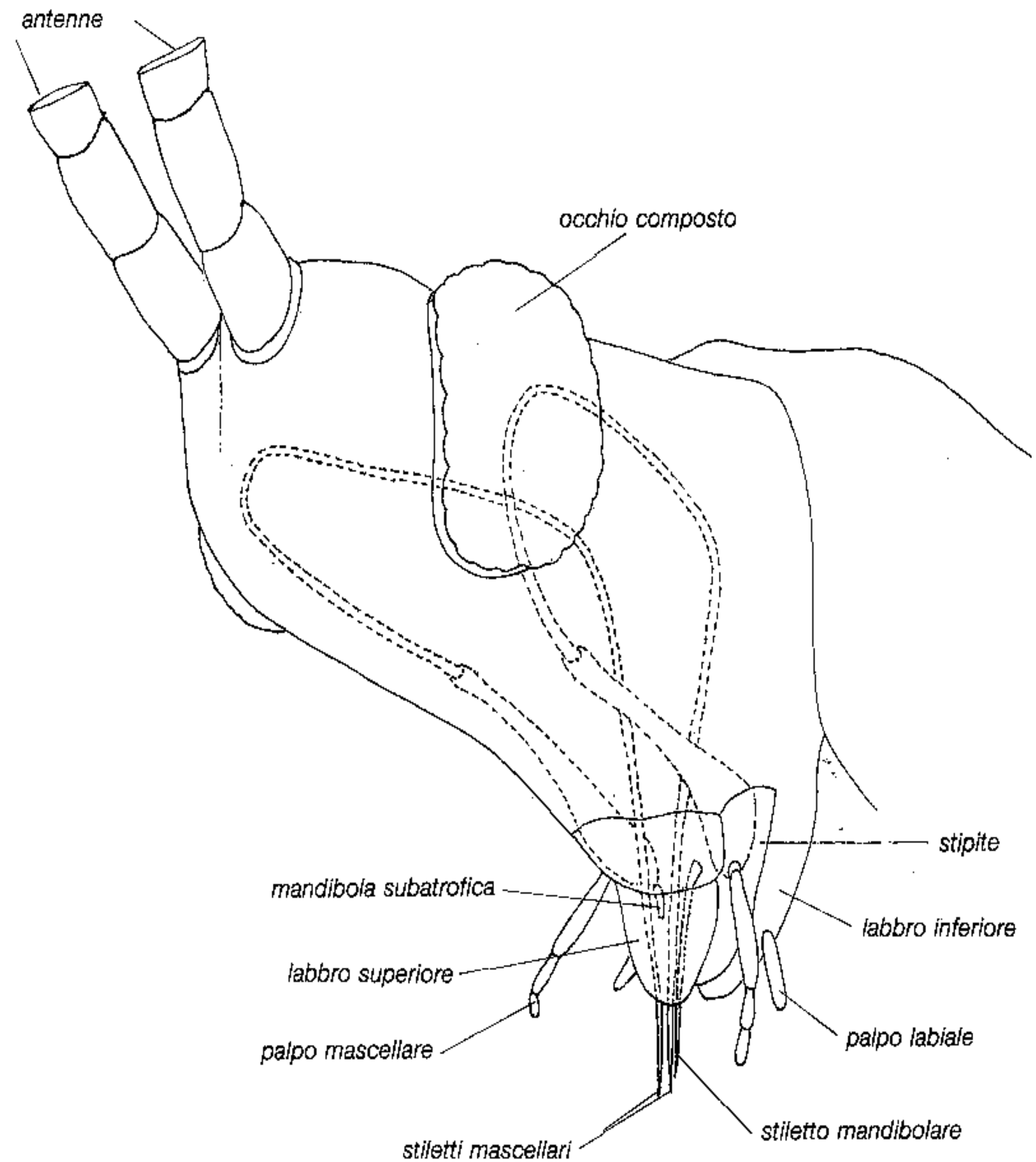


▽ mandibole

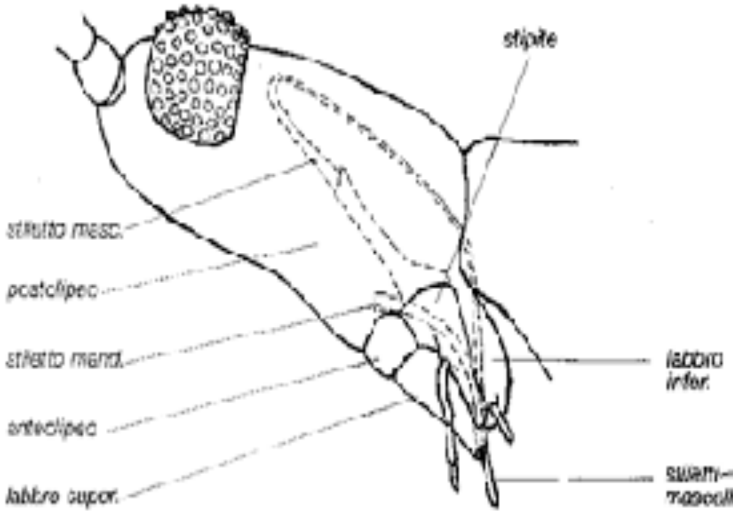
▽ mascella



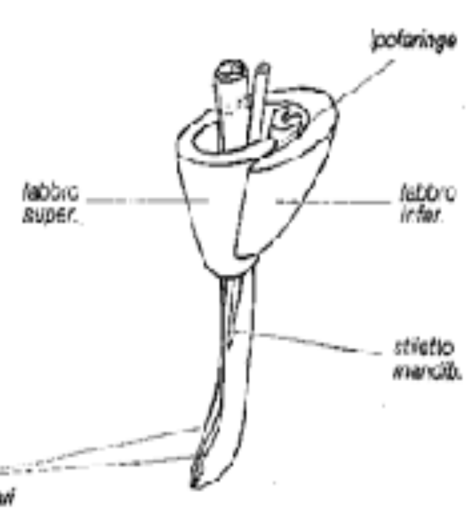



antenne
occhio composto
stipite
mandibola subatrofica
labbro inferiore
labbro superiore
palpo labiale
palpo mascellare
stiletto mandibolare
stiletti mascellari

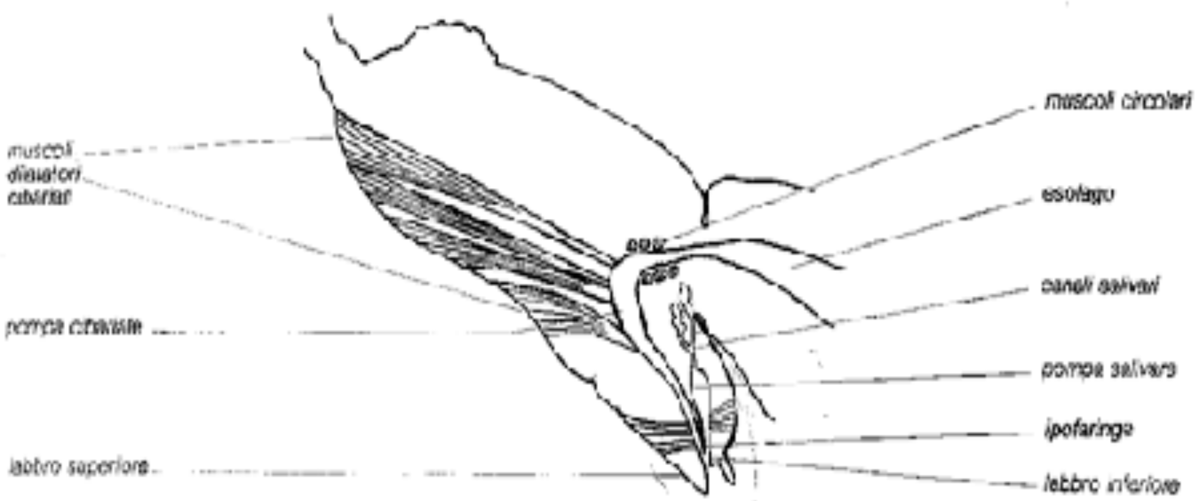
▽ CAPO DI PROFILO



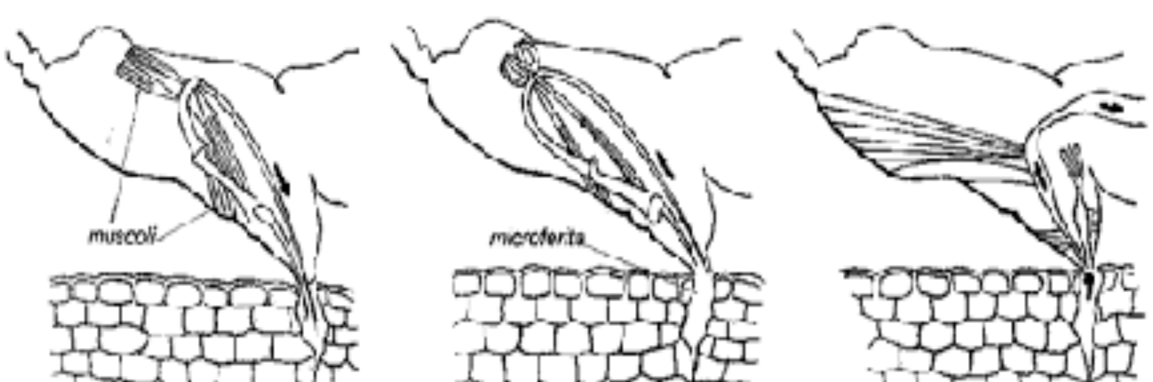
▽ SPACCATO DEL CONO BOCCALE E STILETTI CON FUNZIONE PUNGENTE

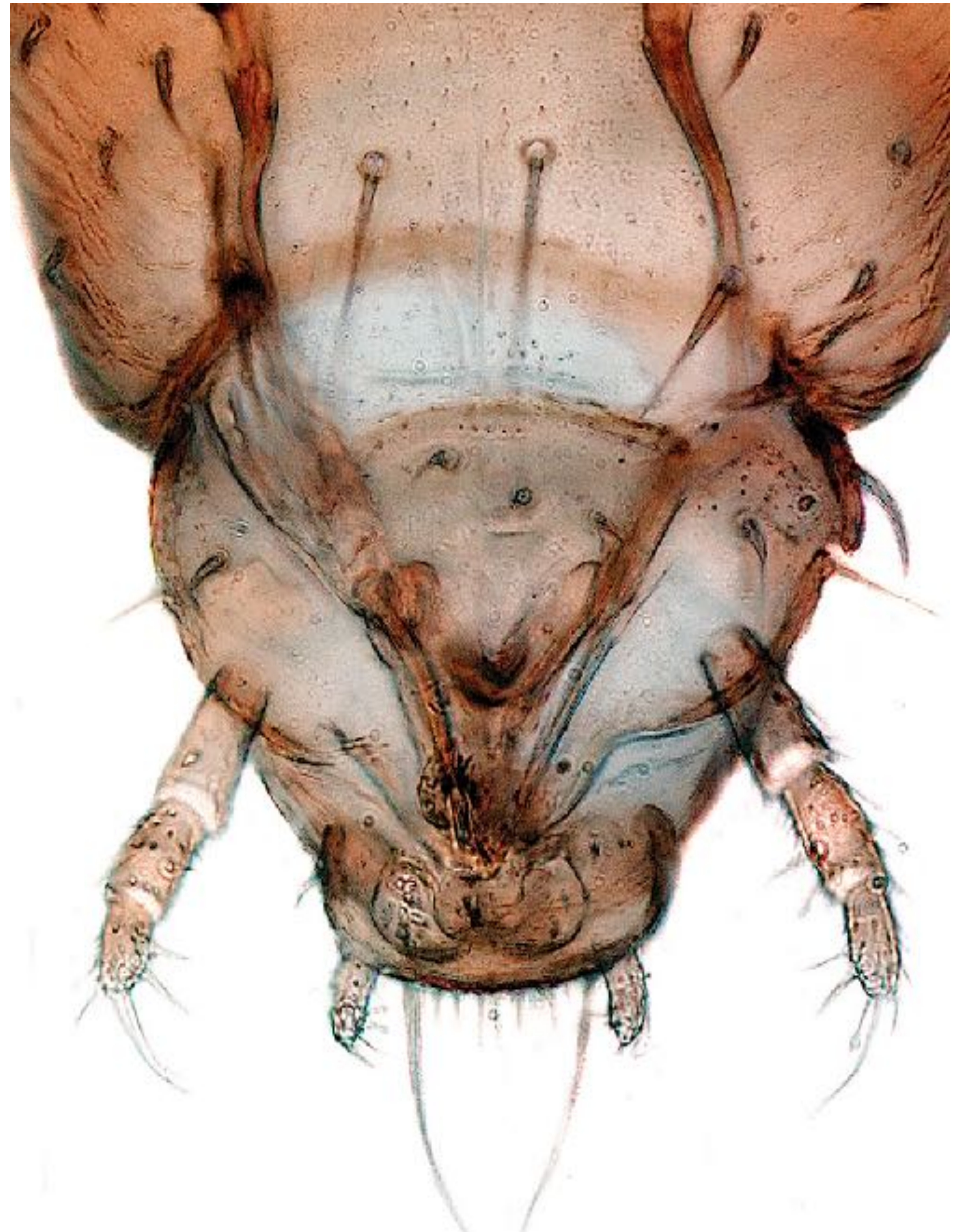


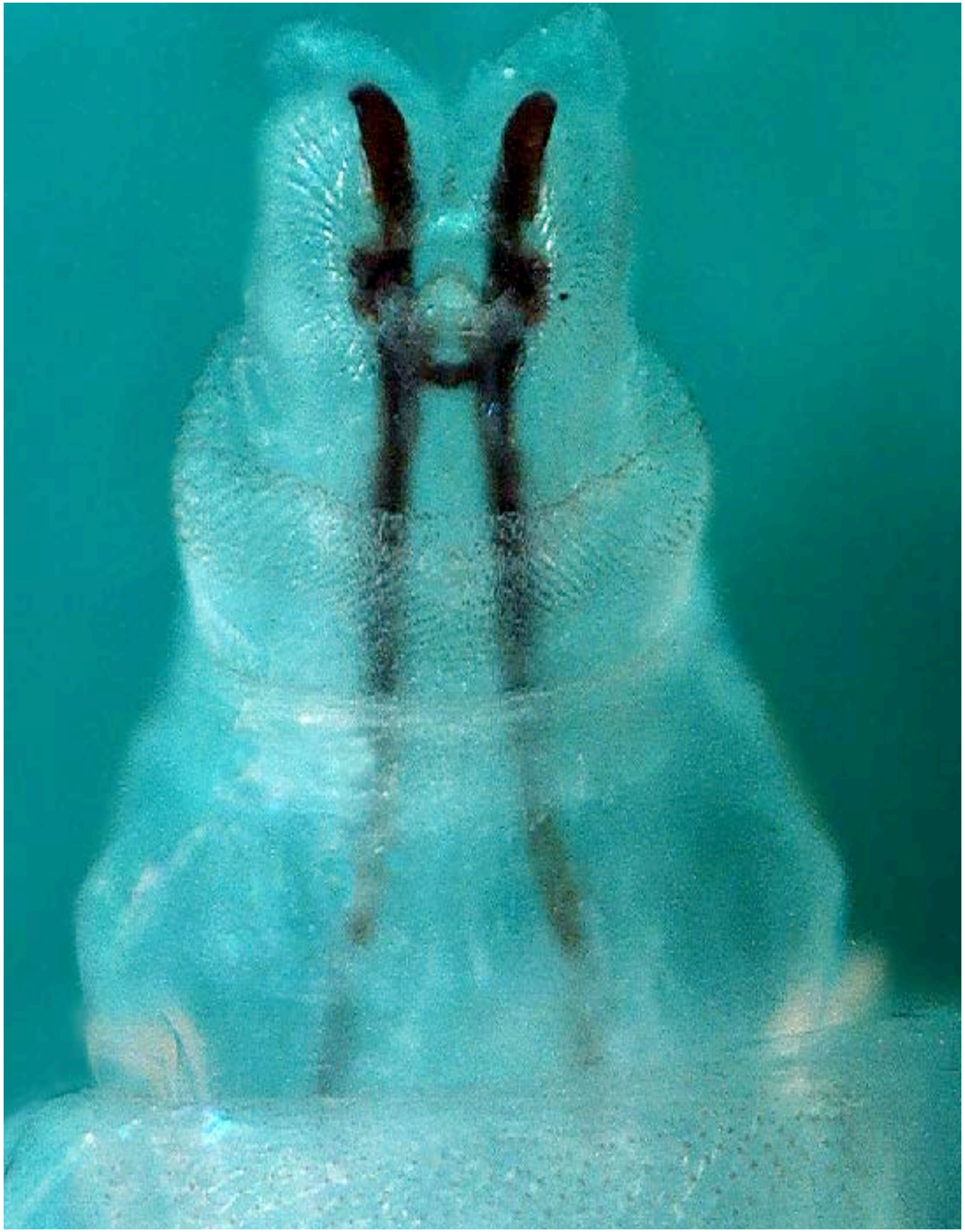
▽ SEZIONE LONGITUDINALE - MEDIALE DEL CAPO

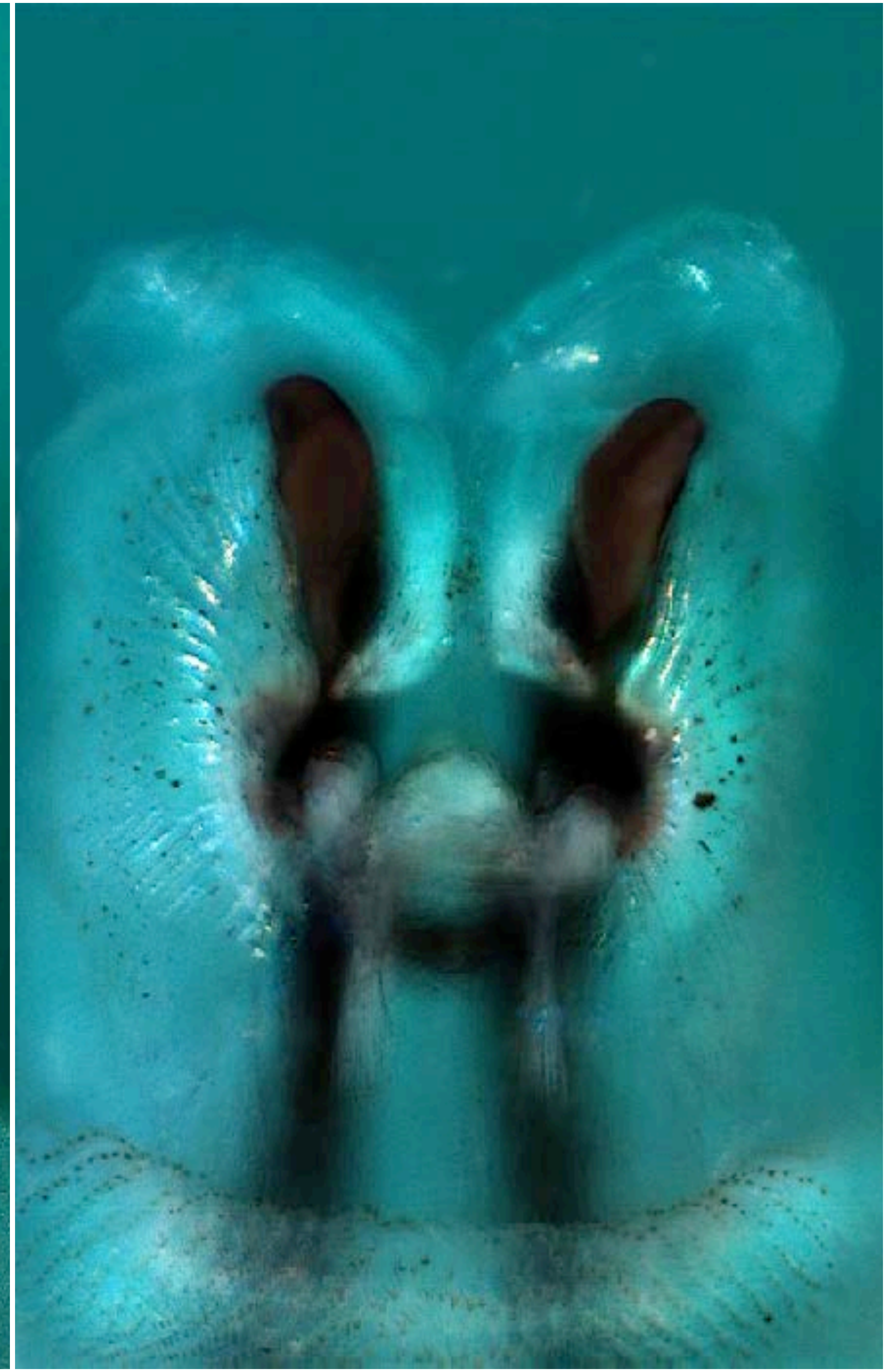


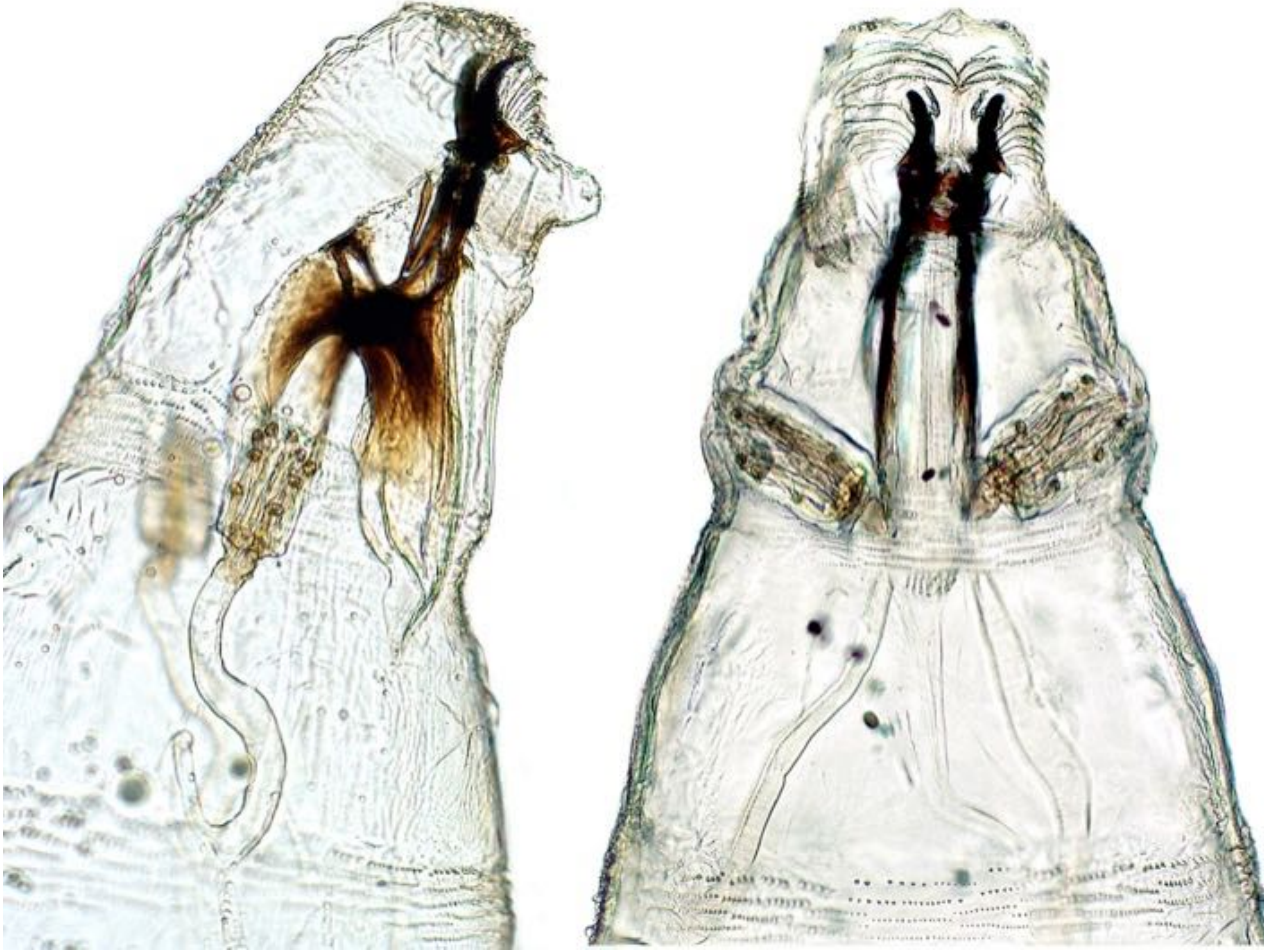
▽ MODALITÀ DI PENETRAZIONE E RETRAZIONE DEGLI STILETTI (RISPETTIVAMENTE A SINISTRA E AL CENTRO) E DI SUZIONE (A DESTRA)

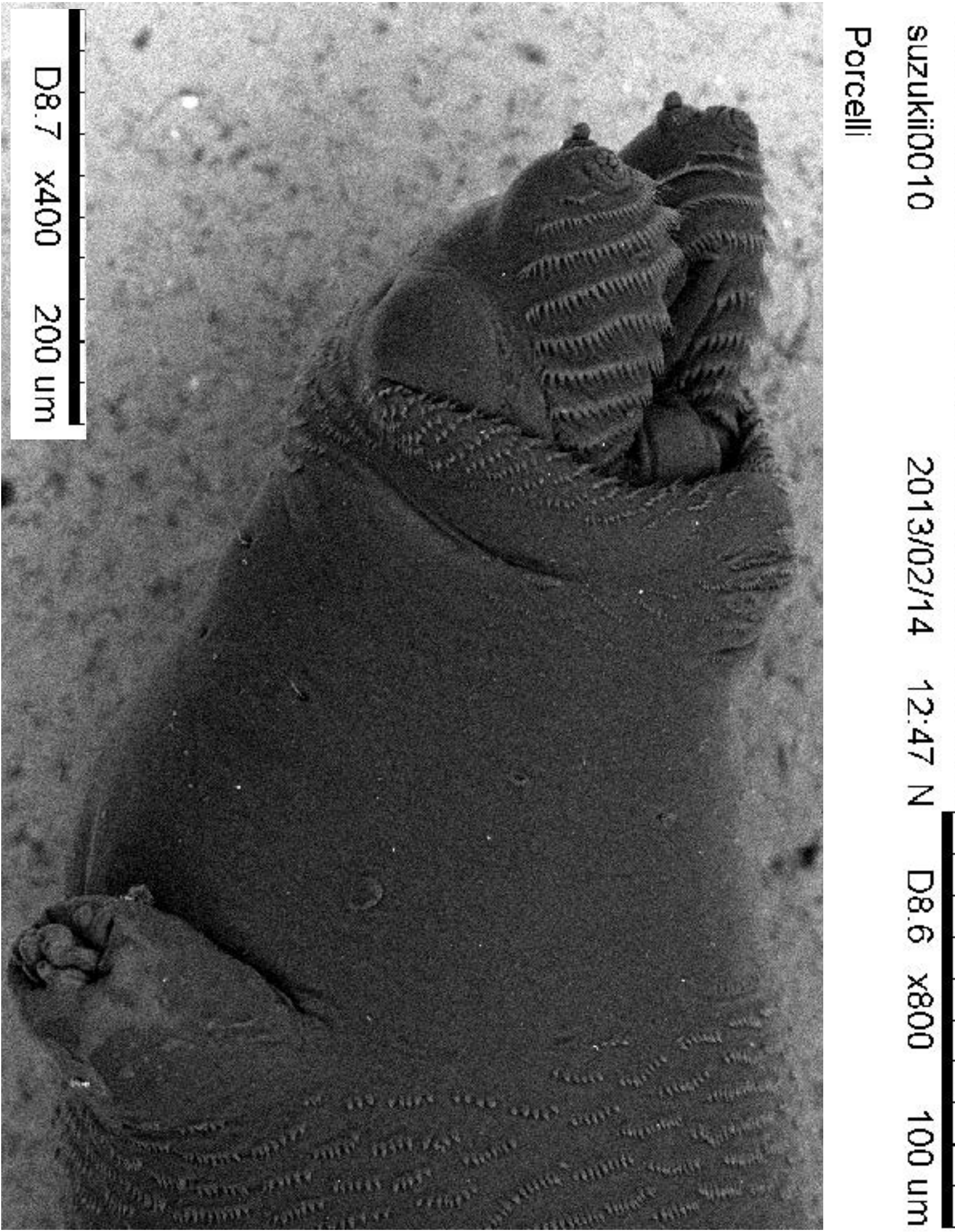


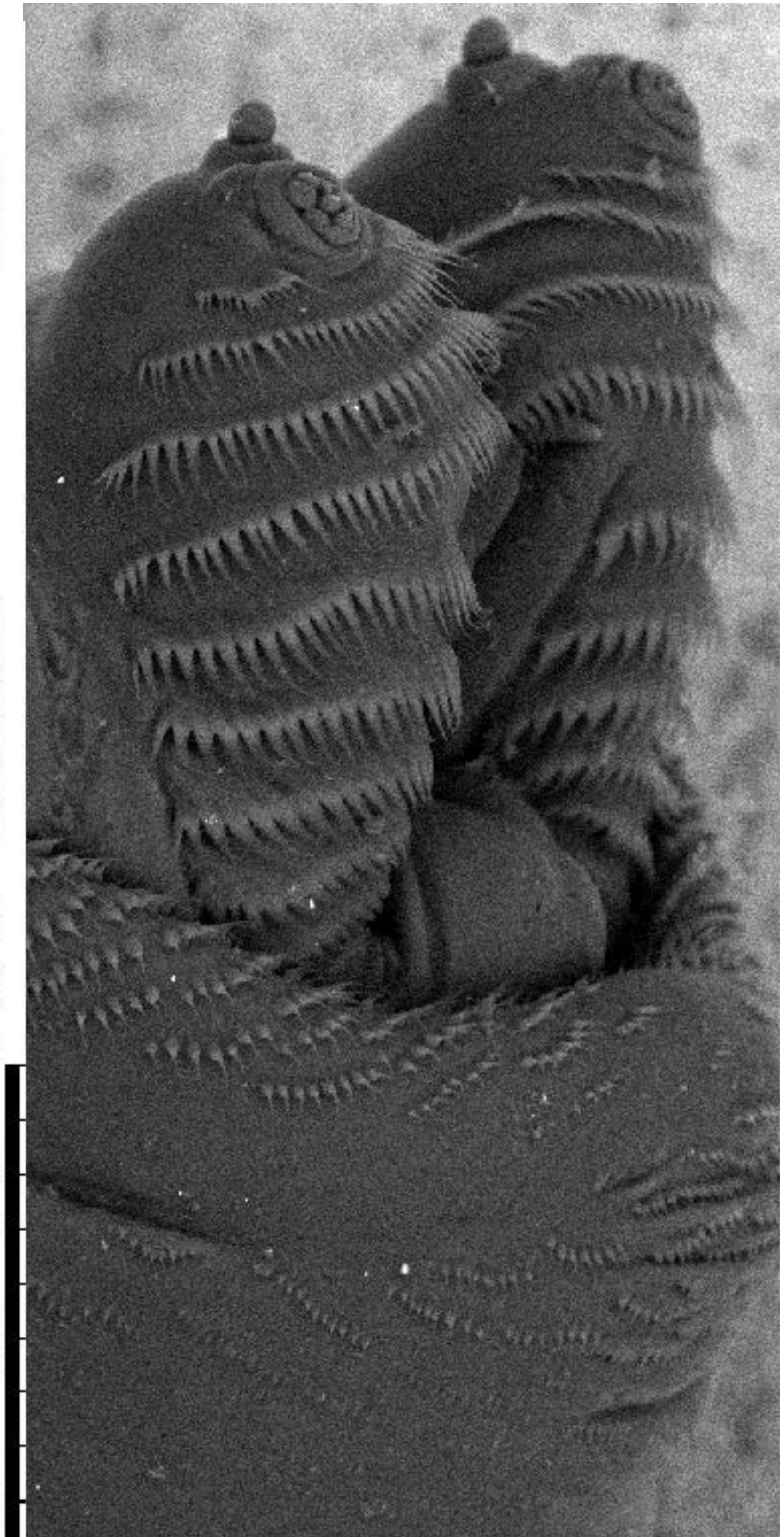


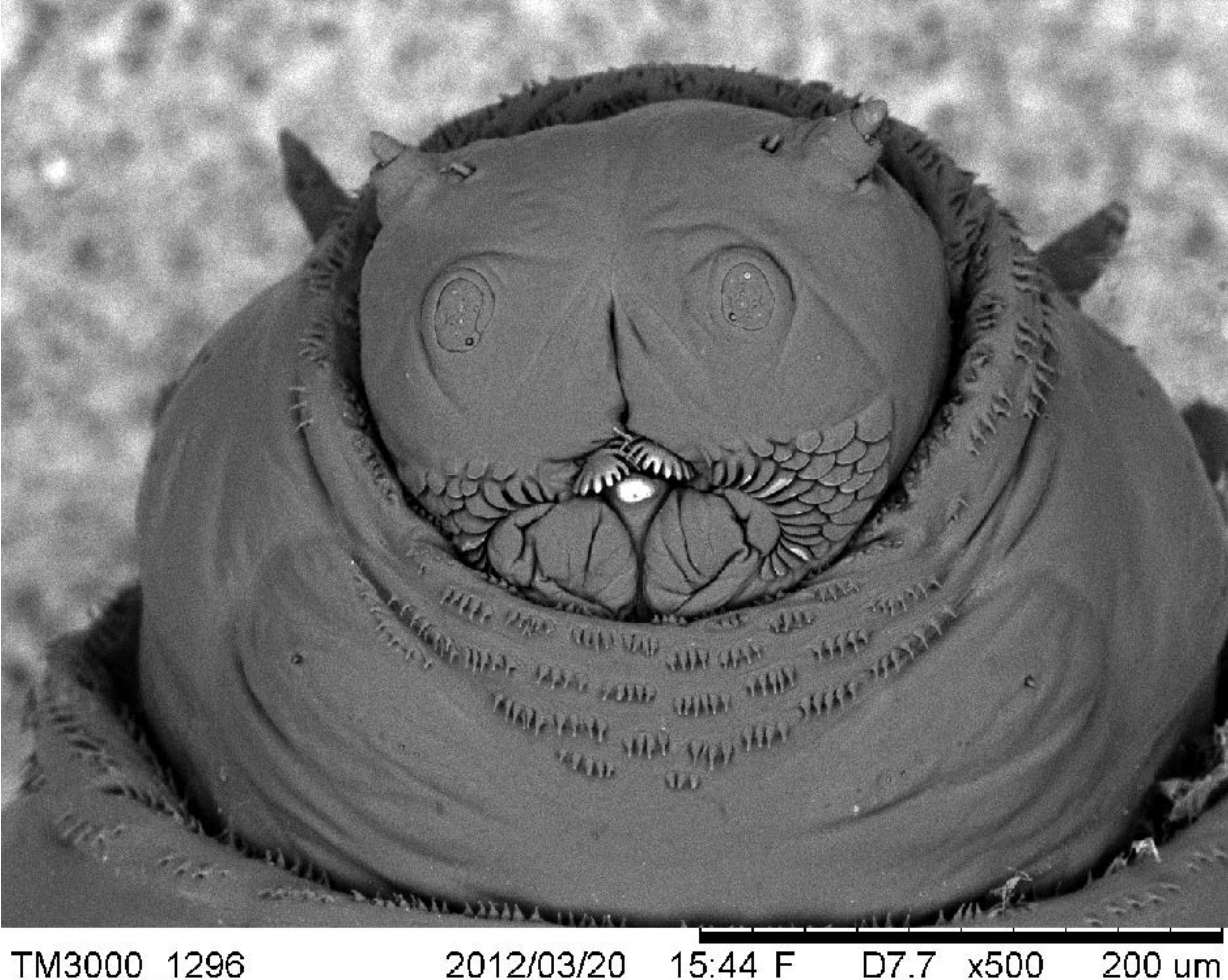


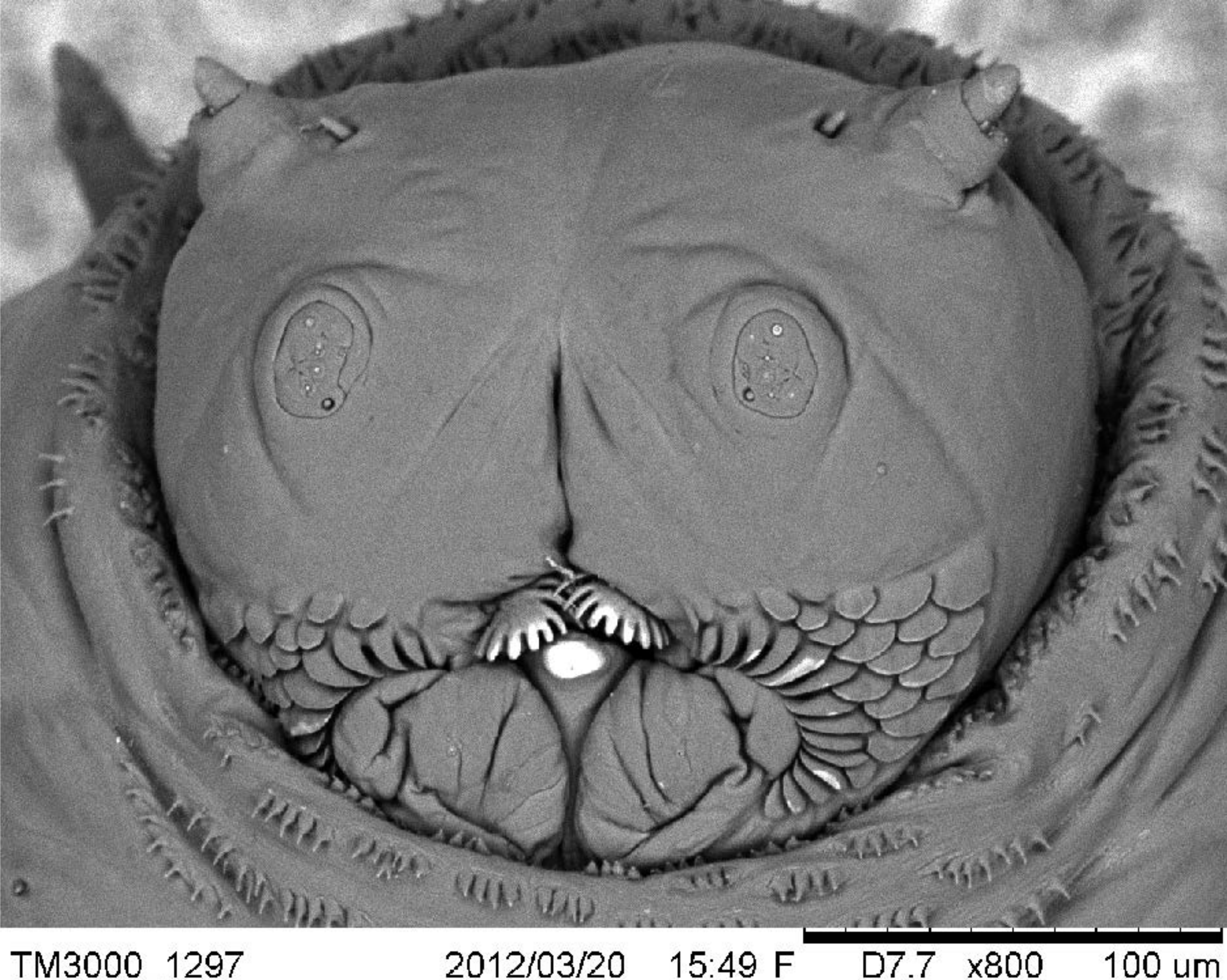


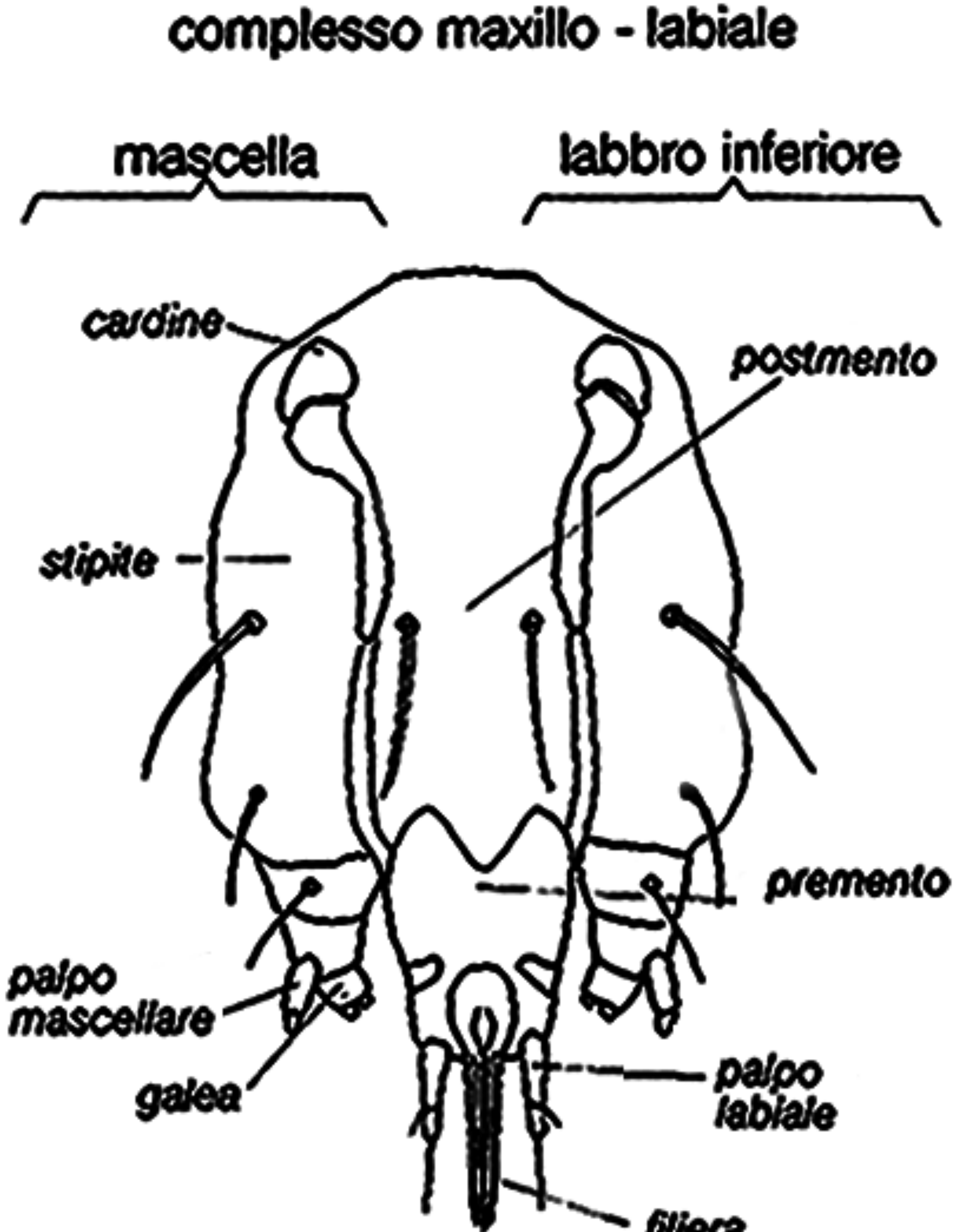


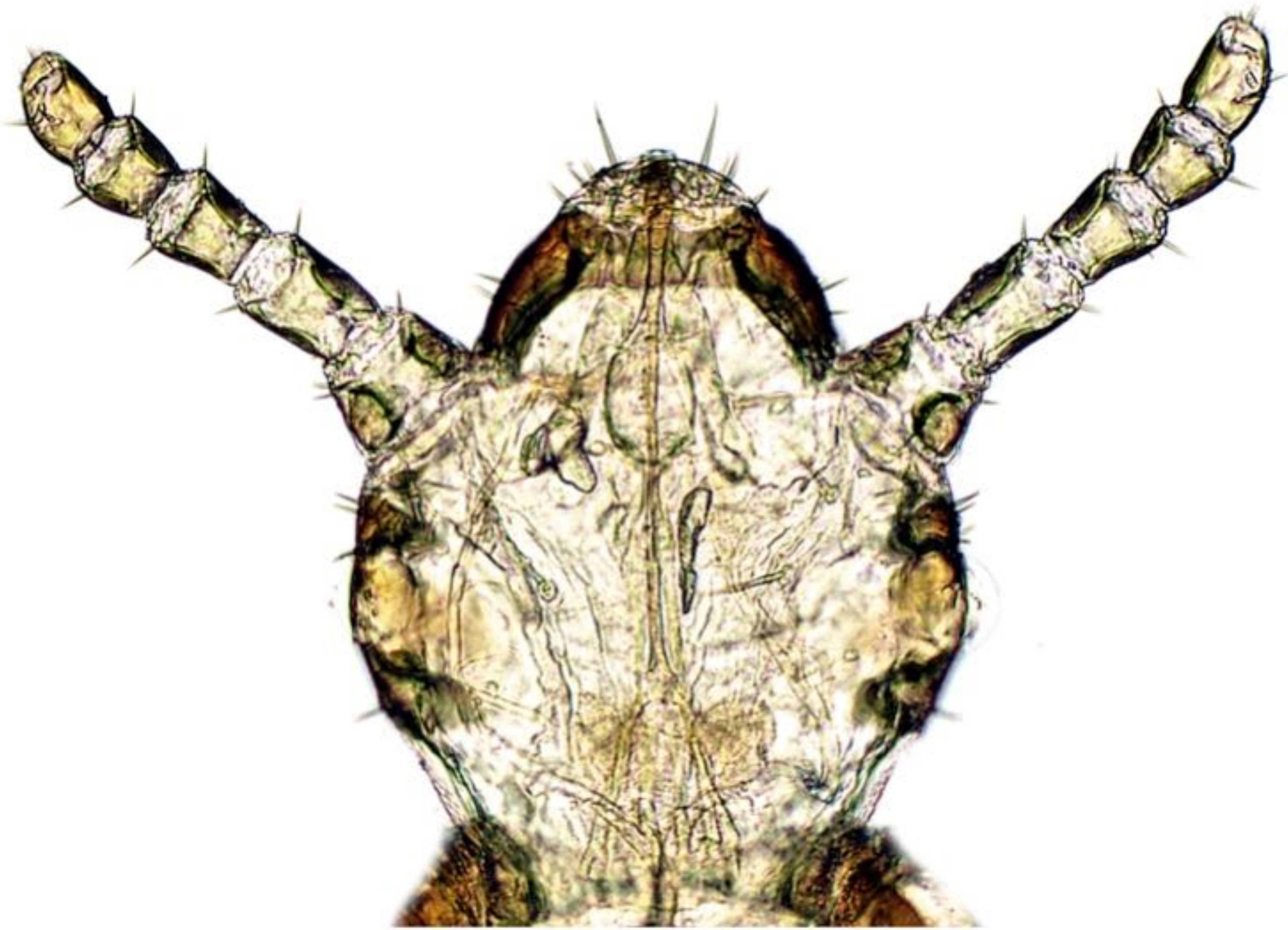

D8.7 x400 200 um
suzukii0010
Porcelli
2013/02/14 12:47 N
D8.6 x800 100 um



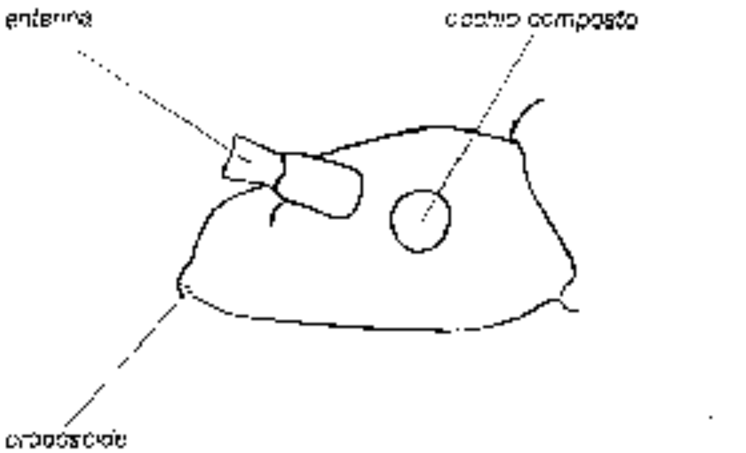

TM3000_1296
2012/03/20
15:44 F
D7.7
x500
200 um


TM3000_1297
2012/03/20
15:49 F
D7.7
x800
100 um

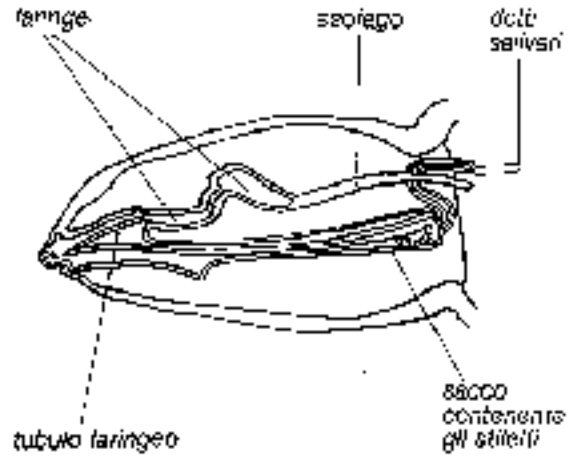

complesso maxillo - labiale
mascella
labbro inferiore
cardine
postmento
stipite
premento
palpo
mascellare
galea
palpo
labiale
filiera



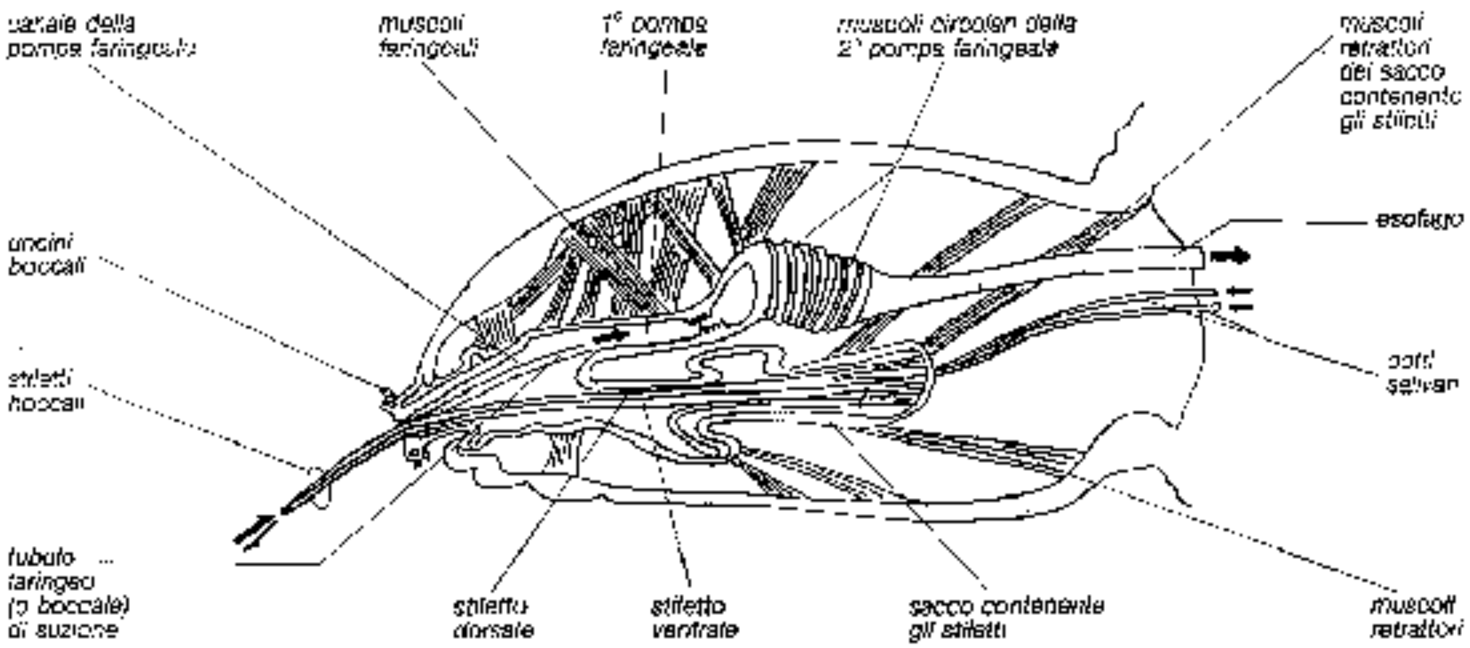
▽ CAPO DI PROFILO



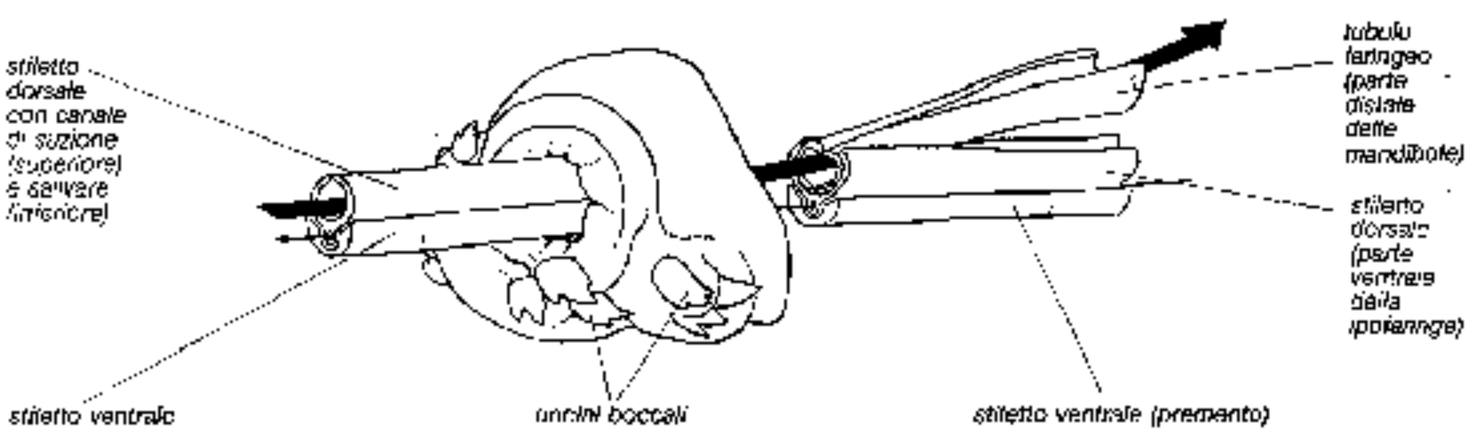
▽ CAPO IN SEZIONE LONGITUDINALE CON STILETTI BOCCALI RETRATTI

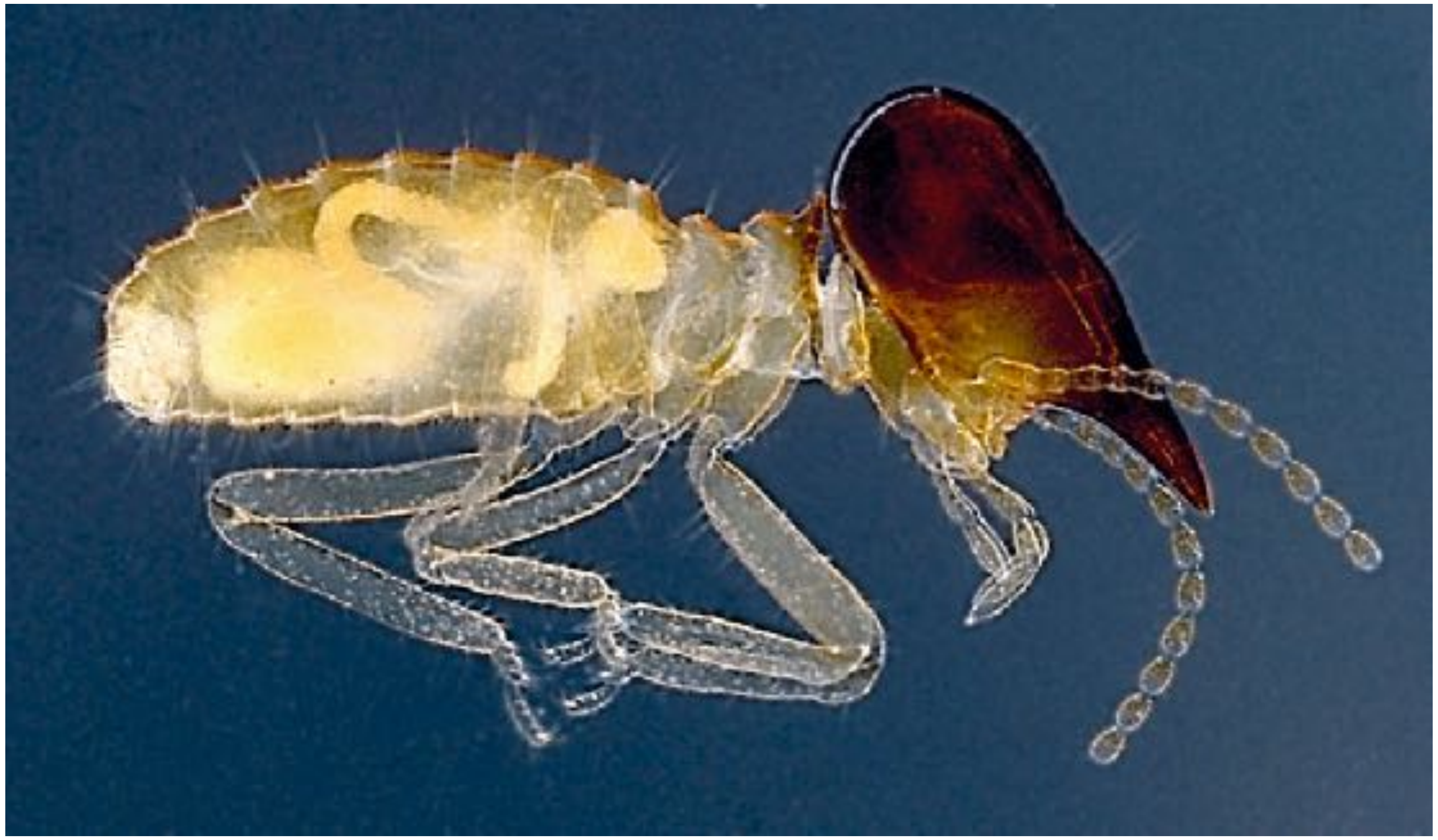


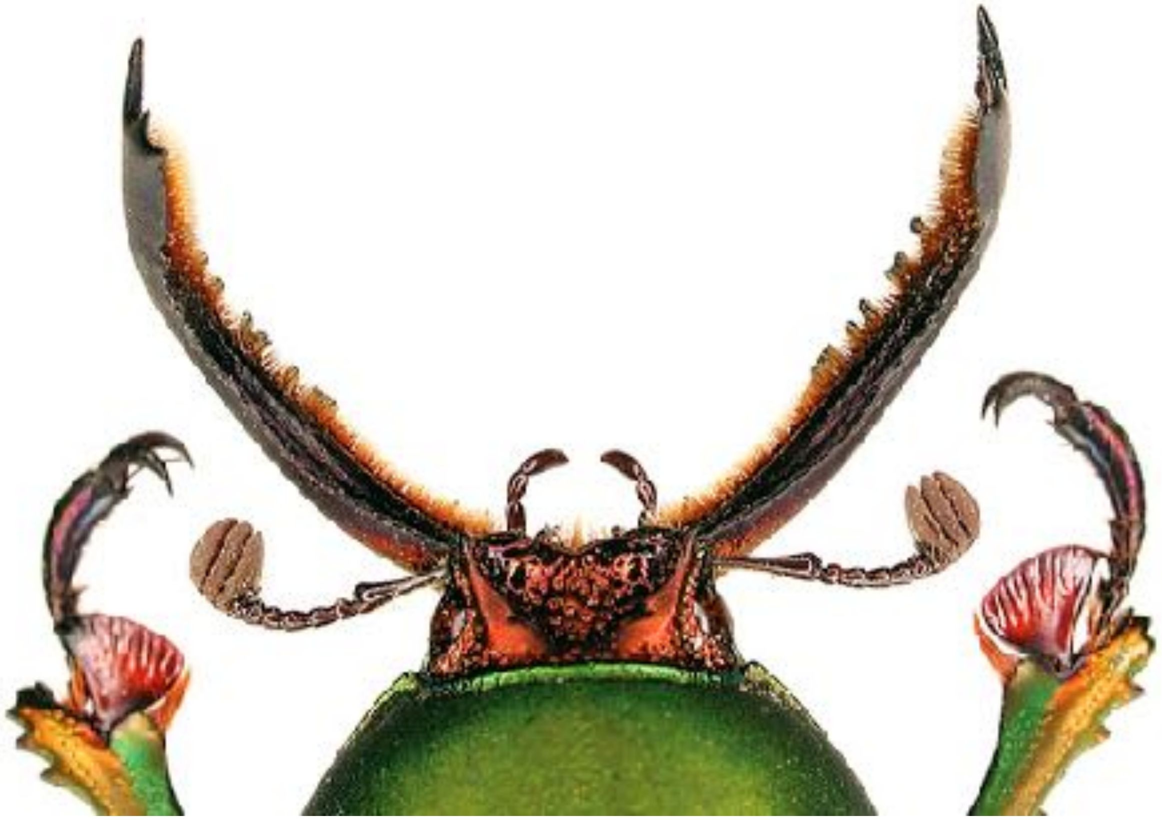
▽ SEZIONE LONGITUDINALE CON STILETTI ESTROFLESSI

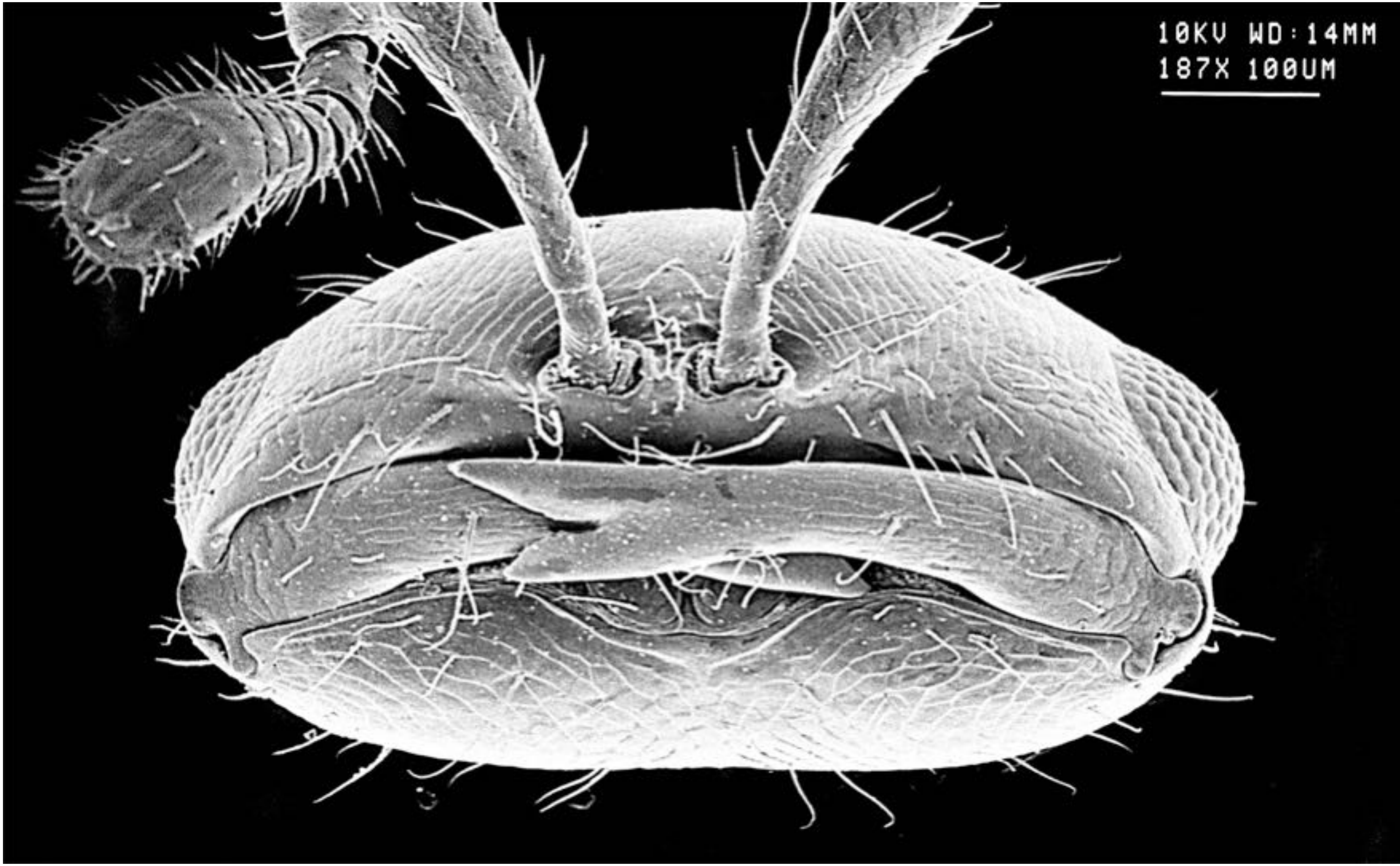


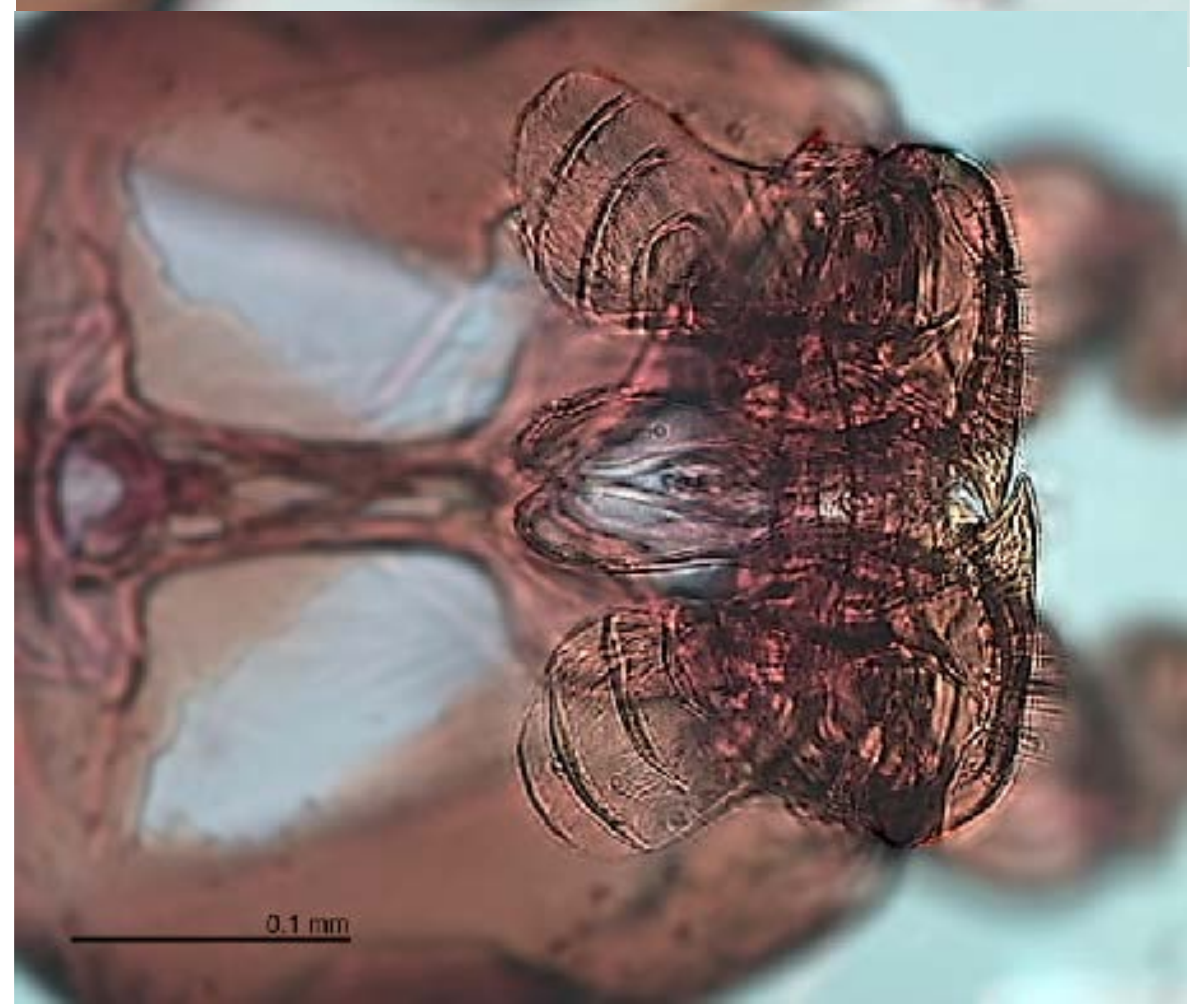
▽ DETTAGLIO DELLA PROBOSCIDE CON GLI STILETTI ESTROFLESSI PER PUNGERE E CON IL TUBULO FARINGEO CHE RACCOGLIE IL CIBO PROVENIENTE DALLO STILETTO DORSALE



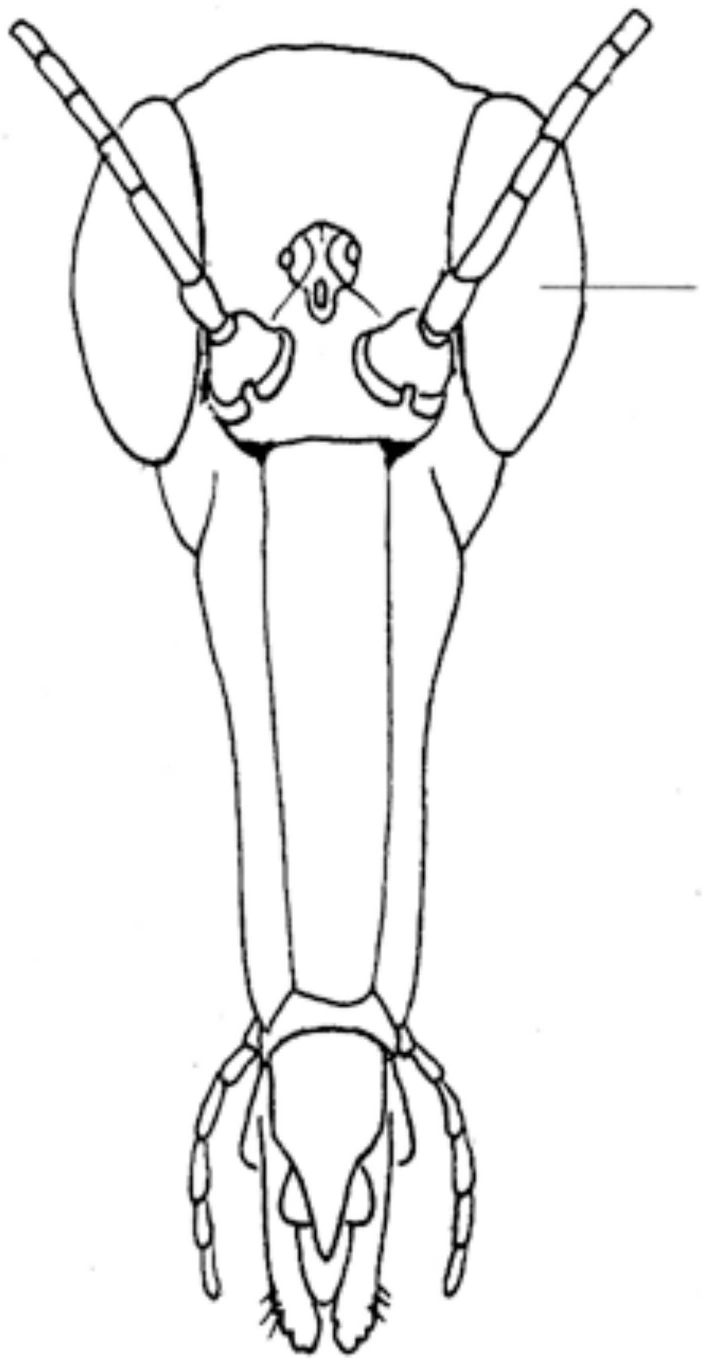


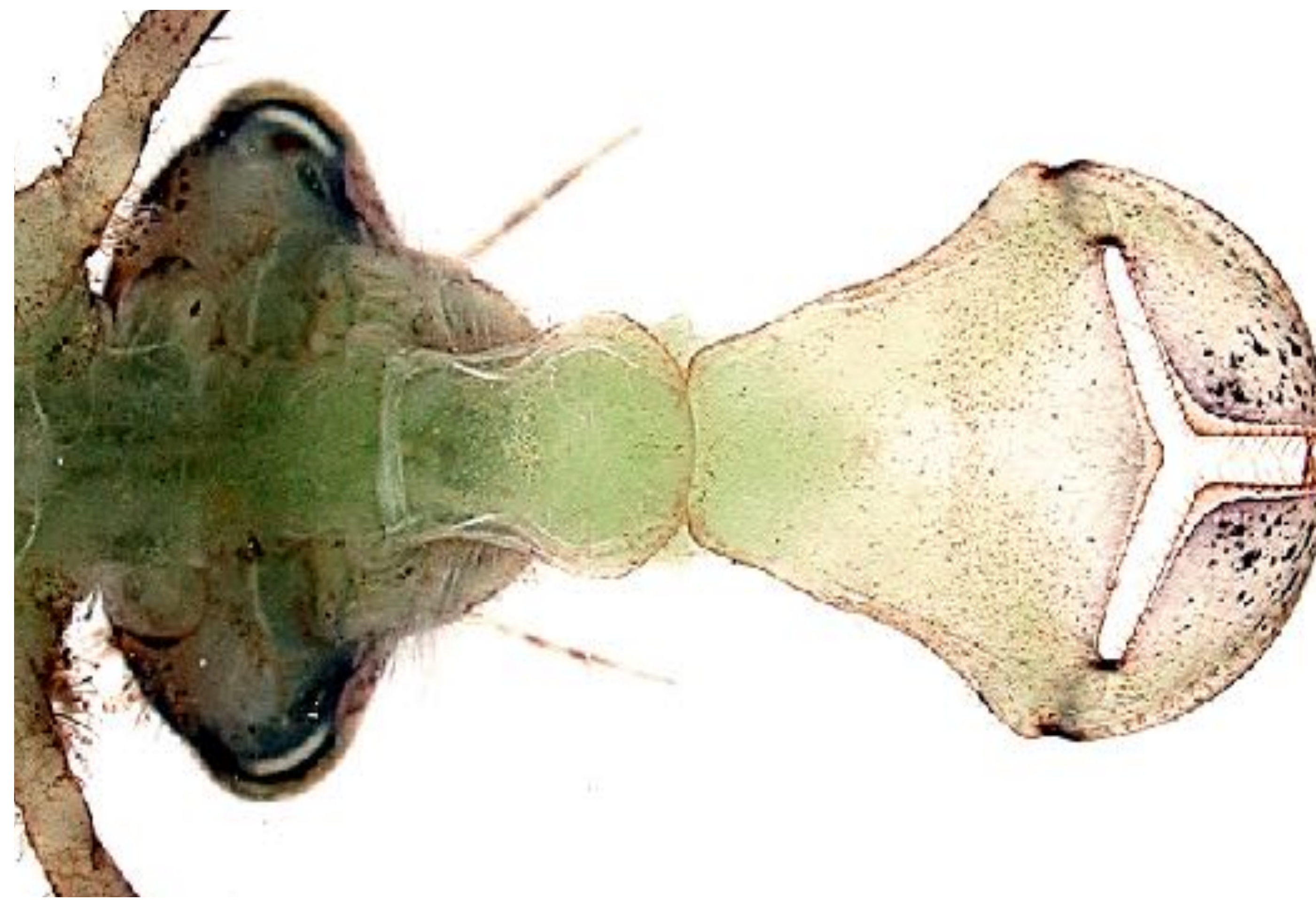



10KV WD:14MM
187X 100UM


0.1 mm

▽ Mecottero
Panorpide

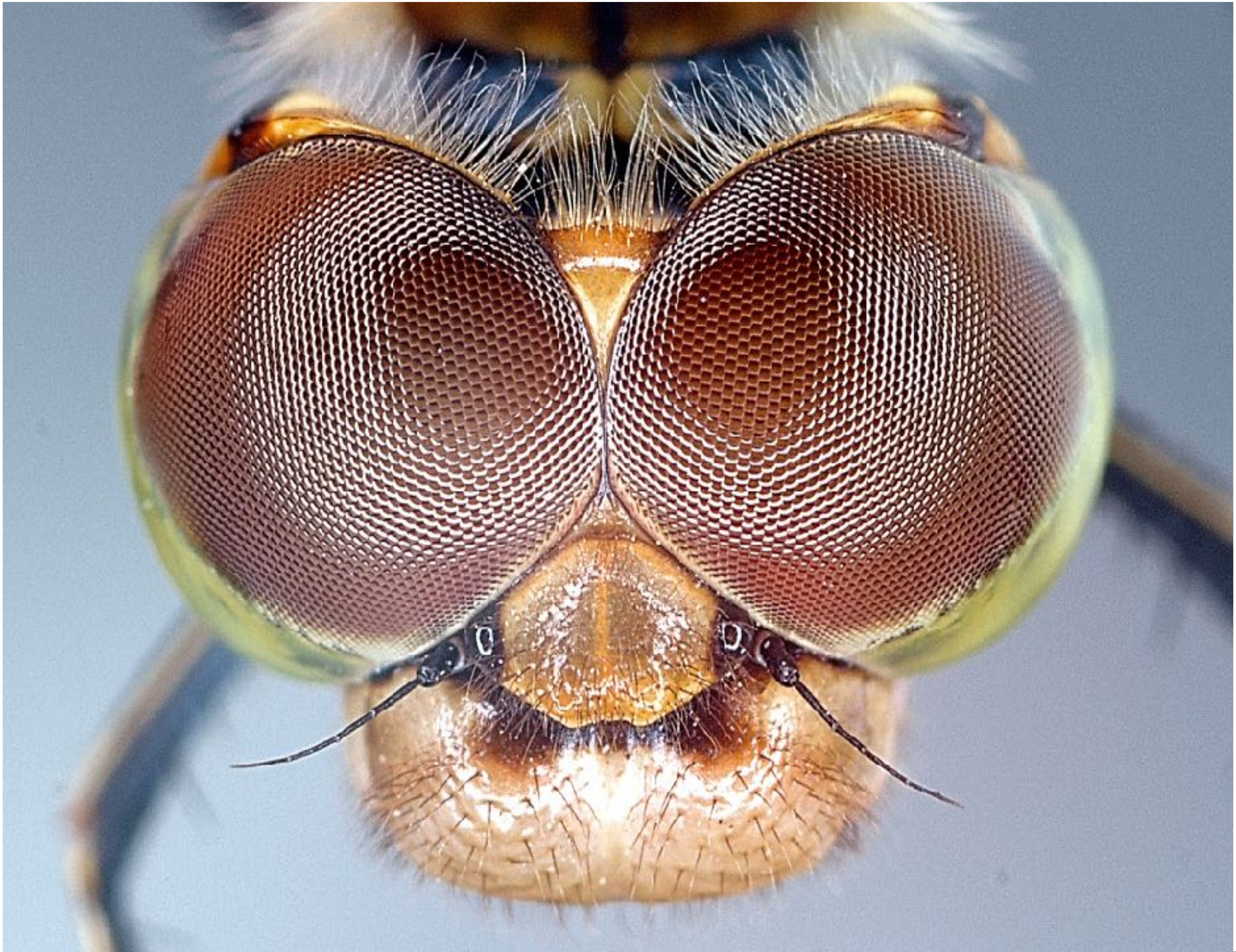


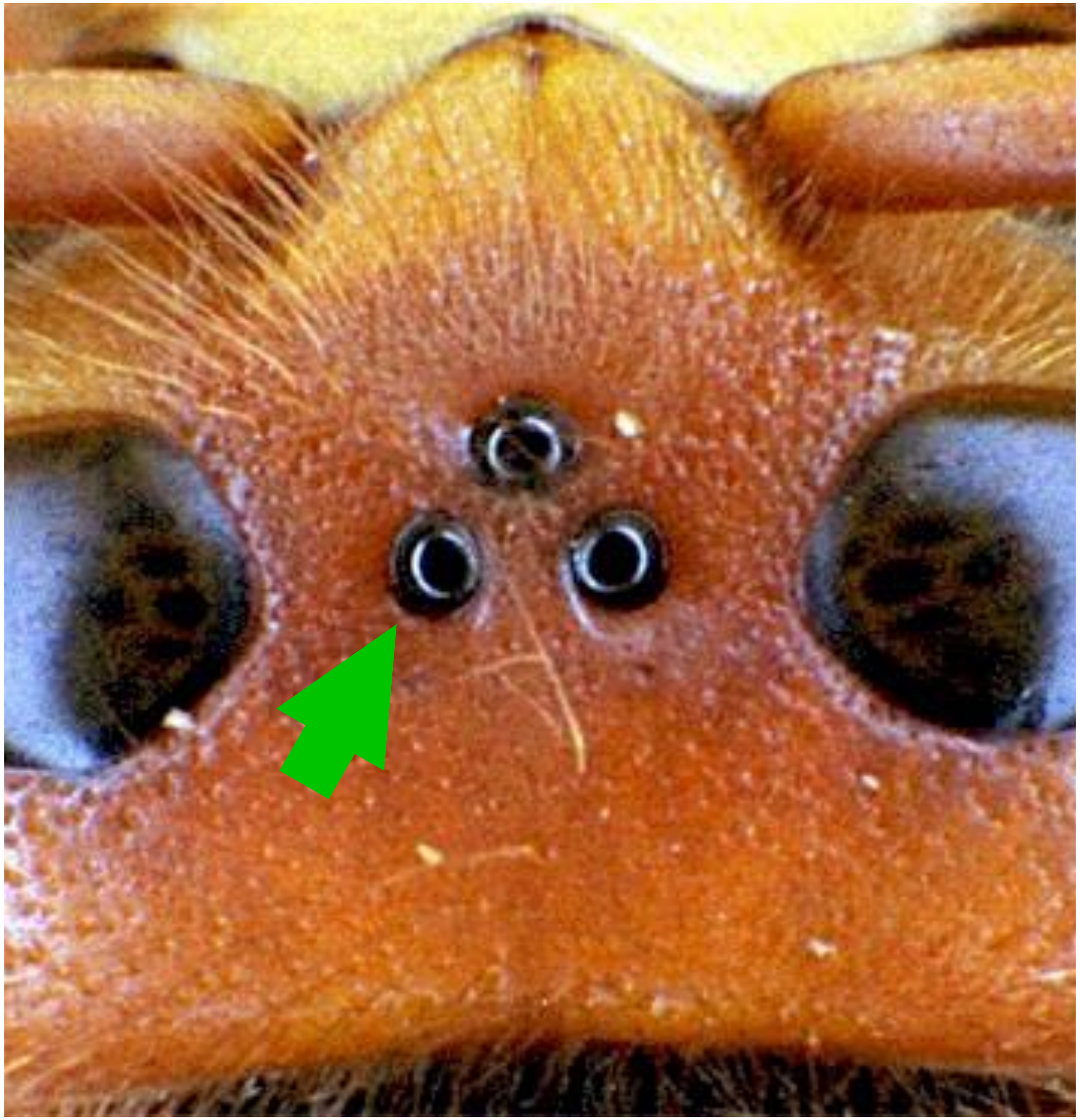


Insect Eye is the organ of sight or vision that is capable of interpreting or processing information in the visual band of the electromagnetic spectrum. An insect eye is composed of numerous Ommatidia arranged in well defined groups on each side of the head. The term is properly applied to compound eyes only, but is sometimes used to designate the so-called simple eye or Ocellus.

The insect Compound Eye is a paired aggregations of separate visual elements (Ommatidia) that are located on the head. Compound eye is a common anatomical feature among arthropods. Compound Eyes are always paired and cyclops-like insects (with one median compound eye) are unknown. Some insects (Ephemeroptera and Gyrinidae) appear to have four Compound Eyes, but this condition is the result of extreme modification of the entire eye to service optical needs from above and below the animal. Some highly evolved insects are eyeless, but this condition is derived and represents an adaptation to a specialized environment (caves) or lifestyle (parasitism); ancestors of these eyeless insects had eyes. Compound Eye is derived from epidermal cells of integument. Compound Eyes typically occur in lateral part of head with Antennae positioned between them and may represent appendage-like structures of a primitive segment in groundplan head. This eye-bearing segment occurs behind antennal segment and in front of mandibular segment. Some primitive insects (Protura and Diplura) are blind; Collembola have Ommatidia; Archaeognatha and Thysanura have true Compound Eyes. Transition from eyeless to eyed apterygotes suggests that Compound Eyes developed later in evolutionary history of insects than integument. Compound Eye size varies considerably. When Compound Eyes are large and meet medially, condition is called holoptic. Holoptic condition occurs in some Diptera.

The Ommatidium is the basic visual element which forms the compound eye. Elements of the Ommatidium include a Lens, Cone, Rhabdom, and Pigment Cells. The number of Ommatidia that form the compound eye varies considerably among Species. Some insects are eyeless ; workers of some ants and fleas have one Ommatidium; Drosophila adults have about 700 Ommatidia; the cockroach Periplaneta americana and many dragonflies have about 2,000 Ommatidia in each compound eye; the compound eye of the bollworm Helicoverpa armigera (Hubner) contains ea 8,900 Ommatidia. Sizes and shapes of Ommatidia also vary considerably among Species. Dimensions of an Ommatidium typically vary from 17-22 width and 70-125 in length. In some insects, Ommatidia in dorsal part of compound eye are larger than Ommatidia in ventral part of eye. In Diptera such as some Blephariceridae and Axymiidae, compound eyes are divided into dorsal and ventral parts.





The Ocellus (Pl. Ocelli) is the 'simple eye' of many adult insects, positioned on the Vertex and between compound eyes. Most holometabolous insects display three Ocelli; 1-2 Ocelli occur in some insects or may be absent in other Species. Anatomically, an Ocellus consists of a biconvex lens on the Vertex. Light collected by lens is cast onto sense cells (Rhabdom). Usually, an Ocellus is circular in outline but in some insects (e.g. Odonata and some bumblebees) it is bilobed. An Ocellus does not form a visual image because light collected by lens is focused beneath sensory cells, but it is sensitive to low intensities of light. Functions of Ocelli are diverse: involved in entrainment to light cycles and mediates a general stimulatory effect on insect. For instance, honeybee forages earlier in morning and longer in day if it's Ocelli are intact. Ocelli may orientate insect toward linearly polarized light, modulate phototactic behaviour or orient insect toward edges and certain objects. Ocelli probably constitute part of visual groundplan system because they occur in most insects. The anterior (Median) Ocellus probably represents fusion of two Ocelli because it is innervated from both sides of Deutocerebrum. Some termites lack Ocelli; other termites have two lateral Ocelli but lack a median Ocellus. When Ocelli are absent, condition is termed anocellate; most Lepidoptera are anocellate. Ocelli may be correlated with other anatomical features. Wasp Sclerodermus shows apterous and macropterous individuals of same Species: Macropterous individuals display Ocelli and ap- terous individuals lack Ocelli. Thysanoptera: Ocelli are present in winged adults only.

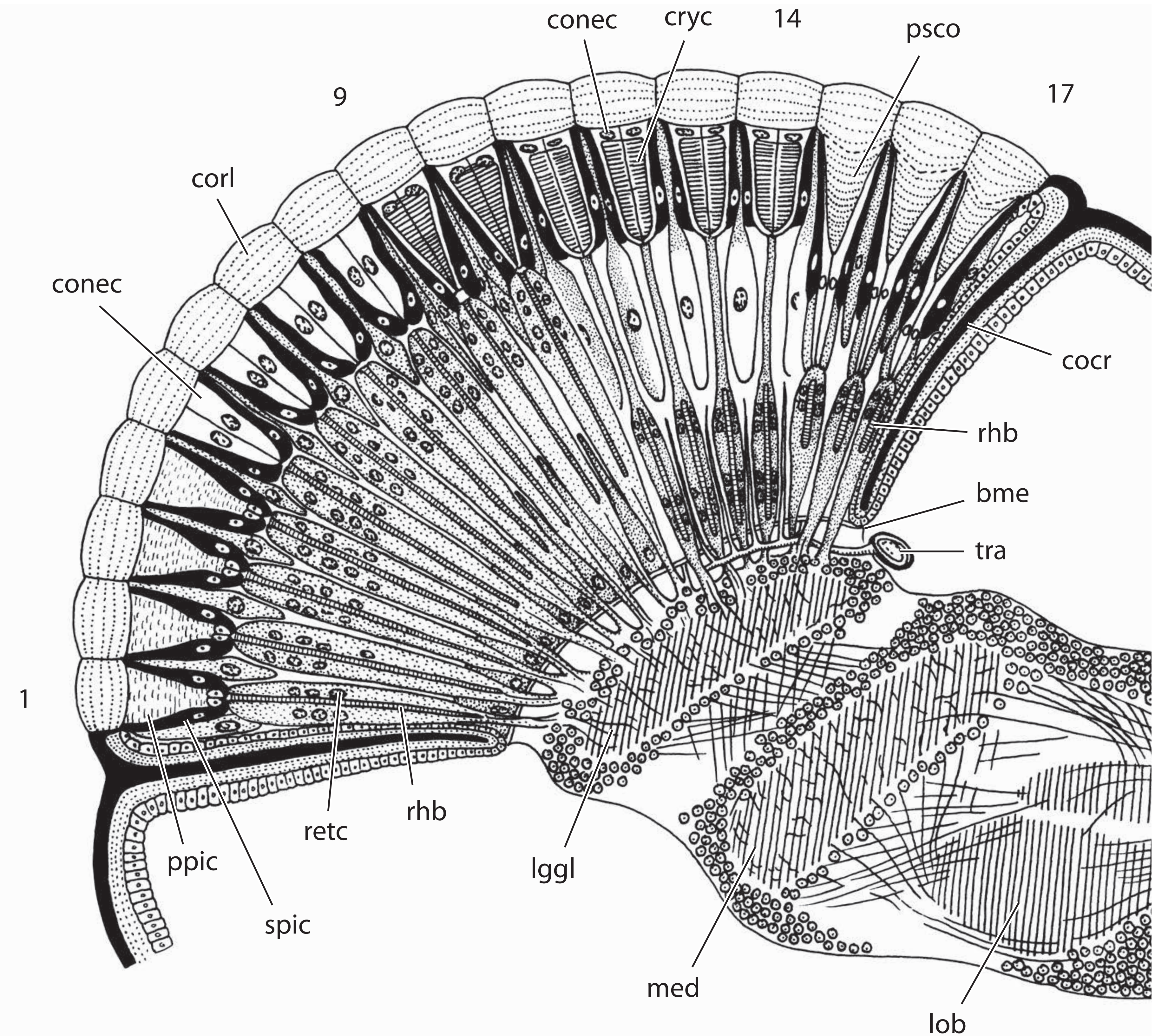
The Stemma (Pl. Stemmata) is a simple eye or single-lens optical device found on the head of most holometabolous larvae in the region of the head where the compound eye will develop. Stemmata have not been reported in fleas or apocritious Hymenoptera; they are reduced in size or apparently lost in some wood-boring Symphyta larvae, mining Lepidoptera and Brachycera. Stemmata were first described by Malpighi. Variable in number, not homologous with the Ocellus. The biconvex lens of the Stemma forms an image on a Rhabdom. However, information collected is not used for image formation. Instead, visual information is used to detect motion. When several Stemmata are clustered together, a mosaic pattern of the environment can be formed. Some larvae use Stemma to detect the plane of polarized light.

Photoreceptor organs

Extraocular (non-visual, non-image-forming) photoreception was described for several hexapod orders. This can be either direct photoreception by the central nervous system, often related to the circadian clock, or function via light-sensitive areas of the body surface involving epidermal cells with pigments and a connection to the nervous system (dermal photoreception). Simple dermal photoreception is apparently often related to the perception of the length of the photoperiod, which is known to affect certain developmental processes. Known examples are beetle larvae, butterfly caterpillars, roaches, eye-less beetles, and adults of certain species of Lepidoptera. Interestingly, photoreceptive areas occur on the genitalia of both sexes of Papilionidae (Lepidoptera). Apparently, the specialized light-sensitive cells (phaosomes) monitor the genitalia during copulation.

Compound eyes are complex and highly efficient photoreceptor organs. They occur in extant and extinct lineages of Euarthropoda and are arguably an autapomorphy of this extremely successful lineage. Apparently, compound eyes evolved in the Early Cambrian (ca. 550 Ma), when ancestral euarthropods (and other groups of organisms) ceased to live within soft marine substrates such as sand or mud. The presence of highly developed eyes is likely linked with the evolution of complex appendages, which allow efficient locomotion on the substrate surface. Compound eyes of hexapods usually possess a large visual field and they are suitable to detect fast movements, and in some groups polarized light. The paired compound eyes are almost always placed at the lateral sides of the head. They are usually distinctly convex and can cover extensive areas, in some cases almost the entire cephalic surface. The shape varies strongly. In most groups they are round, oval or kidney-shaped. Typical compound eyes are composed of numerous functional units of equal architecture, the ommatidia, each of which is equipped with an individual external corneal lens. These units are radially arranged and usually adjacent with each other, but in some groups separated externally by chitinous bridges (e.g., Strepsiptera). The number of ommatidia varies strongly. Approximately 30.000 are present in some species of Odonata, ca. 300 in females of fireflies (Lampyridae [Coleoptera]), 12 in Lepismatidae (Zygentoma), and eight is the maximum number in Collembola. A complete reduction of the compound eyes occurs in many groups. They are constantly absent in extant Protura and Diplura (“Non-oculata”), in wingless morphs of Zoraptera (and other groups), and in many cave-dwelling (e.g., Anophthalmus [Carabidae]) or parasitic species. The diameter of the ommatidial facets may differ in different regions of the compound eyes. They are larger in the anterior and upper region in Tabanidae (Diptera). Partially or completely divided compound eyes occur in different groups, such as for instance Ephemeroptera (males of many species) and Gyrinidae (“whirligig beetles” [Coleoptera]). The upper “turban eye” of ephemeropteran males appears pedunculate and contains an elongate haemolymphatic space in its “stalk”. Its facets are distinctly larger than those of the smaller ventral part of the compound eye. It is adapted to low light intensity. The hexapod ommatidium is composed of a dioptric apparatus and a proximal sensory part. The corneal lens is the external part of the light-gathering apparatus. It usually has a hexagonal shape and is also referred to as facet. In many cases the facets are biconvex, and they are always formed by a portion of transparent cuticle. Each corneal lens is formed by a pair of epidermal cells, the corneagenous cells. Below it four cone cells (Semper cells) form a second lens in many groups, the tetrapartite crystalline cone.

Acone compound eyes lack a crystalline cone (e.g., in Tipulidae [Diptera], Hemiptera). In the eucone type it is formed by intracellular secretions of the cone cells, with the nuclei always located between the corneal lens and the cone. The pseudocone type is characterized by the extracellular formation of the cone, which is adjacent with the corneal lens and sometimes fused with it, thus forming a pseudocone. In this type the cone cells are shifted proximally towards the retinula. The sensory elements are elongate photoreceptor cells arranged along the longitudinal axis of the ommatidium. Together they form the club-shaped retinula. Eight retinula cells are present in almost all groups of Hexapoda, but six or nine occur in some lineages, and the number can be distinctly increased in Coleoptera (Scarabaeoidea). The retinula cells contain screening pigment granules and the part oriented towards the longitudinal axis of the ommatidium is densely packed with a set of microvilli showing a strict parallel arrangement, the rhabdomere. In the typical case, the rhabdomeric microvilli are set at an angle to those of the adjacent cell, but aligned with those of the retinula cell on the opposite side. The unit formed by the rhabdomeres of each ommatidium is called the rhabdom. In some groups, the rhabdomeres of a given ommatidium are separated from each other. This configuration is called an open rhabdom. It occurs in Dermaptera and Diptera, and also in some groups of Heteroptera and Coleoptera. However, in most groups the rhabdomeres are connected along their longitudinal axis within their ommatidium, thus forming a fused rhabdom. The retinula cells of ommatidia of this type have the same visual field, whereas those of hexapods with open rhabdoms have separate fields of view, shared with retinula cells of other ommatidia. The ommatidia are more or less completely isolated from each other by secondary pigment cells, which contain numerous screening pigment granules. The primary pigment cells enclose the crystalline cone with narrow proximal processes. The secondary pigment cells (12–18 per ommatidium in most groups) usually cover the proximal part of the primary pigment cells and at least the distal region of the retinula cells. The proximal parts of the photoreceptor cells are usually separated by retinula pigment cells. Their number varies between taxa. There are several functional sub-types of the hexapod compound eyes. In the apposition eye, the ommatidia are optically isolated from each other by a pigment sheath comprising both the secondary pigment cells and screening pigment granules present in the retinula cells. In the light-adapted state, when apposition is performed, it is the longitudinal migration of retinular screening pigment granules along the entire rhabdom that enables a complete optical isolation of the ommatidia. Then, each ommatidium functions as an independent unit. Only light passing through the dioptric apparatus parallel to the longitudinal axis of the ommatidium (or at a small angle) reaches the rhabdom. The apposition eye is considered as an adaptation to perceive light at high intensities and ensures high spatial resolution. This is apparently linked with a diurnal life-style. The counterpart is the superposition eye, which usually possesses a shorter rhabdom. Between the crystalline cone and the distal tip of the rhabdom, there is a zone devoid of any screening pigment granules, termed the clear zone. Consequently, the light channeled through one cone may be spread not only to the retinula of the same ommatidium but also to the retinulae of neighboring ommatidia. It is important to note that optical types are never fixed, but may change from apposition into superposition at night (and vice versa before daytime).



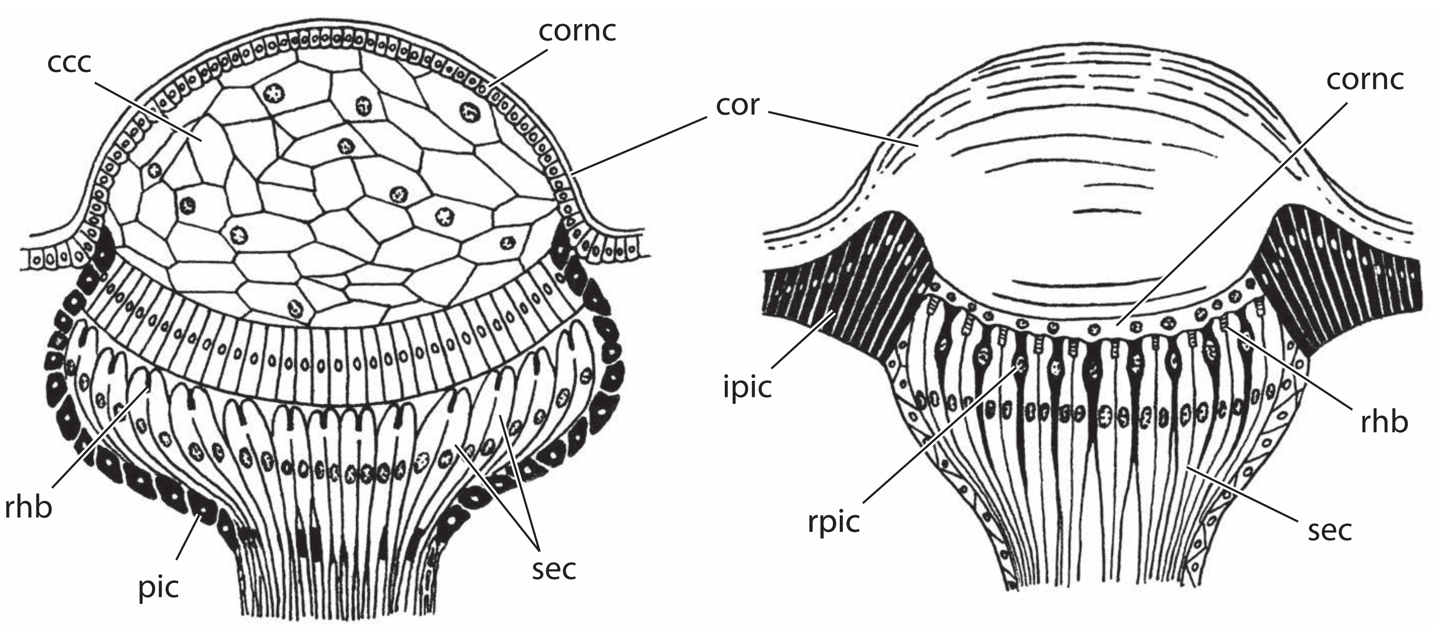
Compound eye, displayed with different types of ommatidia, 1–4, 15–17 pseudocone, with extracellular crystalline cone directly adjacent with cornea, crystalline cone cells shifted towards retina; 5–8 acone, crystalline cone cells (Semper cells) form no cone; 9–14 eucone, crystalline cone formed within cone cells. **bme:** basement membrane, **cocr:** circumocular ridge, **conec:** crystalline cone cells, **corl:** corneal lens, **cryc:** crystalline cone, **lggl:** lamina ganglionaris, **lob:** lobula (medulla interna), **med:** medulla (externa), **ppic:** primary pigment cell, **psco:** pseudocone, **retc:** retinula cell, **spic:** secondary pigment cell, **rhb:** rhabdom, **tra:** trachea.

This is due to photoreceptor dynamics (photoperiodic elongation or shortening of rhabdomeric microvilli), the displacement of entire pigment cell bodies and, most importantly, the withdrawal or migration of screening pigment granules from/into the clear zone. The axons of the retinula cells pass through the basal matrix of the compound eye and are connected with the optic neuropils. Most of them end in the lamina ganglionaris (1st to 6th retinula cell) but some reach the medulla (7th and 8th retinula cells). In hexapods with a fused rhabdom the axon bundle originating from each ommatidium usually remains connected and associated with visual interneurons originating in the lamina ganglionaris and medulla to form a cartridge. In contrast to that, cartridges of hexapods with open rhabdoms receive axons from retinula cells with the same field of vision but belonging to different ommatidia. This recombination of retinular axons in the optic neuropil represents is referred to as neuronal superposition. Up to five different types of photopigments may occur in hexapod compound eyes (Odonata, few Lepidoptera). A visual pigment with a maximum absorption in the green range of the spectrum (maximum 490–540 nm) is always present. Thin tracheae reach into the compound eyes and enter the space between the ommatidia. In some lepidopteran lineages, they form a densely packed light-reflecting inner layer, the tapetum. This structural modification is a characteristic feature of the superposition eye (see above). The taenidia in the tapetum are enlarged and flattened. The entire compound eye is enclosed by a more or less extensive internal circumocular ridge with a central opening for the protocerebral optic lobes. This endoskeletal structure increases the mechanical stability of the head capsule. An additional low external ridge occurs in different lineages. Compound eyes are usually absent in larvae of Holometabola. However, simplified types with a single corneal lens and without a crystalline cone occur in some basal lineages of Hymenoptera. Simplified compound eyes also occur in most groups of Mecoptera, but they are absent in Boreidae (see below) and strongly reduced in Nannochoristidae.

Dorsal ocelli are present in adults of most groups of Hexapoda. They also occur in immature stages but are absent in nymphs of Acercaria and in larvae of Holometabola. In most cases, three ocelli are present and arranged in a triangle, with the unpaired ocellus in front of or below the paired ones. The loss of the unpaired median ocellus has occurred several times independently (rarely of the paired ones). Complete reduction occurs in different lineages, especially in wingless forms (e.g., Grylloblattodea, wingless morphs of Zoraptera, extant Dermaptera, most groups of Coleoptera). The main function of the ocelli is the perception of changes of the light intensity. In most groups, the ocelli are covered by a thickened (not in some orthopterans), transparent and undivided corneal lens. Below it retinula cells (ca. 800 in Locusta) are densely packed with a much less regular arrangement than in the compound eyes. A rhabdomere is present at least on one side of the retinula cells (unidirectional type). Rhabdoms are formed involving between two and seven cells. Accessory pigment cells may be present or absent (e.g., Blattodea). A reflecting tracheal tapetum occurs in some groups. The nerves of the ocelli originate on the dorsal (or frontal) region of the protocerebrum.

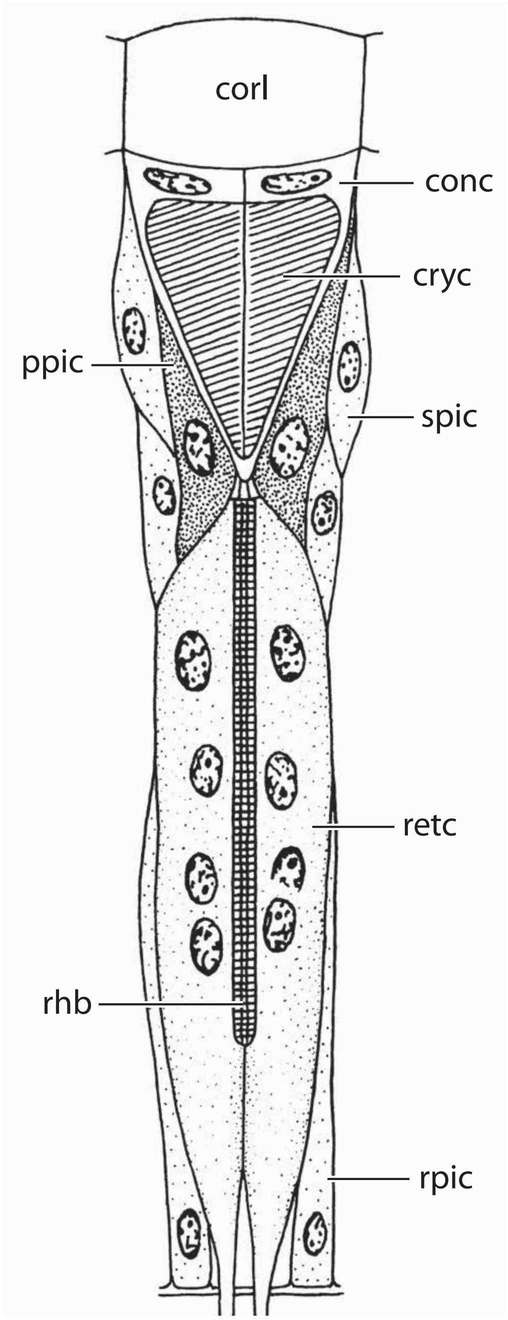
Stemmata are specific lateral eyes (the term “lateral ocelli” is inappropriate) of larvae of most groups of Holometabola. They are replaced by the adult compound eyes during the metamorphosis. The number ranges between seven and one and they are absent in different groups (e.g., Hymenoptera, Mecoptera excl. Boreidae, Siphonaptera, Cyclorrhapha [Diptera]). Structurally, they resemble ommatidia and are suitable to perceive movements, directions and distances. It was shown that specialized stemmata of some predacious beetle larvae (Cicindelinae, Dytiscinae) are image forming lens eyes.

Each stemma is covered by a single biconvex corneal lens and a crystalline cone is also present in most groups (eucone type). It is formed by three or four Semper cells in most groups but the number is increased in Neuropterida. The crystalline cone is usually missing in Coleoptera (acone type). Below it, a regularly arranged cluster of retinula cells is present. Their number is distinctly increased in Neuropterida (up to 40 in Megaloptera). Only one rhabdom is present in the stemmata of most groups (e.g., Boreidae [Mecoptera], Neuroptera [partim], Trichoptera, Lepidoptera, Coleoptera [major part]). Up to 5,000 cells can be contained in the extended and cup-shaped retina of the two largest stemmata of tiger beetle larvae (Cicindelinae). In the two largest stemmata of larvae of Thermonectes (Dytiscidae) several morphologically distinct retinae are arranged on different layers. The optic tracts connecting the stemmata with the protocerebrum are much less developed than the optic neuropils of the adults. They are greatly elongated in the extremely miniaturized first instar larvae of Strepsiptera due to the position of the brain (and other parts of the central nervous system) in the middle region of the post-cephalic body.

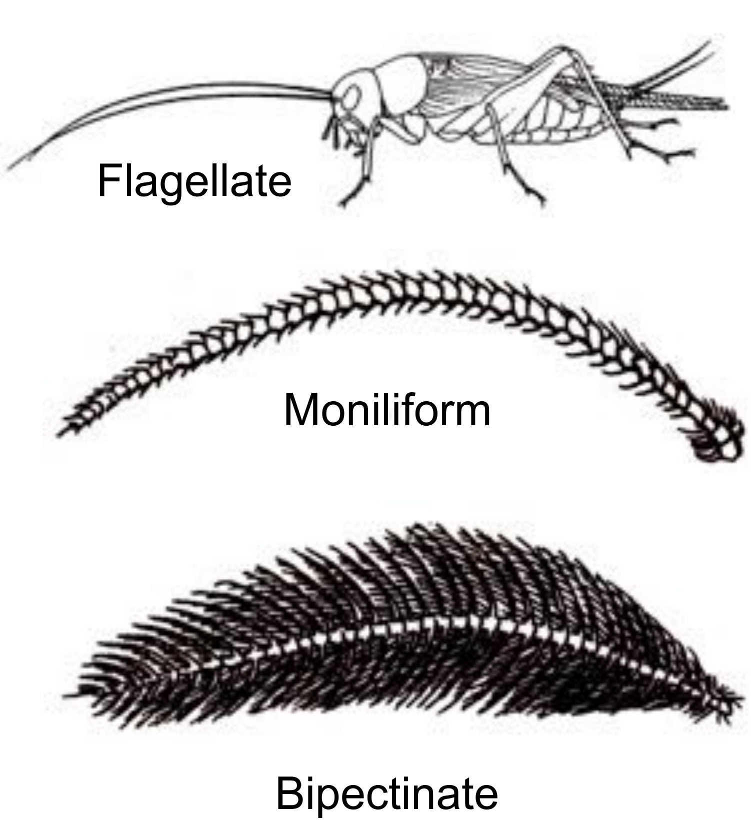


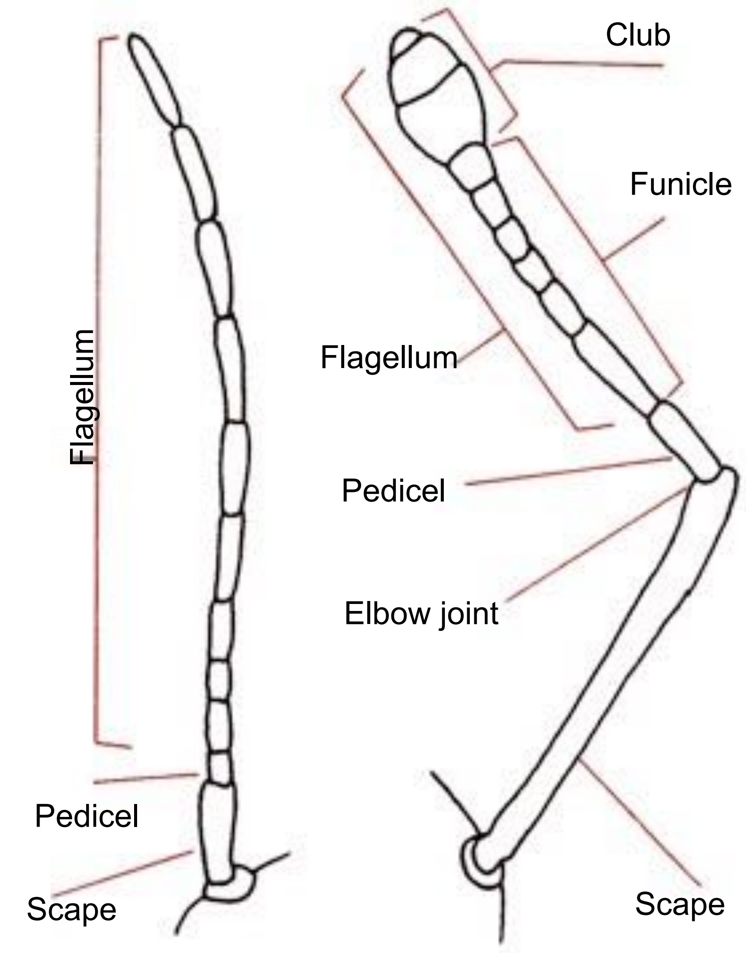
Two types of ocelli. cornc: corneagenous cell, **ccc:** cellular crystalline cone, **cor:** cornea, **ipic:** iris pigment cells, **pic:** pigment cell, **rhb:** rhabdom, **rpic:** retinula pigment cell, **sec:** sensory cell.

Ommatidium. conc: corneagenous cell, **corl:** corneal lens, **cryc:** crystalline cone, **ppic:** primary pigment cell, **retc:** retinula cell, **rhb:** rhabdom, **rpic:** retinula pigment cell, **spic:** secondary pigment cell.

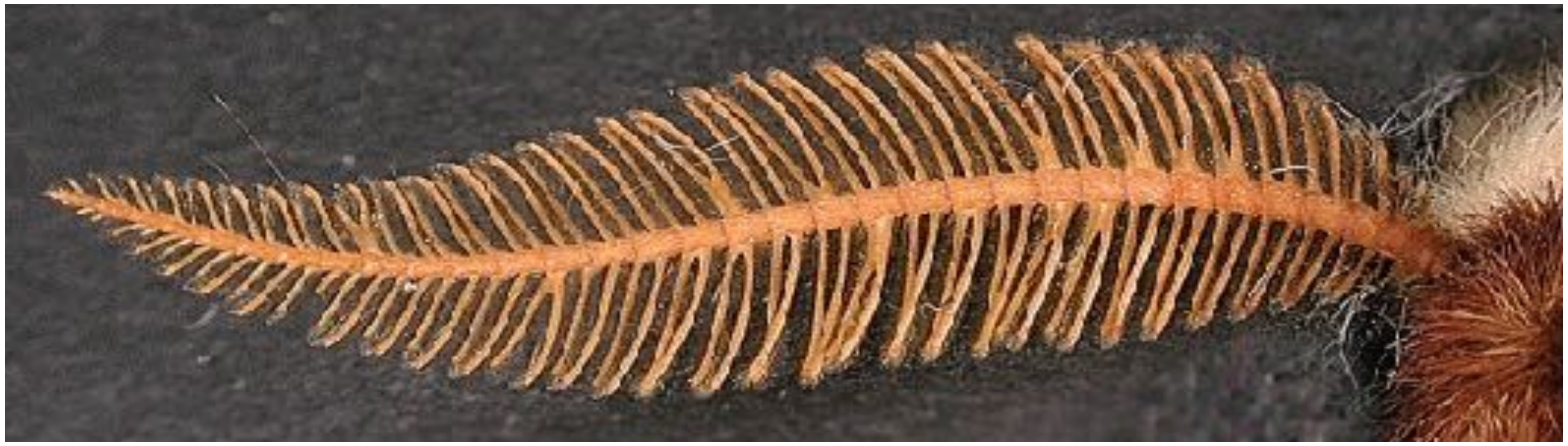


The Antenna are paired, segmented, flexible, sensory appendages located on the head of most arthropods. Antennae are missing from Chelicerata; two pairs occur in Crustacea; a pair occur in Insecta. Among hexapods, Antennae are missing from Protura but are present in Diplura and Collembola. Insect Antenna is the anteriormost appendage of postembryonic head. Antenna is innervated by deutocerebral lobe of Brain and usually attached to head in facial region. Antennal segment number varies considerably (3-70+); Antenna is subdivided into three parts: Scape (attached to head), Pedicel (second segment) and Flagellum (all distal segments). Scape is attached to head via a membranous socket (Torulus) and articulates with head via a small sclerotic process (Antennifer). Antenna is sometimes divided into two types: segmented and annulated. Segmented Antenna occurs in non-insect groups, Symphyla,Collembola and Diplura; each Antennal segment has intrinsic musculature. Annulated Antenna occurs in Pterygota and Thysanura; intrinsic Antennal musculature only occurs in Scape and Pedicel. Flagellar segments of pterygotes are sometimes called Flagellomeres. Antenna functions in olfaction, contact chemoreception, courtship and other activities.

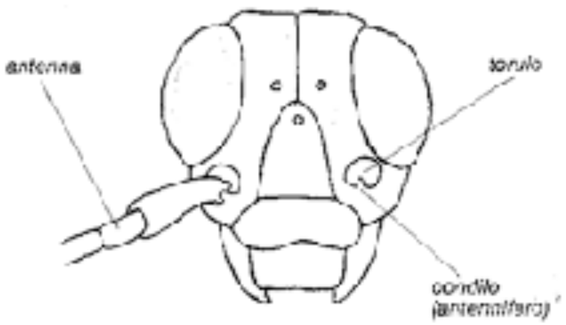




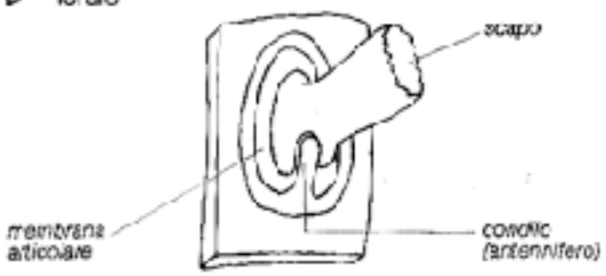
Antenna form is variable, Flagellomere size and shape are serially monotonous or undifferentiated in most lower Orders, highly variable among groups of Holometabola and frequently a source of profound sexual dimorphism. Antennae may be Aristate, Capitate, Clavate (Clubbed), Filiform, Flabellate, Geniculate (Elbowed), Lamellate, Moniliform, Pectinate, Ramose, Setaceous. Antenna is moved in part by extrinsic musculature that usually originates on Anterior Arms or Dorsal Rami of the Tentorium and insert on base of antennal scape.
An Antennal Cleaner exists in Hymenoptera: A grooming device intended to clean the Antenna and consists of a basomedial fringe of Setae, 'hairs' or spines on the medial surface of the anterior Basitarsus; the Setae form a comb-like structure through which the Antenna may be drawn. The Antenna is held in place against the comb by an enlarged, often curved or forked tibial spur that is at the tibial apex. Similar structures are on the fore Tibia of other insects.



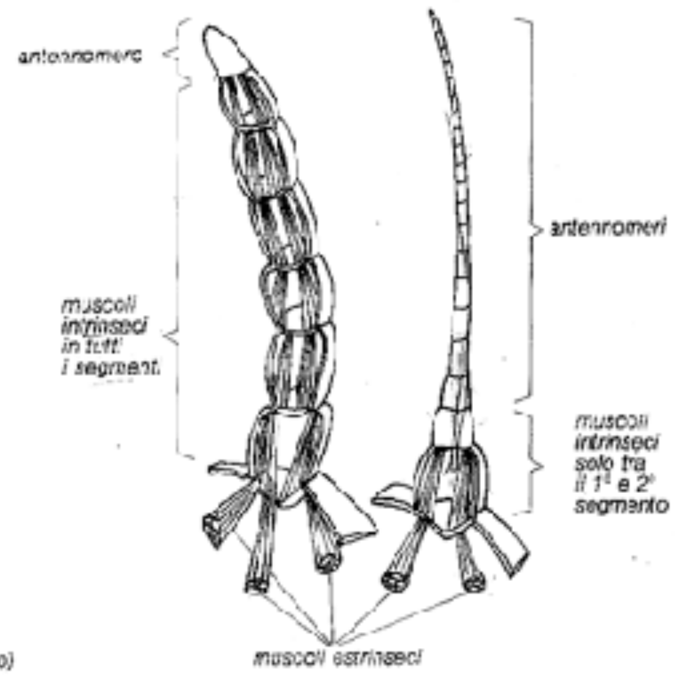
▽ ARTICOLAZIONE DELLE ANTENNE



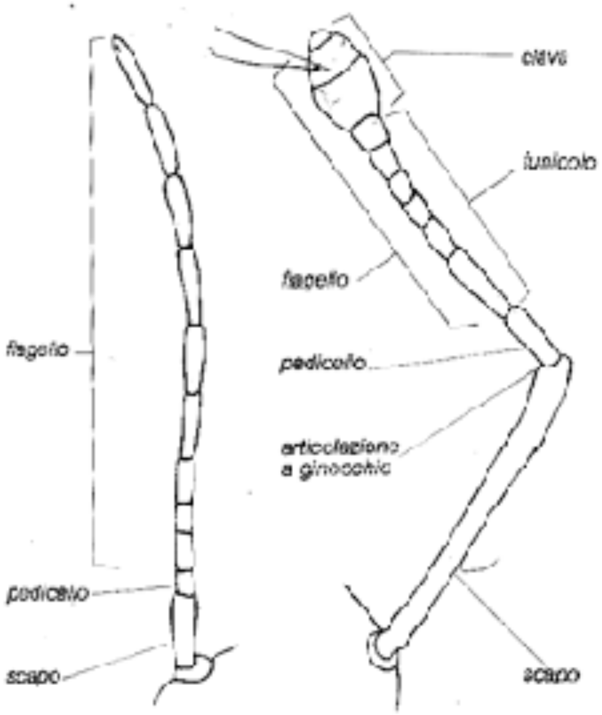
▷ torulo



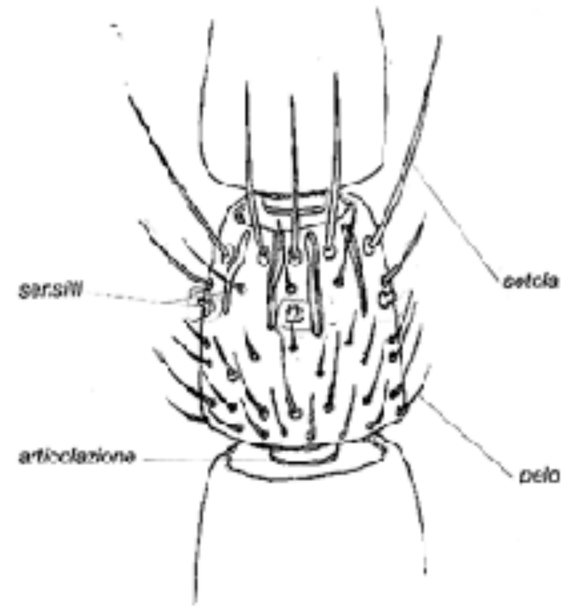
▽ ANTENNA SEGMENTATA (A SINISTRA) ED ANULATA (A DESTRA)



▽ DENOMINAZIONE DEI SEGMENTI ED ANTENNOMERI IN ANTENNE ANULATE: MONILIFORME (A SIN.) E CLAVATO - GENICOLATA (A DEST.)



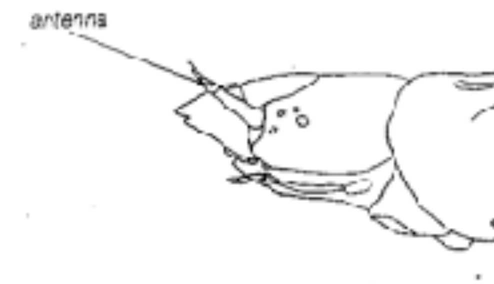
▽ ANTENNOMERO CON SETOLE, PELI E SENSILLI



▽ ANTENNA SUBATROFICA

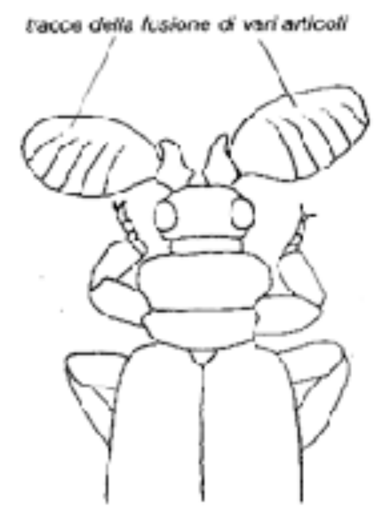
◁ Larva di Imenottero Vespide

▽ ANTENNA DI 3 ARTICOLI



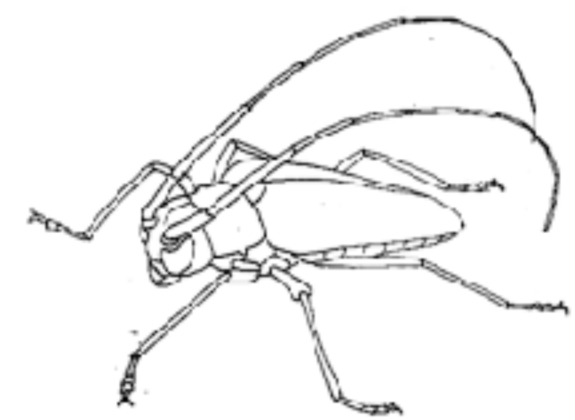
△ Larva di Coleottero Meloide

▽ ANTENNA CON VARI ARTICOLI DEL FLAGELLO FUSI IN UNA CLAVA



△ Adulto di Coleottero Pausside

▽ ANTENNA CON 11 ARTICOLI VISTOSAMENTE SVILUPPATI IN LUNGHEZZA



△ Adulto di Coleottero Cerambicide

▽ ANTENNA FILIFORME CON NUMEROSE DECINE DI ANTENNOMERI

△ Adulto di Ortottero Ensifero

▽ ANTENNE CON ARTICOLI DEL FLAGELLO SIMILI FRA DI LORO

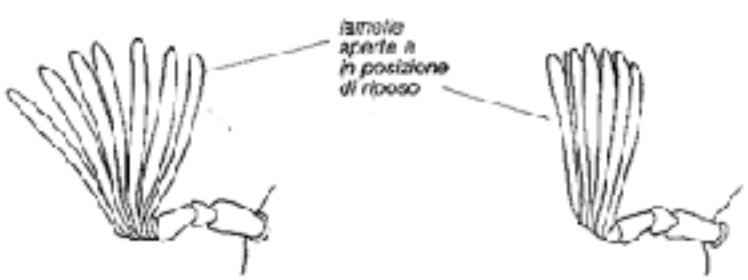
◁ antenna setiforme di Ortottero Ensifero

▽ antenna imbricata di Coleottero Cerambicide (Prionus)

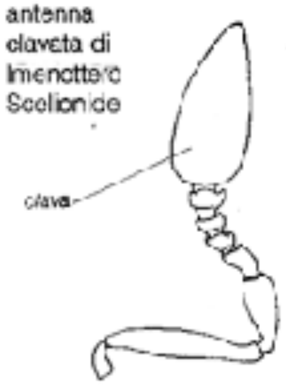
▷ antenna pettinata di Coleottero Elateride

▽ ANTENNE CON ARTICOLI DEL FLAGELLO DIVERSI FRA DI LORO

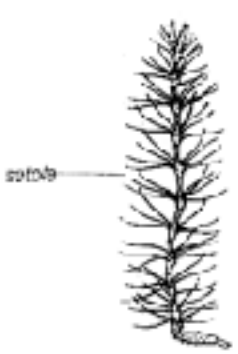
▽ antenna lamellata di Coleottero Scarabeide



▽ antenna clavata di Imenottero Scelionide



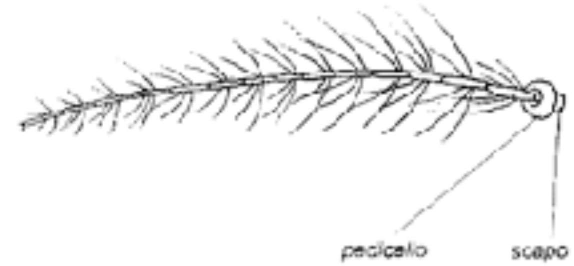
▽ ANTENNE CON ARTICOLI DEL FLAGELLO PROVVISTI DI APPENDICI



◁ antenna verticillata di Imenottero Scelionide

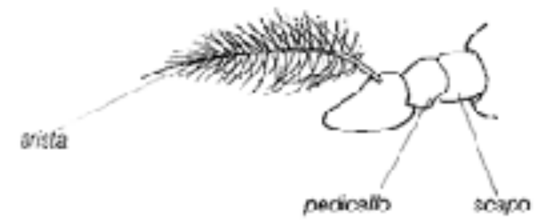
▷ antenna plumosa di Dittero Chironomide

▽ DIFFERENZE FRA GRUPPI SISTEMATICI NEI DITTERI



△ antenna verticillata

△ Dittero Nematocero



△ antenna aristata

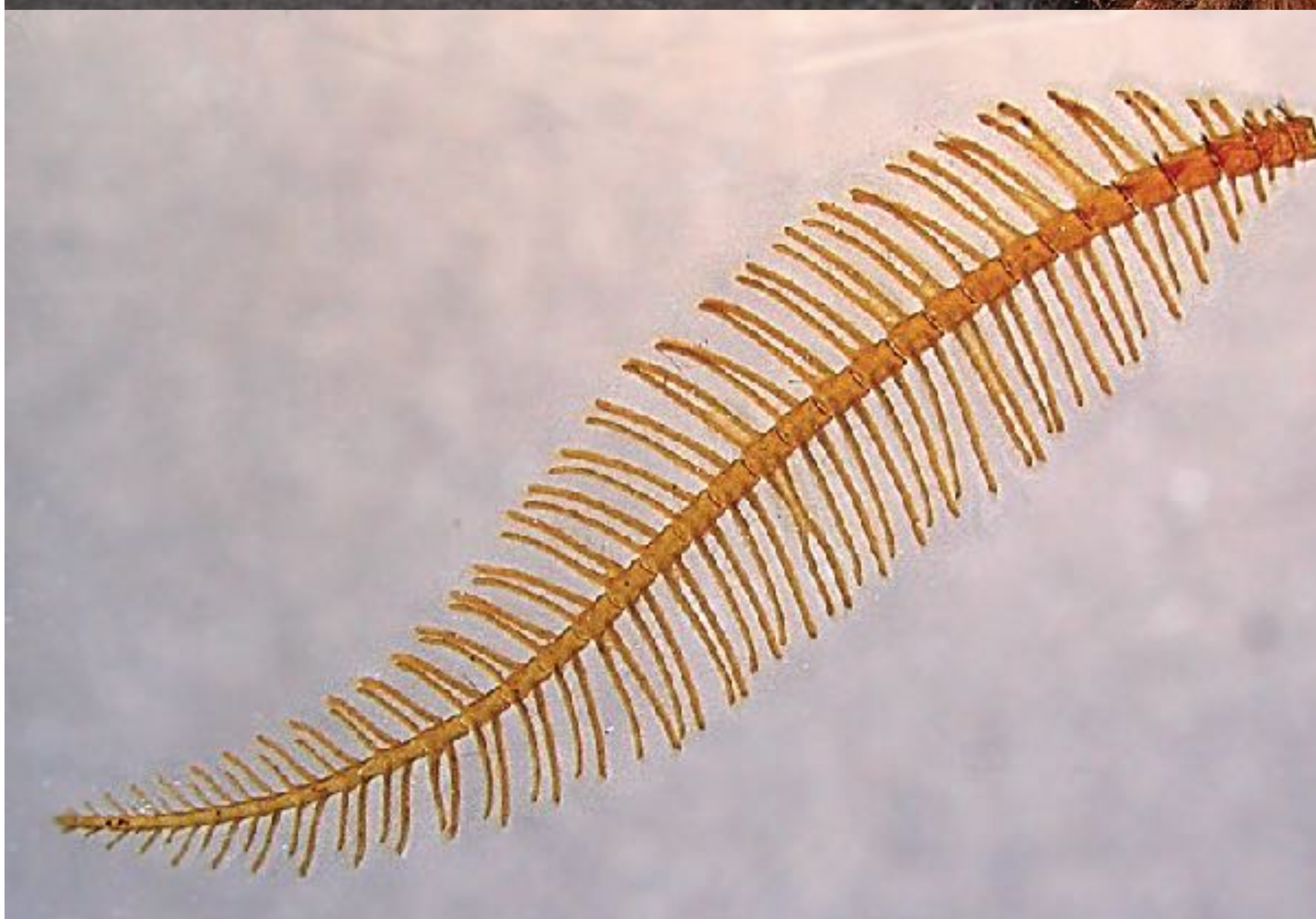
△ Dittero Brachicero

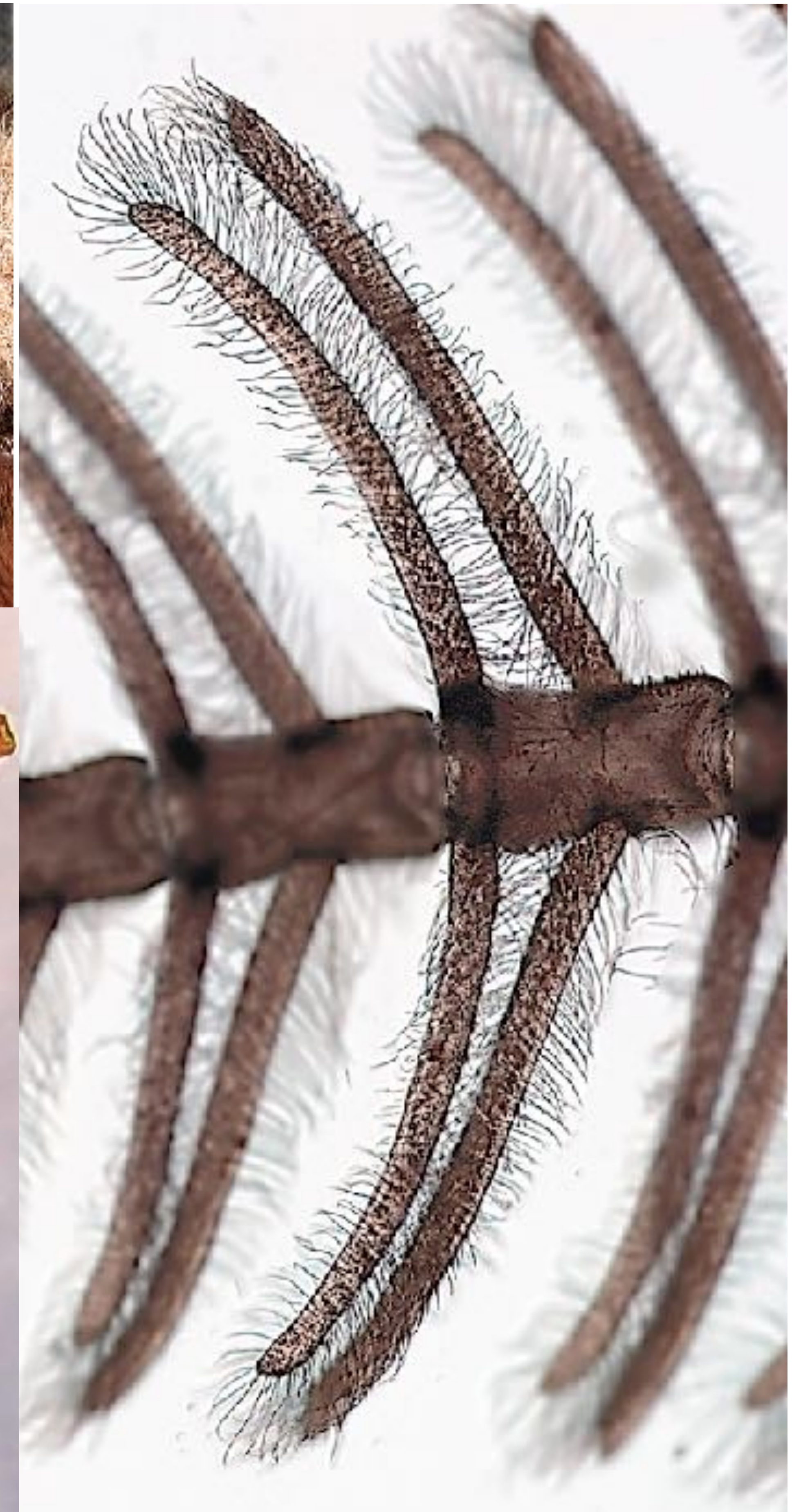
▽ DIFFERENZE FRA I SESSI NEI LEPIDOTTERI

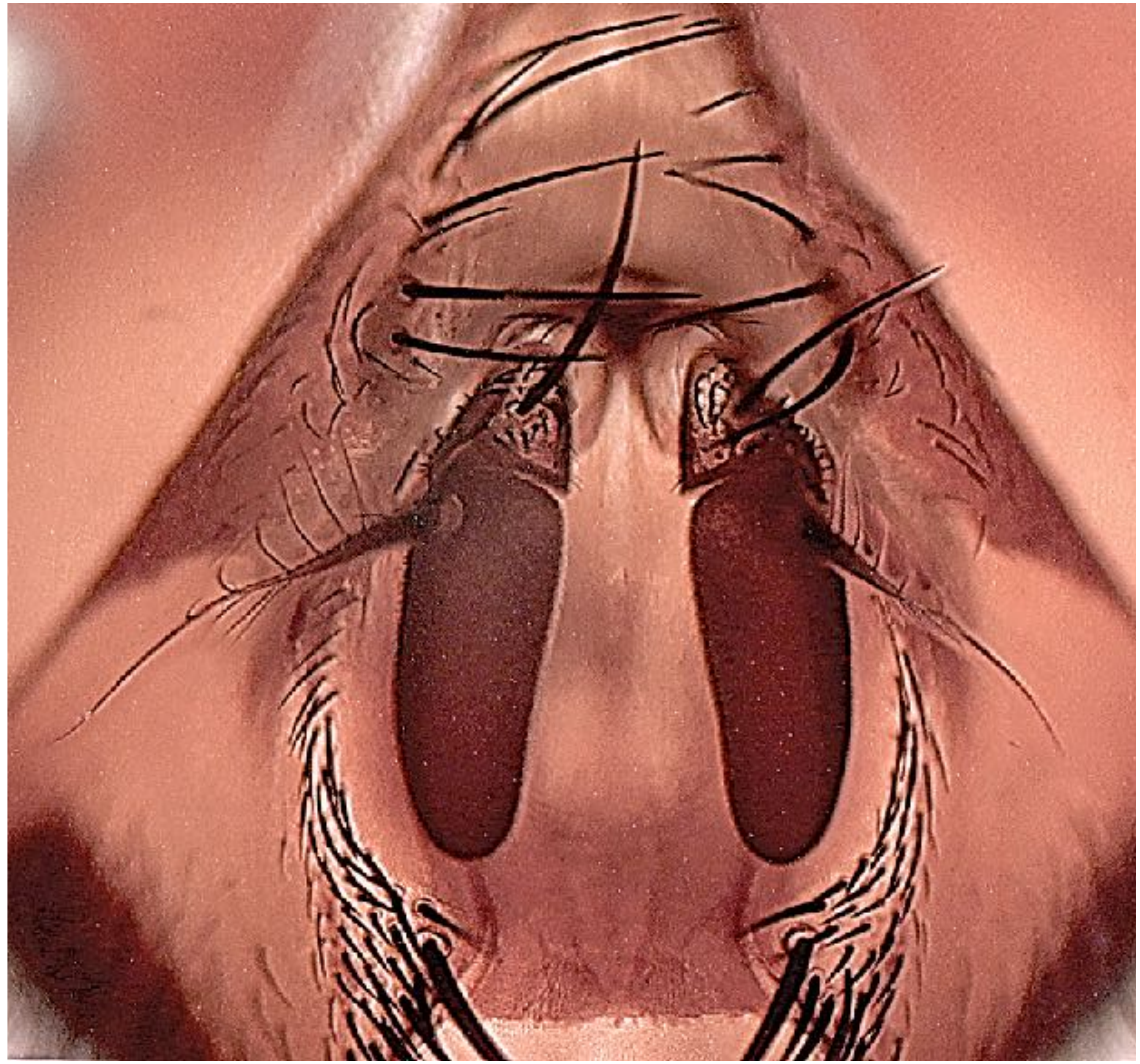
△ antenna bipettinata

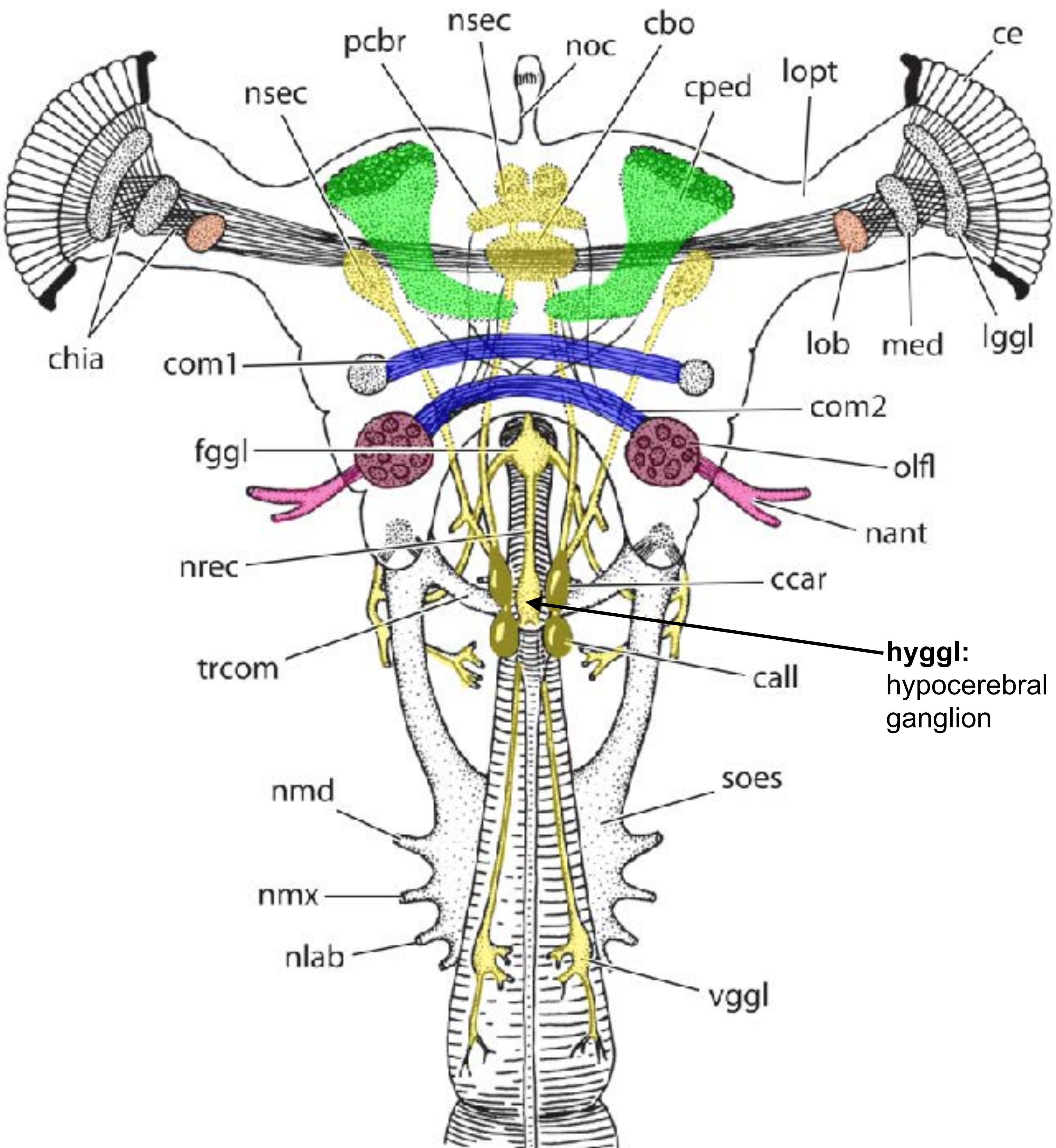
△ antenna moniliforme

△ Lepidottero Lemoniide:
▽ ♂ in alto e ♀ in basso

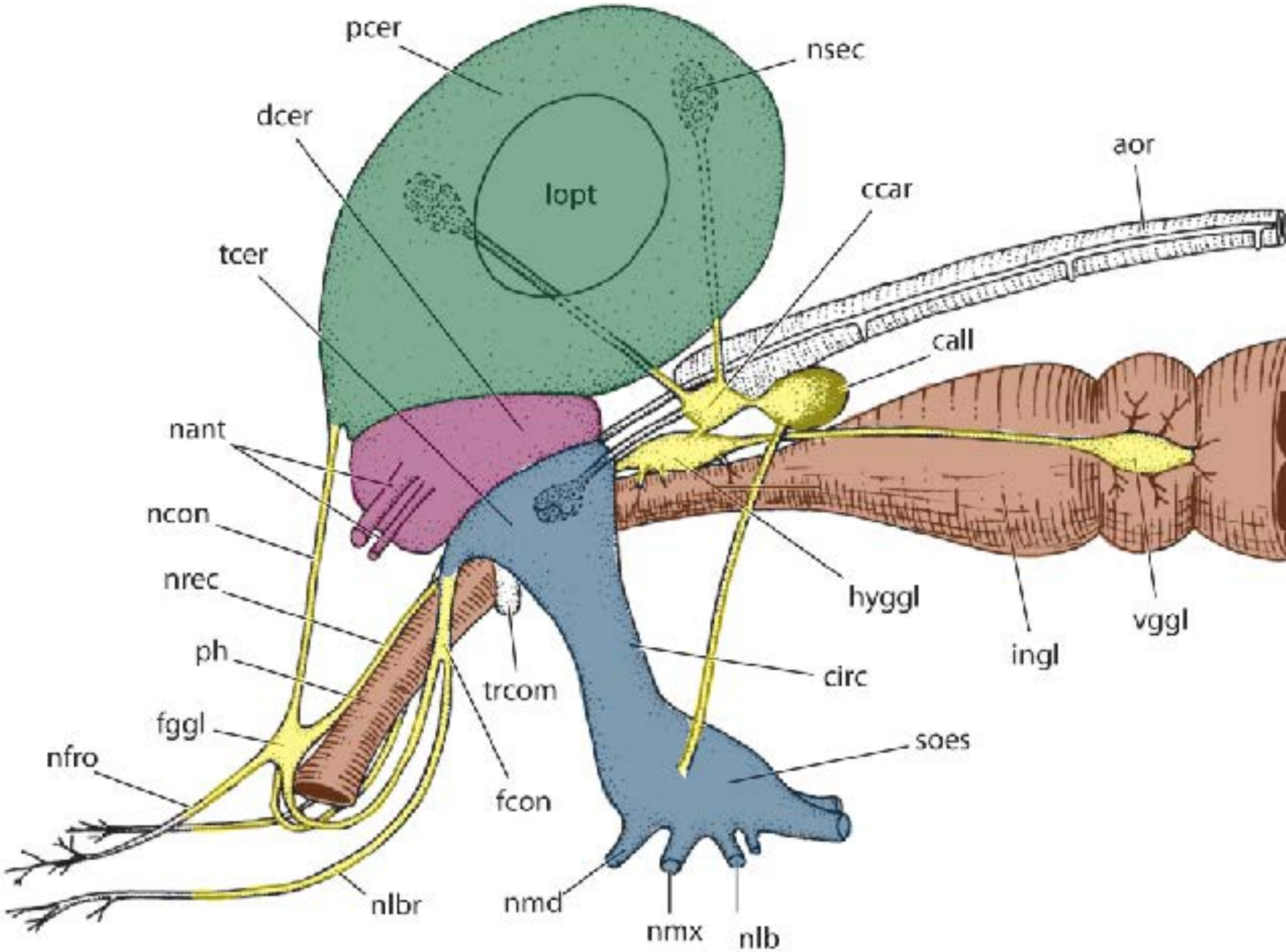




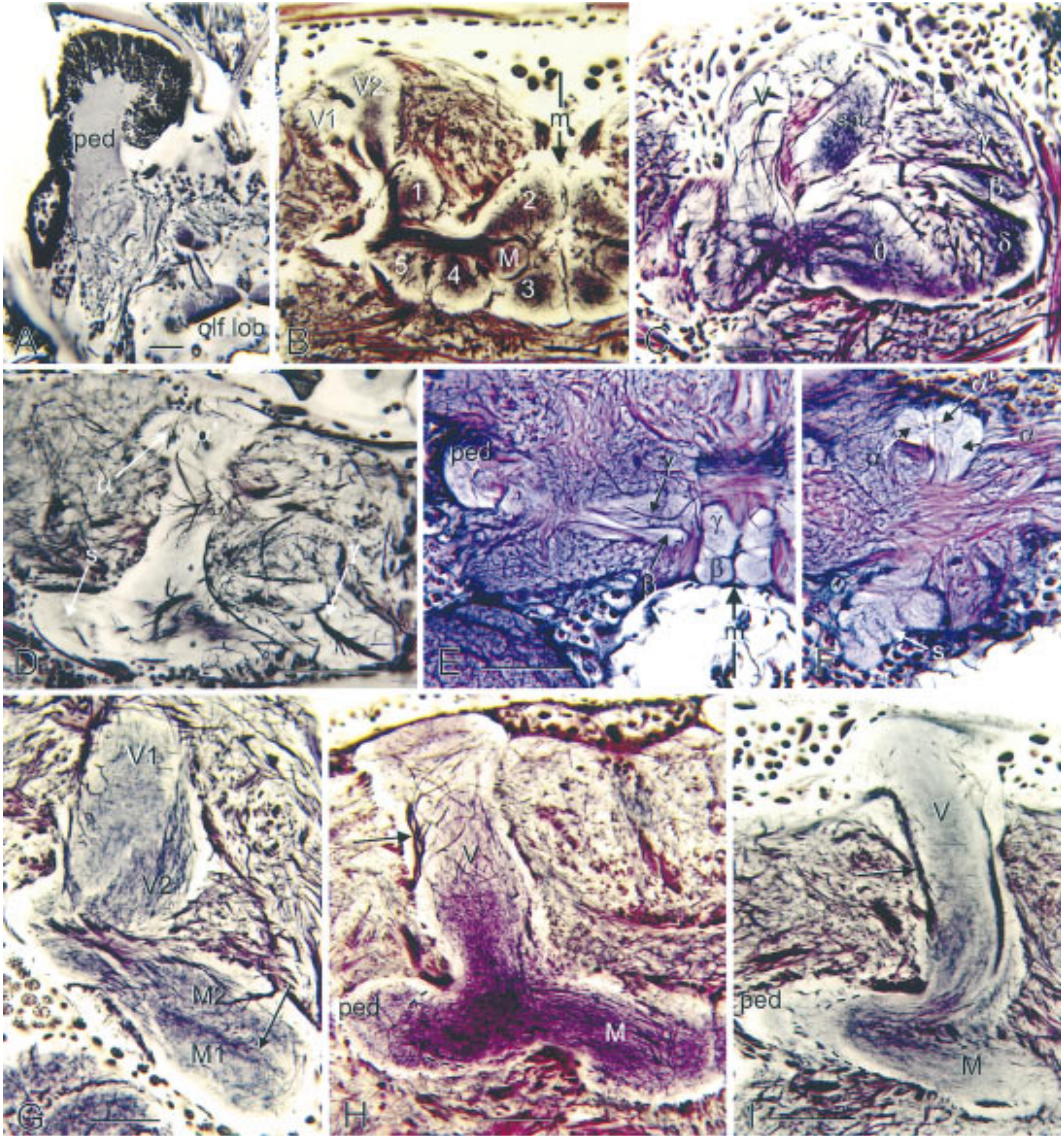




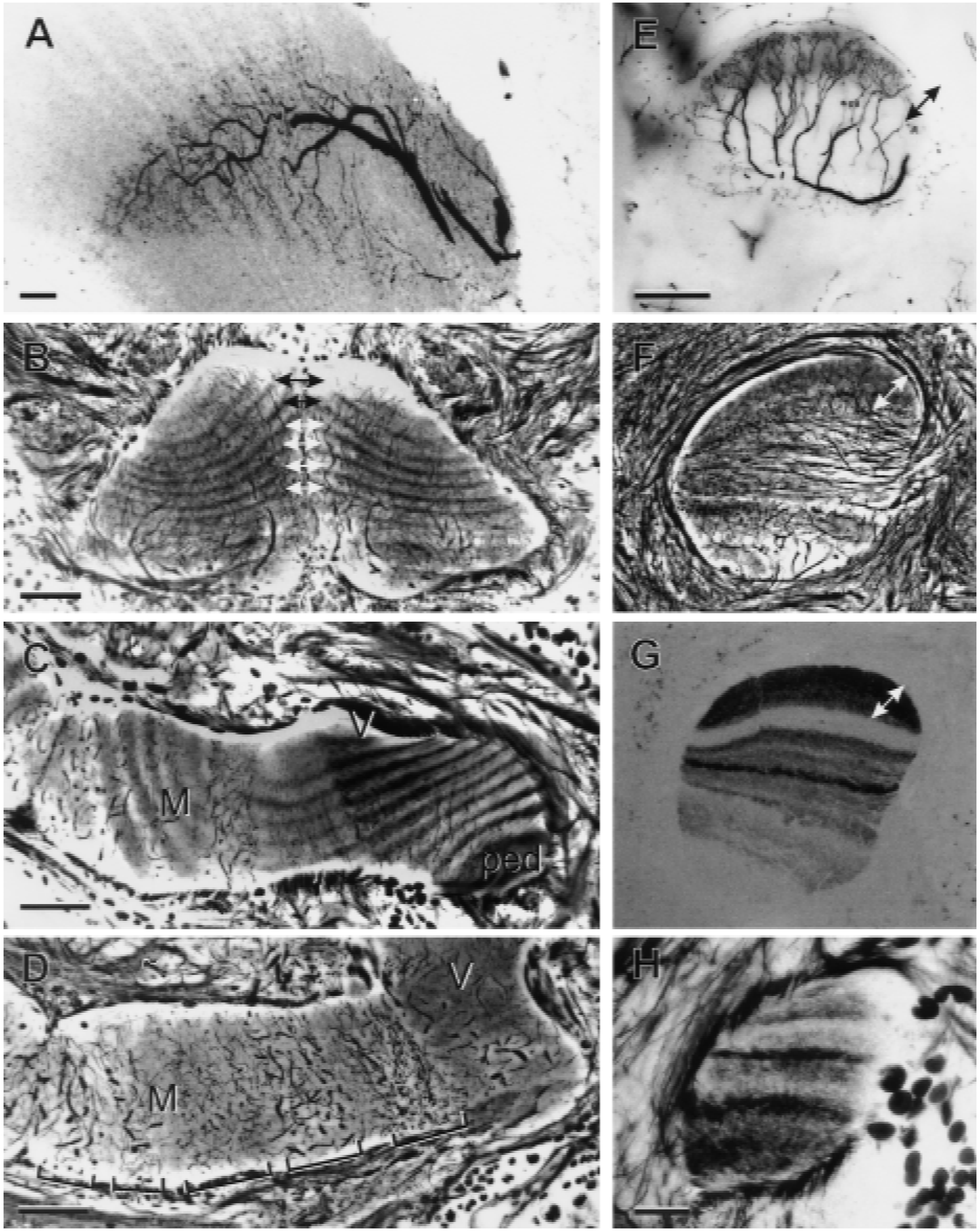
Brain and suboesophageal ganglion with associated organs, dorsal view. call: corpora allata, **cbo:** central body, **ccar:** corpora cardiaca, **ce:** compound eye, **chia:** chiasmata, **com1/2:** 1st/2nd commissure, **cped:** corpora pedunculata, **fggl:** frontal ganglion, **lggl:** lamina ganglionaris, **lob:** lobula, **lopt:** lobus opticus, **med:** medulla, **nant:** nervus antennalis, **nlab:** nervus labialis, **nmd:** nervus mandibularis, **nmx:** nervus maxillaris, **noc:** ocellar nerve, **nrec:** nervus recurrens, **nsec:** neurosecretory cells, **olfl:** olfactory lobe, **pcbr:** protocerebral bridge, **soes:** suboesophageal ganglion, **trcom:** tritocerebral commissure, **vggl:** ventricular ganglion.



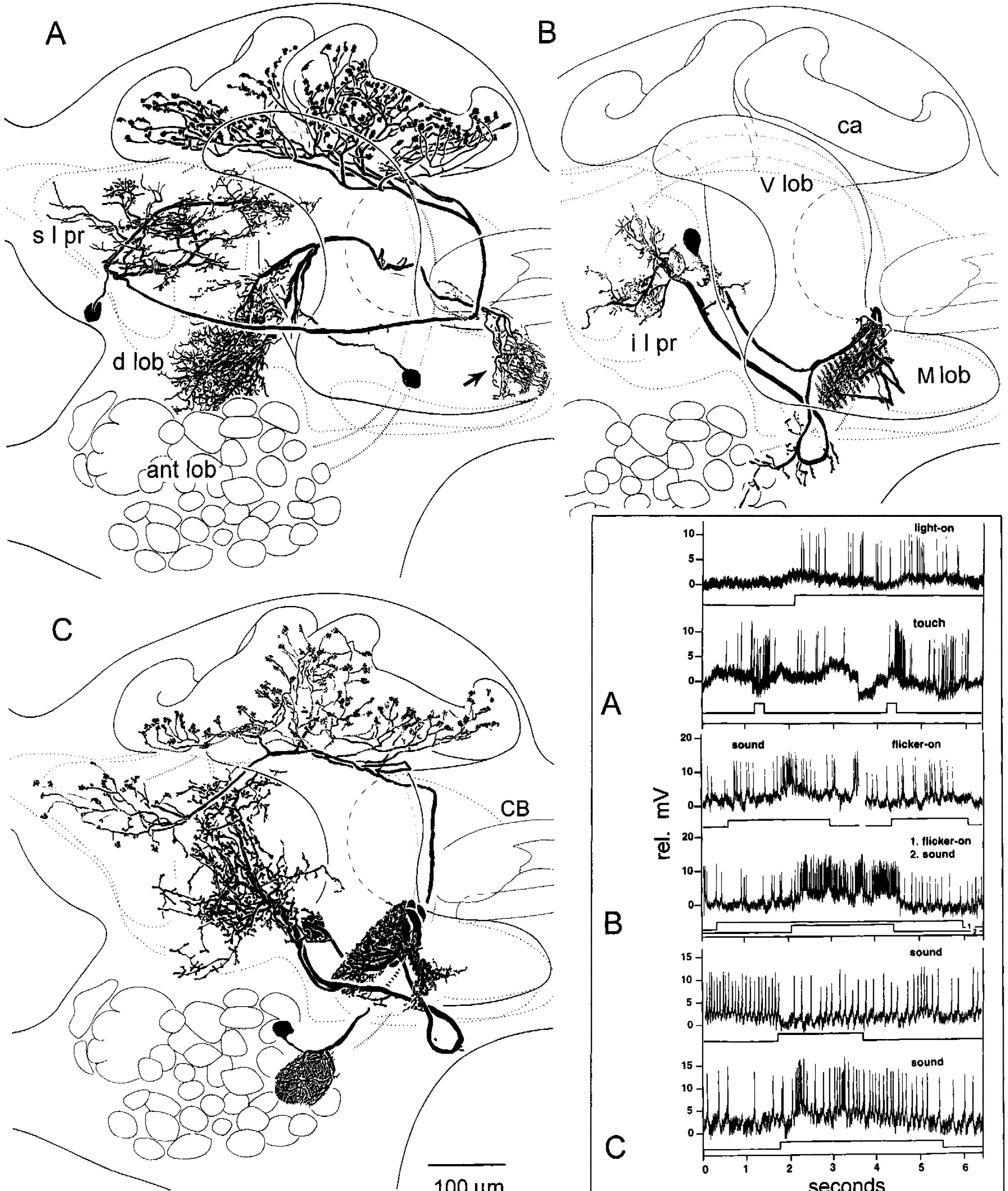
Brain and suboesophageal ganglion with associated organs, lateral view. aor: aorta, **call:** corpora allata, **ccar:** corpora cardiaca, **circ:** circumoesophageal connective, **dcer:** deutocerebrum, **fcon:** frontal connective, **fggl:** frontal ganglion, **hyggl:** hypocerebral ganglion, **ingl:** ingluvies, **lopt:** lobus opticus, **nant:** nervus antennalis, **ncon:** nervus connectivus, **nfro:** nervus frontalis, **nlbr:** nervus labralis, **nlb:** nervus labialis, **nmd:** nervus mandibularis, **nmx:** nervus maxillaris, **nrec:** nervus recurrens, **nsec:** neurosecretory cells, **pcer:** protocerebrum, **ph:** pharynx, **soes:** suboesophageal ganglion, **tcer:** tritocerebrum, **trcom:** tritocerebral commissure, **vggl:** ventricular ganglion.



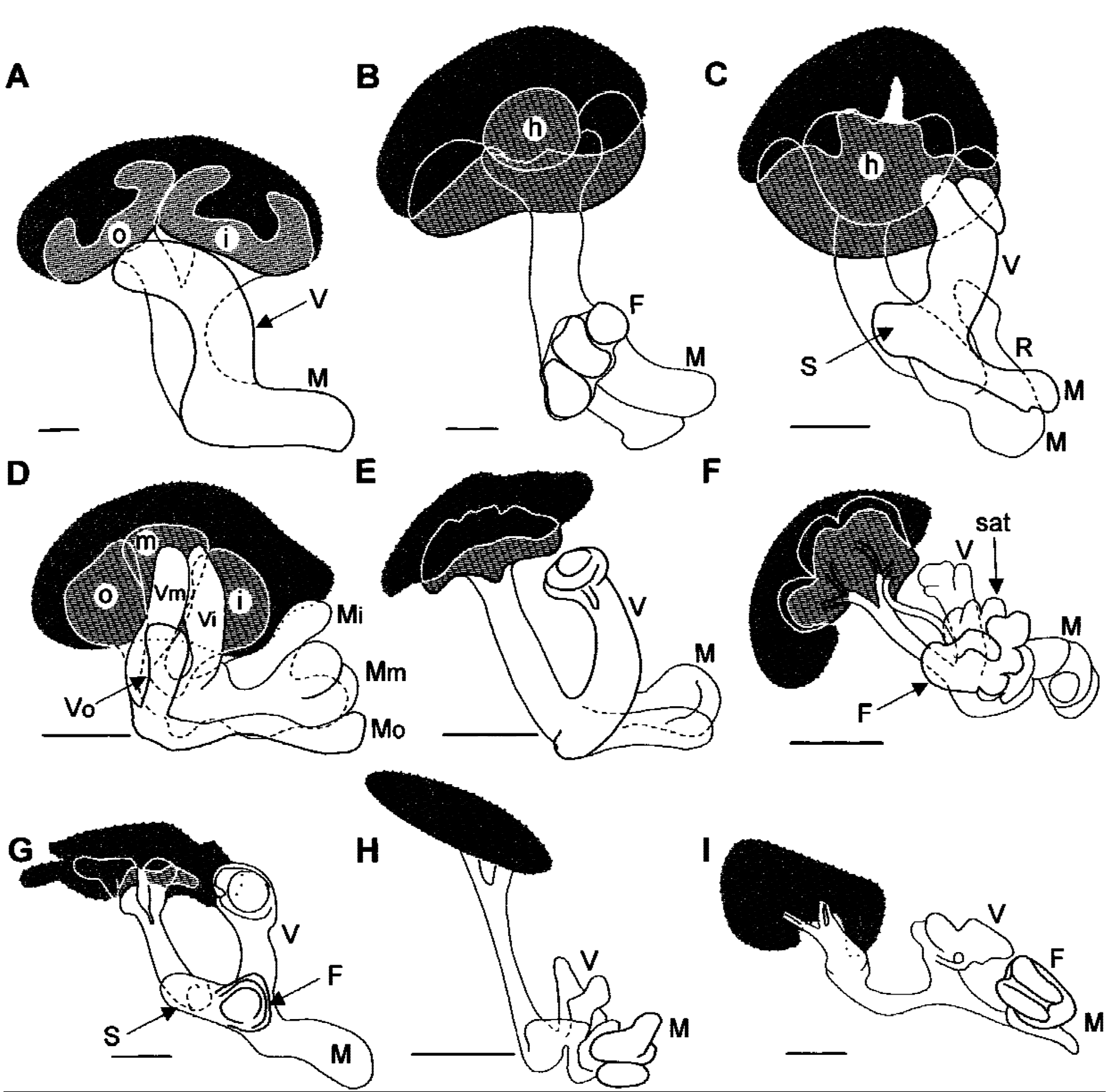
Mushroom body lobes of an annelid compared with those of insects. (A) Mushroom body of the scale worm *Arctenöe vittata* has its pedunculus (ped) capped by many thousands of globuli cells. Its pedunculus and single lobe receive inputs from the olfactory lobe (olf lob). (B) Apterygote *Thermobia* (firebrat) has a divided vertical lobe (V1, V2) and five glomerular medial lobes (1–5) flanking a smaller lobe in the middle (M). (C) Medial lobes of the hummingbird moth *Hemaris thisbe* are elaborately subdivided with the lobe, lying alongside the vertical lobe (V). Like in other Lepidoptera, the medial lobe is subdivided into many components, with satellite neuropil (sat) provided by a small bundle of Kenyon cell axons (not in plane of section). (D) Medial lobe of the fleshfly *Sarcophaga carnaria*, like *Drosophila*, does not show obvious division into separated and components. (E,F) In the horsefly *Tabanus*, the medial lobes show complete terminal separation of the and components and the vertical lobe F is deeply divided into two components (and). The spur (s) is an outgrowth of the junction of the pedunculus with the vertical and medial lobes. In this tabanid, the spur is divided into three components. (G) Vertical and medial lobes of the tettigonid *Scudderia furcata*, like those of many other orthopterans, show striking longitudinal zonations. A dense band of Kenyon cells (arrow) is flanked by two parallel divisions M1, M2, corresponding to V1, V2 of the vertical lobe. (H,I) Vertical (V) and medial lobes (M) of a predatory tiger beetle (H, Cicindelidae) are proportionally as large as those of the water beetle *Dytiscus marginalis* (I), although the latter has a greatly reduced calyx. Note the extrinsic neuron axons (arrow) leaving the distal end of the vertical lobe. The pedunculus (ped) of each is sectioned obliquely to show two parallel divisions (broken lines in H, I) comprising thick and thin Kenyon cell axons. Scales in A, G, H, I, 50 µm; scales in B–F, 100 µm. The midline in B and F is indicated by an arrow (m).



Internal organization of the mushroom bodies in hemi- and holometabolous insects (*Periplaneta*; A–D,H and *Apis*; E–G). (A) Laminar organization of efferent neuron dendrites matches Kenyon cell laminae. (B) Oblique sections through the tips of the left and right medial lobes reveal the alternating pale and dark Kenyon cell laminae, which, in any individual, are symmetrical about the midline (double arrows). (C) Oblique section, through the base of the pedunculus (ped), the origin of the vertical lobe (V), and the medial lobe (M) shows the unbroken continuity of Kenyon cell laminae. Profiles at right angles to the laminae belong to efferent dendrites arranged as palisades, as shown in frontal sections (bracketed in D). (E) In honeybees (*Apis mellifera*), processes of extrinsic neurons invade specific laminae. The equivalent levels in E–G are indicated by double-headed arrows. In Apis, Kenyon cell laminae are of unequal width (F) and have different affinities to antibodies raised against peptides (e.g., anti-gastrin staining, shown in G). (H) Immature fourth instar pedunculus of *Periplaneta* showing laminae of unequal width and different staining affinities, reminiscent of the adult honeybee. Scale bars in A, 20 μm; B–G, 50 μm; H, 10 μm.



Multimodal and context-modified responses in the efferent neurons of *Periplaneta* mushroom bodies relate to afferent identities. (A) In addition to their supply from the antennal lobes (ant lob; shown in C), the calyces (ca) are supplied by afferent neurons originating in superior lateral protocerebrum (s l pr) and responding to nonolfactory modalities (visual and tactile; top traces, inset A). Another afferent is shown originating in the dorsal lobes (d lob) and terminating at the tip of the medial lobe (arrow). (B) Combinations are more effective than unimodal stimuli in eliciting a response from this efferent neuron linking the medial lobe to the inferior lateral protocerebrum (i l pr). There is no response to light ON, a weak response to acoustic stimulation, and vigorous activation by both combined (inset B). (C) An efferent neuron from the medial lobe to the inferior medial protocerebrum was inhibited by acoustic stimuli after presentation of visual and olfactory cues (top trace, inset C) but excited by sound after flicker and tactile cues (lower trace, inset C).



Mushroom body variation in insects. Organization of globuli cell groups (dotted outline enclosing dark gray areas), calyces (light gray), pedunculi and lobes (open profiles) in odorant-sensitive (A–F) and anosmic (G–I) insects.

A) *Periplaneta americana* (Blattodea);
B) *Barytettix psolus* (Acrididae);
C) *Acheta domesticus* (Acrididae);
D) *Labidura riparia* (Dermaptera);
E) *Calosoma scrutator* (Coleoptera);
F) *Huebnerniana trifolii* (Lepidoptera);
G) *Dytiscus marginalis* (Coleoptera);
H) *Notonecta undulata* (Hemiptera);
I) *Argia* sp. (Odonata).

In some species, the calyx is divided into inner, middle, and outer components (i, m, o); (V,M,F,R) vertical, medial, frontal, and recurrent lobes (in some species, lobe subdivisions represent inner, middle, and outer calyces); (S) spur. sat, satellite neuropil. Scale bars, 100 µm.

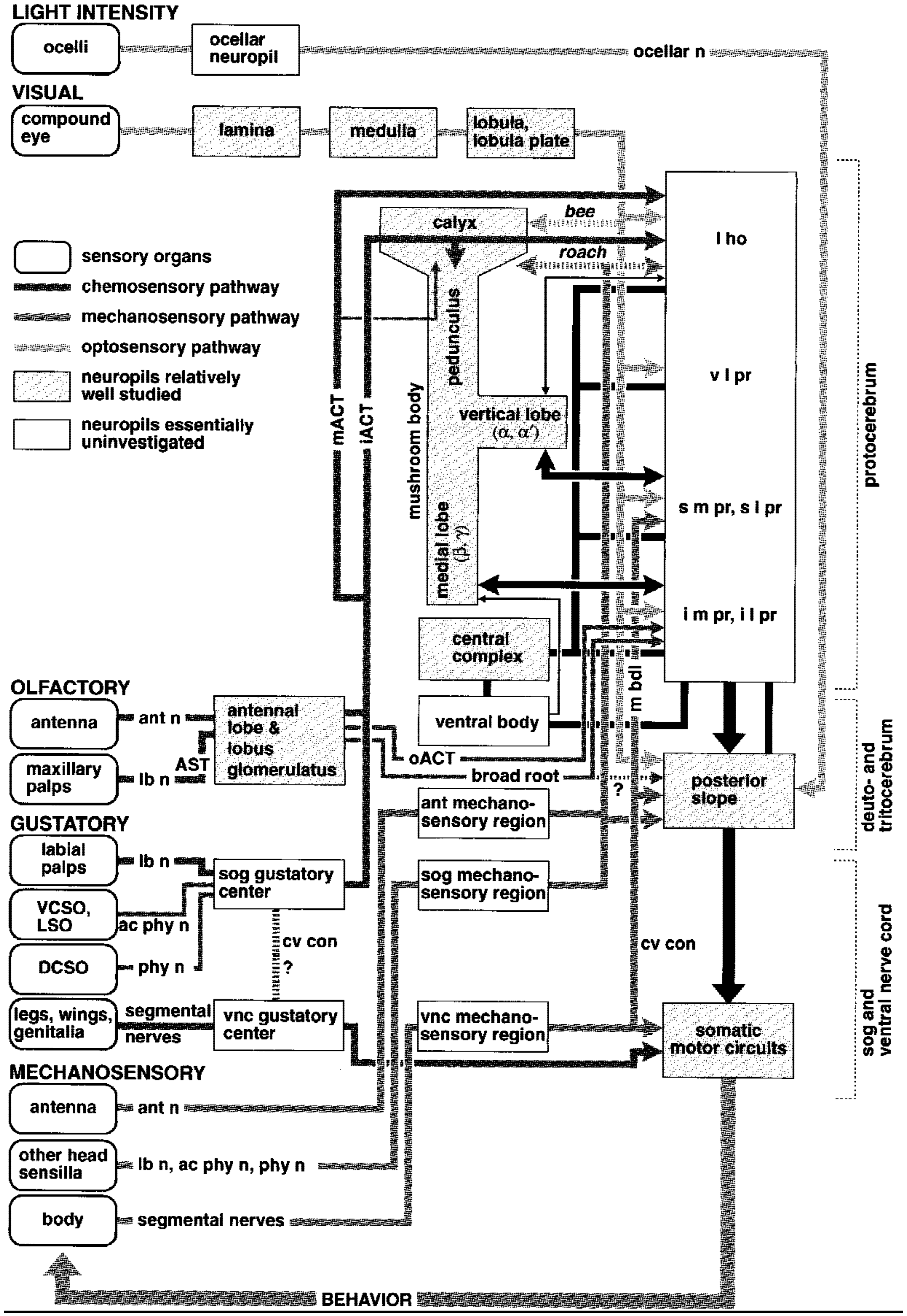
Surface-tessellated reconstructions of mushroom bodies.

A) Primitive calyxless condition in the silverfish *Lepisma*.

B) Single calyx in *Schistocerca* (locust)

C) Double calyces of the honeybee, *Apis mellifera*.

(cb) Globuli cell bodies; (V,M) vertical and medial lobes, respectively.



Relationships between the mushroom body and other parts of the nervous system. (Round-cornered boxes) Sensory organs grouped according to modality. (Shaded boxes) Neuropil regions relatively well investigated. (White boxes) Regions essentially uninvestigated. (Thick shaded lines) Major tracts connecting neuropil regions. (Arrows) Supposed direction of information (omitted where evidence for polarity is lacking).

BRAIN

The brain is the principal association center of the body, receiving sensory input from the sense organs of the head and, via ascending interneurons, from the more posterior ganglia. Motor neurons to the antennal muscles are also present in the brain, but the majority of nerve cell bodies found here belong to interneurons and the bulk of its mass is composed of their fibers. Many of the interneurons are concerned with the integration of activities; others extend down the nerve cord to the more posterior ganglia, transmitting information that controls the insect's behavior from the brain.

Three regions are recognized in the brain, the protocerebrum, deutocerebrum and tritocerebrum.

The protocerebrum is bilobed and is continuous laterally with the optic lobes. In hypognathous insects it occupies a dorsal position in the head and, as with other ganglia, the somata are largely restricted to a peripheral zone while the central region is occupied by neuropil. Anterodorsally, in a region called the pars intercerebralis, a group of somata occurs on either side of the midline. Also within the pars intercerebralis are neurosecretory cells, the axons of which decussate (cross over each other to the opposite side) within the brain and extend to the corpora cardiaca.

At the sides of the pars intercerebralis are the mushroom bodies, or corpora pedunculata. Each consists of a flattened cap of neuropil, the calyx, from which a stalk (peduncle) runs ventrally before dividing into two or sometimes three lobes, known as the alfa, beta and gamma lobes. The mushroom bodies are given their form by a large number of interneurons, called Kenyon cells, that have their somata above the calyx. The relative size of the corpora pedunculata is related to the complexity of behavior shown by the insects. They are small in Collembola, Heteroptera, Diptera and Odonata, of medium size in Coleoptera, Orthoptera, Blattodea, Lepidoptera and sawflies, and most highly developed in social insects.

Changes occur in the mushroom bodies with age and experience. Over the first week of adult life, the number of fibers in the mushroom bodies of *Drosophila* increases by more than 20% and is then maintained at a plateau until the flies are very old. These changes are reflected in an increase in volume of the calyx and probably result from an increase in the number of Kenyon cells. Changes also occur in the overall size of the mushroom bodies over the first ten days of life of worker honeybees.

In all insects, the mushroom bodies receive input from neurons carrying information from the antennal lobes. Within the calyx, each of these neurons communicates with a large number of Kenyon cells. The mushroom bodies are involved in olfactory, and, perhaps, in some insects, visual learning.

The optic lobes are lateral extensions of the protocerebrum to the compound eyes. Each consists of three neuropil masses, known as the lamina, the medulla and the lobula complex which, in Lepidoptera, Trichoptera and Diptera, is subdivided into the lobula and the lobula plate. Within these masses, the arrangements of arborizations of different sets of neurons produce a layered appearance. Between successive neuropils the fibers cross over horizontally forming the outer and inner optic chiasmata so that the neural map of the visual image is reversed and then re-reversed.

In the lamina of most insects, the axons of retinula cells from one ommatidium remain together and are associated with neurons originating in the lamina and the medulla to form a cartridge. In insects with an open rhabdom, however, each cartridge contains the axons from retinula cells with the same field of view rather than from the same ommatidium. In either case, the number of cartridges in the lamina is the same as the number of ommatidia.

The deutocerebrum contains the antennal (olfactory) lobes and the antennal mechanosensory and motor center. The latter is a relatively poorly defined region of neuropil containing the terminal arborizations of mechanosensory neurons from the scape and pedicel, and perhaps also from the flagellum of the antenna. It also contains dendritic arborizations of the motor neurons controlling the antennal muscles.

The antennal lobes are regions of neuropil, one in relation to each antenna, within which are discrete balls of dense synaptic neuropil which in some insects are surrounded by a layer of glial cells. These structures are called glomeruli. Axons from olfactory sensilla on the antenna terminate in the glomeruli, and each axon only goes to one glomerulus. Within a species, individual glomeruli appear to be constant in form and position. This is most obvious in the males of many Lepidoptera and of Periplaneta, insects that are attracted to females by pheromones, where two or three larger glomeruli are grouped together forming a macroglomerular complex to which the axons of sex pheromone-specific neurons converge. The axons from olfactory receptors on the maxillary and labial palps also terminate in a glomerulus which, at least in *Manduca*, does not receive inputs from the antennae.

The tritocerebrum is a small part of the brain consisting of a pair of lobes beneath the deutocerebrum. From it, the circumesophageal connectives pass to the subesophageal ganglion, and the tritocerebral lobes of either side are connected by a commissure passing behind the esophagus. Anteriorly, nerves containing sensory and motor elements connect with the frontal ganglion and the labrum.

Endocrine organs and the hormone system

The endocrine system of hexapods is well-developed even though less complex than in vertebrates. Hormones are substances produced by endocrine glands, by neurosecretory cells, or by neurohaemal organs. They are transported to other body regions by blood or haemolymph where they can have different physiological effects, in hexapods mainly related to development and molting, but also to other important body functions.

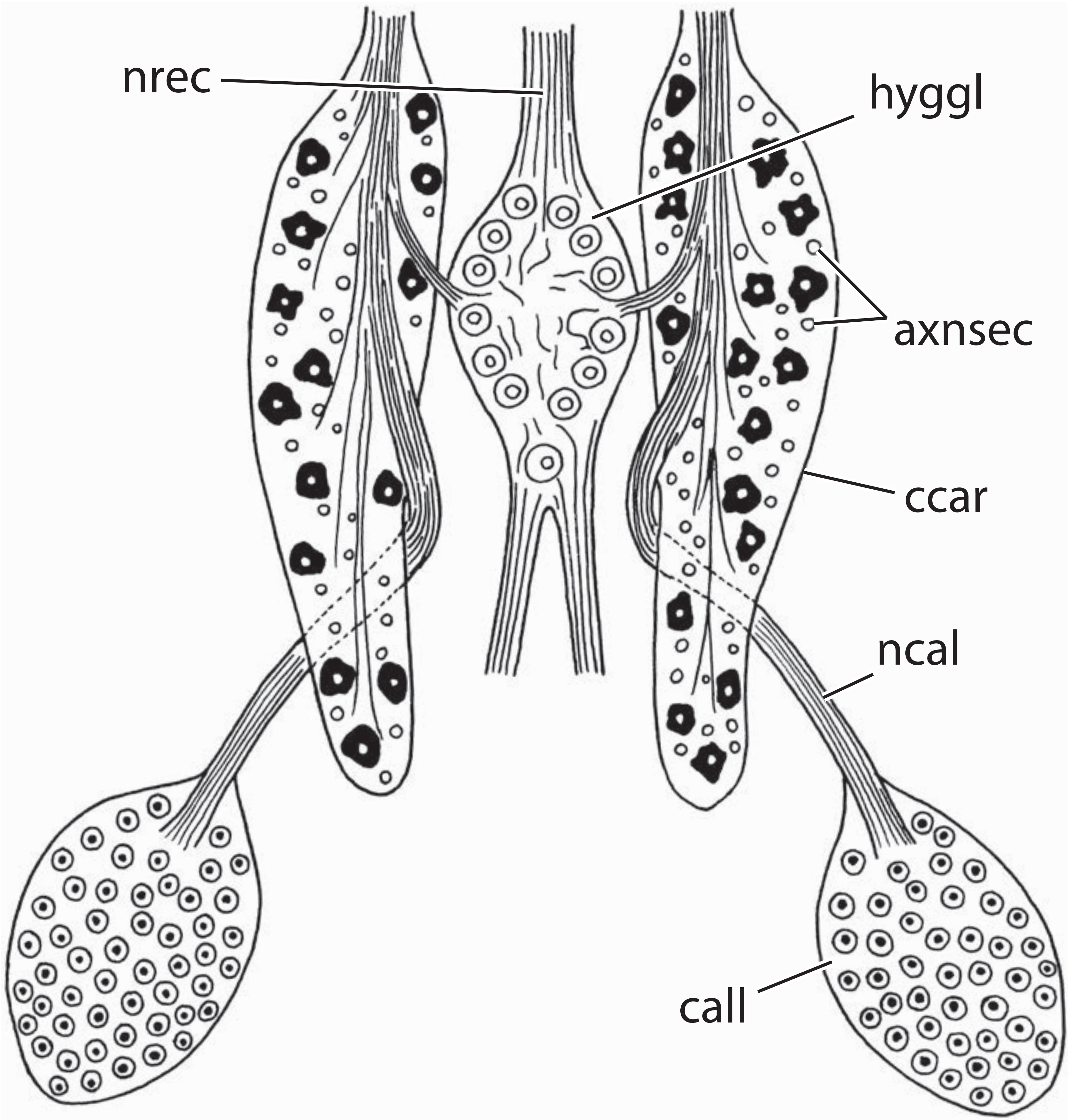
Groups of neurosecretory cells (Nc) of the brain are important elements of the endocrine systems. The Nc are characterized by numerous grana (ca. 100–400 nm), an unusually high content of rough endoplasmatic reticulum, and extended terminal vesicles of the axons, where grana are stored. They can release their secretions directly at the perikaryon or via the axon. Lateral protocerebral Nc produce the prothoracicotropic hormone (PTTH) and the group in the pars intercerbralis of the protocerebrum the neurohormone D (synonyms: Pea-CAH I, myotropin I). The eclosion hormone, which plays an important role in the molting process, is produced by Nc in the tritocerebrum.

Neurohaemal organs are elements of the endocrine system associated with secretory neurons and the haemolymph system. The corpora cardiaca (Cc) and the corpora allata (Ca) are closely connected with the brain, whereas the segmental perisympathetic organs (PSO) are associated with the postcephalic ganglionic chain. The Cc are small organs below the posterior brain region and usually close to the anterior opening of the cephalic aorta. They are primarily paired but fused in few groups. In some cases they are fused with the hypocerebral ganglia and they are ontogenetically derived from these neuronal structures. The Cc receive different neurohormones (e.g., PTTH, neurohormone D) from neurosecretory cells in the brain and store them or deliver them to the haemolymph. They also produce several neurohormones (e.g., adipokinetic hormone) which are involved in the regulation of the water balance and the lipid - and carbohydrate concentration of the haemolymph. The Ca are usually well-defined, small, round or ovoid organs posterior to the brain and the Cc, above the foregut and immediately laterad the cephalic aorta. Ontogenetically they are formed as ectodermal invaginations. They are usually paired but like the Cc medially fused in different groups. Their intrinsic cells produce the juvenile hormone which suppresses the molt to the adult stage and regulates developmental processes. Its secretion is suppressed by allatostatin and stimulated by allatotropin. Both substances are produced by neurosecretory cells in the brain. The perisympathetic organs are located in the postcephalic body and closely linked to the segmental ganglia of the thorax and abdomen. They contain neurosecretory axons ensheathed with glia cells and irregularly scattered gland cells. They produce numerous multifunctional neuropeptides.

The cerebral groups of neurosecretory cells are connected with the Corpora cardiaca (Cc) and Corpora allata (Ca) (see below) by the nervi corporis cardiaci and nervi corporis allati. The nervus corporis cardiacis II extends from the lateral protocerebrum through the Cc and reaches the Ca posteriorly. A short nerve connects the Cc with the hypocerebral ganglion in most groups.

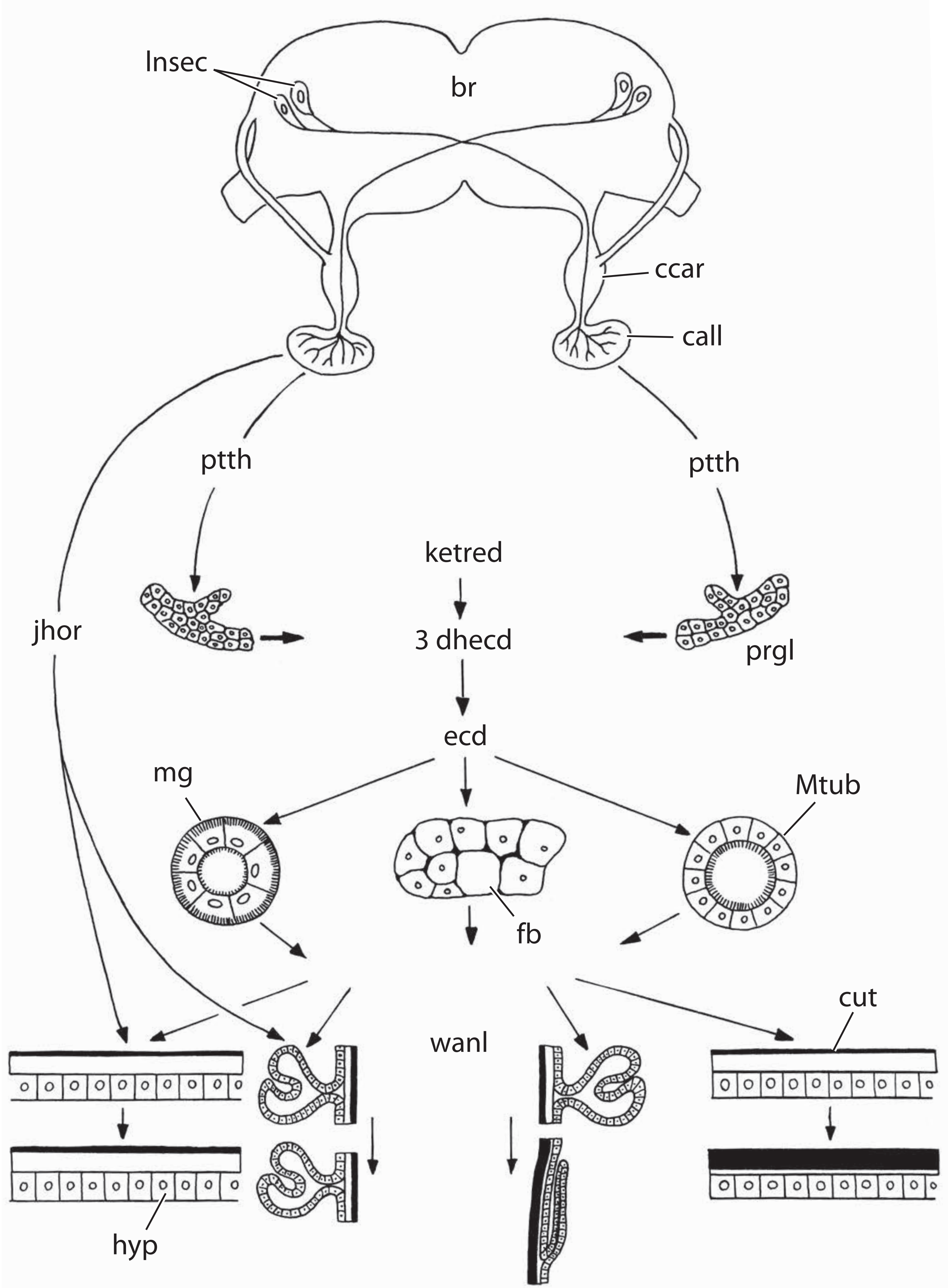
An important element of the endocrine system of immature hexapods is the paired prothoracic gland, which is usually located in the anterior thoracic region, but occasionally also in the posterior region of the head (ventral gland). Ontogenetically it develops in the lateral area of the labial segment. It is usually elongated and branched in some groups. It is formed by rather diffuse tissue and often extends along tracheae or is embedded between fat body lobes. It receives its innervation either from the suboesophageal complex or from the pro- or mesothoracic ganglion. It produces the molting hormone ecdysone, which is later transformed into the active form 20-hydroxy-ecdysone by cells of the fat body, midgut or Malpighian tubules. The prothoracic glands are stimulated by the prothoracicotropic hormone (PTTH), which is produced by neurosecretory cells in the brain (see above). They degenerate after the adult stage is reached. At least in some adult hexapods, production of small amounts of ecdysone takes place in the ovaries and testes, respectively.

Hormone producing cells interspersed between digestive cells of the midgut are referred to as the diffuse endocrine system. They produce peptide hormones also occurring in vertebrates, as for instance gastrin, insulin, glucagon, vasopressin or β-endorphin. However, the functions of these substances in hexapods are still unknown.



Neurohaemal organs.

axnsec: axon of neurosecretory cells,
call: corpora allata,
ccar: corpora cardiaca,
hyggl: hypocerebral ganglion,
ncal: nervus corporis allati,
nrec: nervus recurrens



Hormononal control of molting and metamorphosis in *Manduca sexta* (Lepidoptera, Sphingidae).
br: brain,
3dhecd: 3 dehydroxy ecdysone,
ecd: ecdysone,
call: corpora allata,
ccar: corpora cardiaca,
cut: cuticle,
fb: fat body,
hyp: hypodermis,
jhor: juvenile hormone,
ketred: ketoreductase,
Insec: lateral neuroscereetoric cells,
mg: midgut,
Mtub: Malpighian tubules,
prgl: prothoracic gland,
ptth: prothroacotropic hormone,
wanl: wing buds

Peptide family	Abbreviation	Function/activity
1 Adipokinetic hormone	AKH	Mobilize stored lipids and/or carbohydrates; inhibit protein synthesis; modulate immune reactions; stimulate visceral muscle
2 Adipokinetic hormone/corazonin-related peptide	ACP	Unknown
3 FGLa-related allatostatin	FGLa/AST	Inhibit JH biosynthesis; inhibit visceral muscle activity; regulate food intake
4 PISCF-related allatostatin	PISCF/AST	Inhibit JH biosynthesis; inhibit visceral muscle activity; regulate food intake
5 Allatotropin	AT	Promote JH biosynthesis; inhibit ion transport in gut; stimulate visceral muscle activity
6 Arginine-vasopressin-like peptide	AVLP	Diuretic (but acts indirectly on Malpighian tubules)
7 Bursicon (a and b subunits)		Promote cuticle tanning; cuticle plasticization
8 Calcitonin-like diuretic hormone	CT-like DH (CT/DH)	Diuretic (acts directly on Malpighian tubules)
9 Cardioacceleratory peptide 2b	CAP2b	Cardioaccelatory; diuretic and antidiuretic (acts directly on Malpighian tubules)
10 Corazonin	CRZ	Cardioaccelatory; initiate ecdysis; phase transition in locusts
11 Corticotropin releasing factor (CRF)-related diuretic hormone	CRF-related DH (CRF/DH)	Diuretic (acts directly on Malpighian tubules)
12 Crustacean cardioactive peptide	CCAP	Specific CNS neuromodulatory role in ecdysis behavior; stimulate visceral muscle activity; stimulate AKH release; diuretic
13 Ecdysis-triggering hormone and pre-ecdysis-triggering hormone	ETH and PETH	Initiate pre-ecdysis and ecdysis behavior; promote release of EH
14 Eclosion hormone	EH	Promote ETH release; cuticle plasticization
15 FMRFamide-like peptide	FaLP	Stimulate visceral muscle activity; inhibit ecdysteroidogenesis
16 Insulin-related peptide	IRP	Regulate cellular processes involved in metabolism, growth and reproduction; stimulate ecdysteroidogenesis
17 Crustacean hyperglycaemic hormone- (chh)-related ion transport peptide	CHH-related ITP (CHH/ITP)	Stimulate ion and water transport in ileum
18 Kinins	K	Stimulate visceral muscle activity; regulate meal size
19 Myoinhibitory peptide	MIP	Inhibit JH biosynthesis; inhibit visceral muscle activity; inhibit ecdysteroidogenesis
20 Myosuppressin	MS	Inhibit visceral muscle activity; diuretic (acts directly on Malpighian tubules); regulate food intake; inhibit ecdysteroidogenesis
21 Neuroparsin	NP	Uncertain; may be involved in female reproductive cycles
22 Neuropeptide F	NPF	Stimulate feeding
23 Orcokinin	OK	Light entrainment of circadian clock
24 Pigment dispersing factor	PDF	Output of circadian clock
25 Proctolin		Modulate visceral and skeletal muscle activity
26 Prothoracicotropic hormone	PTTH	Stimulate ecdysteroidogenes
27 Pyrokinin/diapause hormone/ pheromone biosynthesis activating neuropeptide (= melanization and reddish coloration hormone)	PK, PK-related DH (PK/DH), PBAN (PK/ PBAN)	Stimulate visceral muscle activity; promote diapause; promote pheromone biosynthesis; initiate cuticle melanization
28 Sex peptide	SP	Male accessory gland secretions; modulate female sexual behavior
29 Short neuropeptide F	sNPF	Control food intake and body size; inhibit JH biosynthesis
30 SIFamide	SIFa	Modulate sexual behavior
31 SulfaKinin	SK	Stimulate visceral muscle activity
32 Tachykinin-related peptide	TRP	Stimulate visceral muscle activity; stimulate feeding

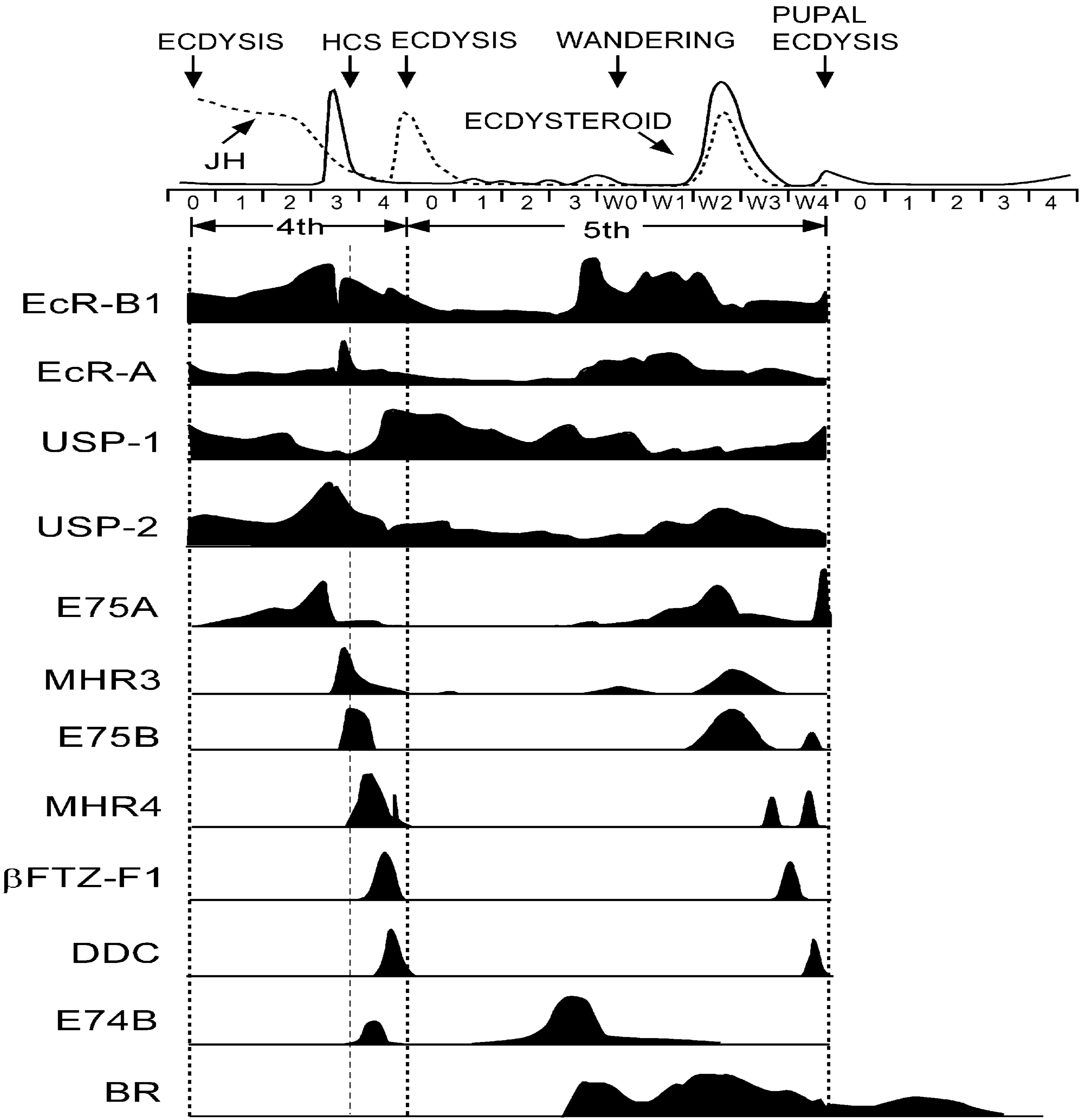
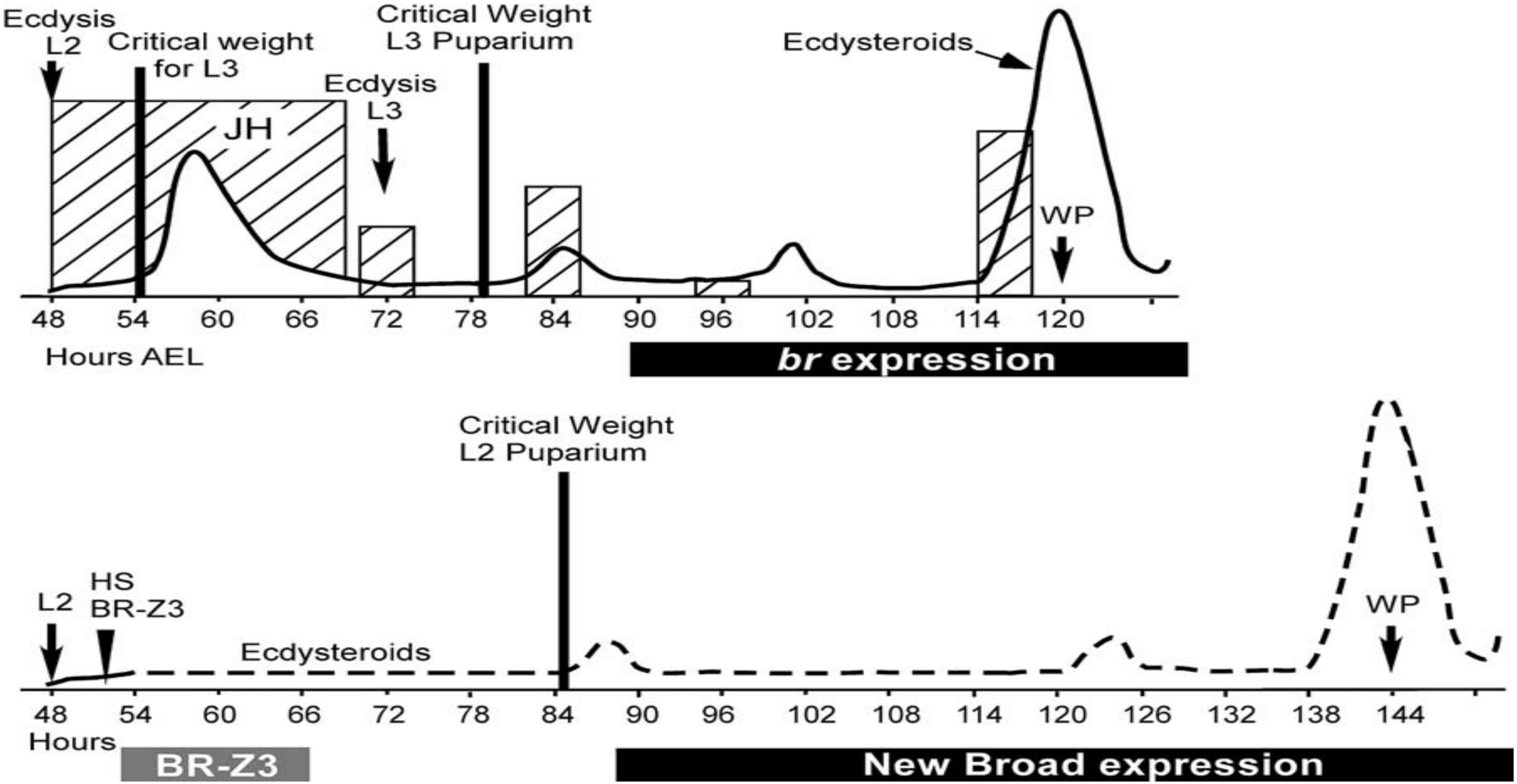


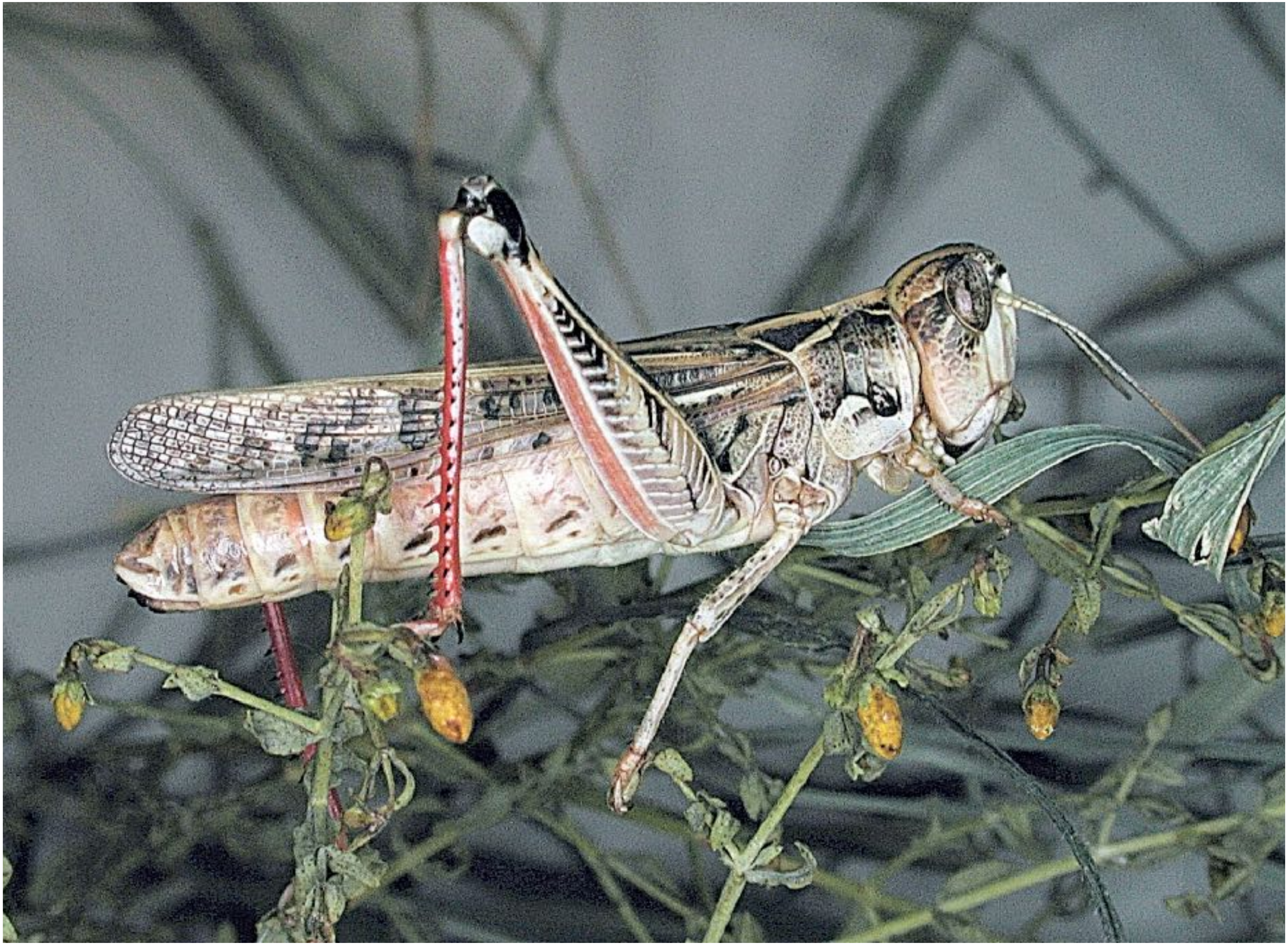
Diagram of the hormone titers and expression of the various ecdysteroid-regulated mRNAs during the **4th** and **5th larval instars and the onset of adult development** of *Manduca sexta*.

Apolysis= physical separation of th old cuticle from Epidermis.
Ecdysis= integuments shedding.



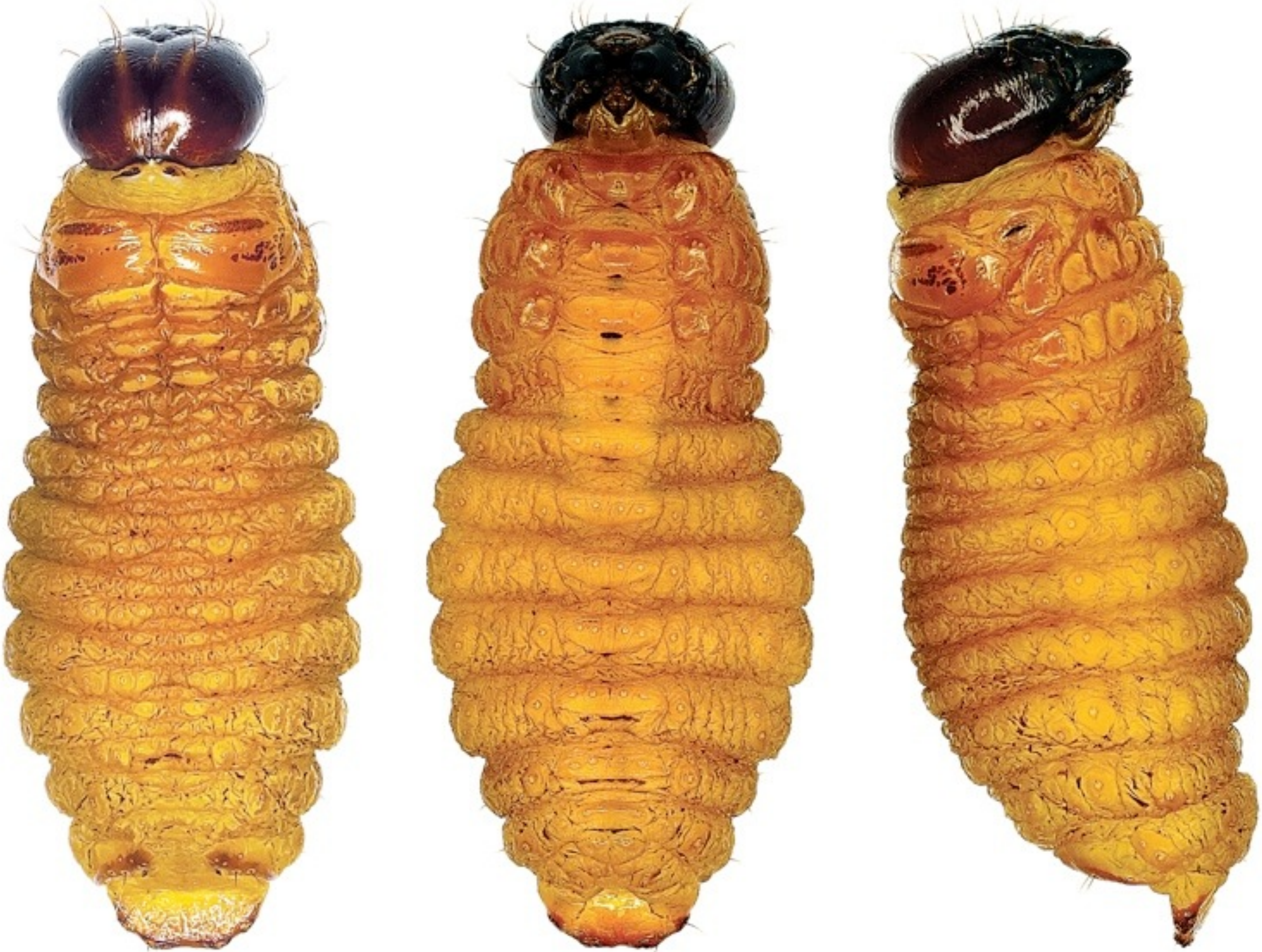
Summary of the hormone titers in *Drosophila melanogaster* and periods when the critical weight is normally attained for molting to the third instar and for formation of the white puparium (WP) (top). The bottom diagram shows the timing of BR-Z3 misexpression protein after heat shock (HS) during the intermolt of the second larval instar to cause the formation of puparia after the second instar. The period of the new BR protein as determined with the Broad core antibody for the formation of the second instar puparium is indicated. **JH**: juvenile hormone; **L2**: second instar larva; **L3**: third instar larva; **WP**: white puparium.

07 Post-embryonic development



Larva, Livadi, Serifos, Greece, May 11, 2015 (Photo by Paolo Mazzei), www.leps.it

Adult, Vivaro (Roma), Italy, July 15, 2006 (Photo by Paolo Mazzei) www.leps.it



Post-embryonic development is divided into a series of stages, each separated from the next by a molt. The form that the insect assumes between molts is known as an instar, that which follows hatching or the intermediate molt being the first instar, which later molts to the second instar, and so on until at a final molt the adult or imago emerges. No further molts occur once the insect is adult except in Apterygota and non-insect hexapod groups. The periods between molts are called stages, or stadia – for example, first larval stage, second larval stage, and so on – although the term instar is commonly used to refer to this period as well as to the form of the insect during the period.

During larval development there is usually no marked change in body form, each successive instar being similar to the one preceding it, but the degree of change from last instar larva to adult varies considerably and may be very marked. This change is called metamorphosis. In morphological terms, metamorphosis is related to the loss of adaptive features peculiar to the larva, and the extent of change occurring as a reflection of the degree of ecological separation of the larva from the adult. It can also be defined in physiological terms as the change which accompanies a molt in the absence of juvenile hormone. The term metamorphosis is sometimes applied to all the changes occurring in the life history, from egg to adult, but it is better not to use it in this wide sense.

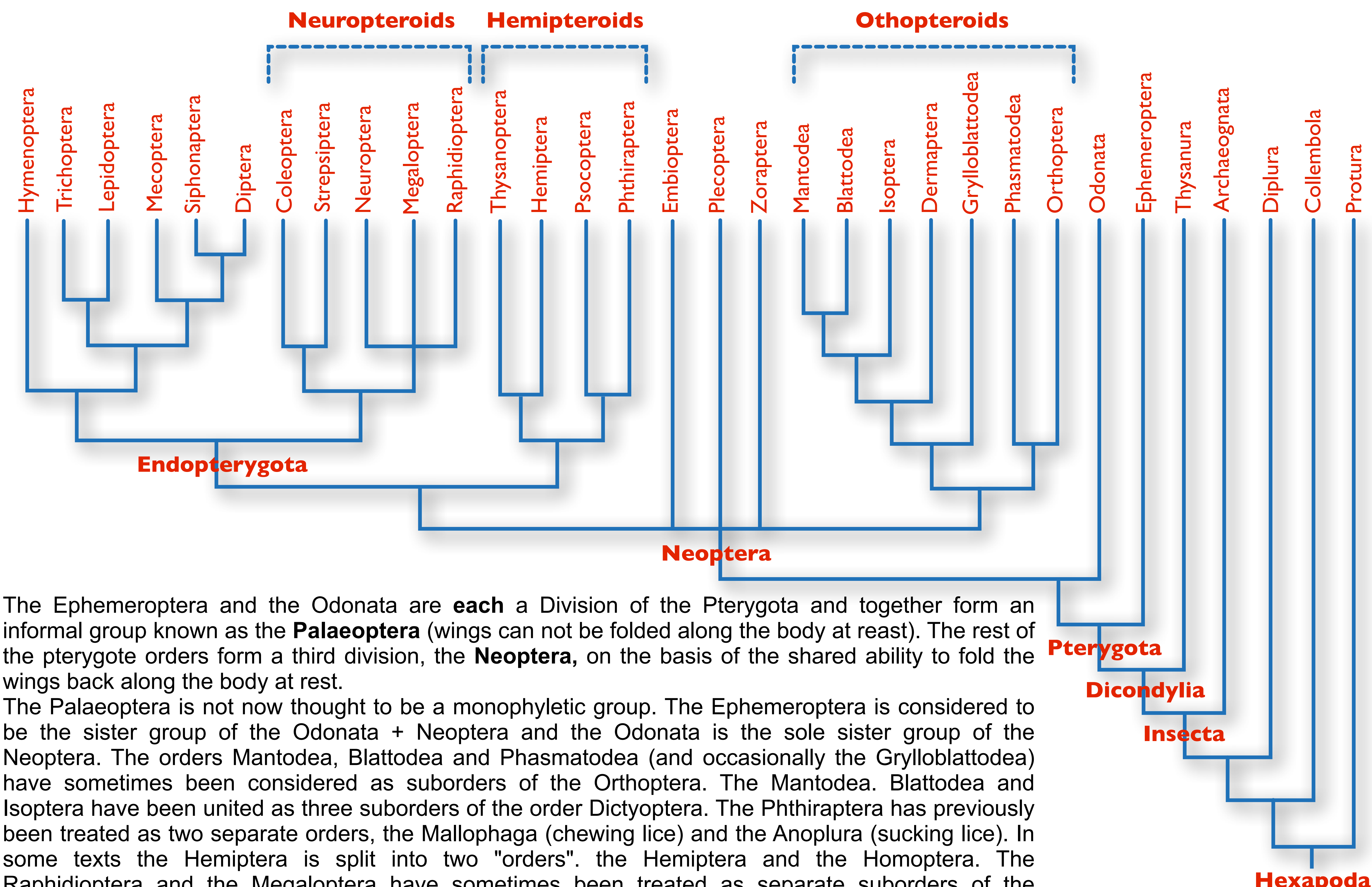
The insects can be grouped in three categories, ametabolous, hemimetabolous or holometabolous, according to the extent of the change at metamorphosis. Ametabolous insects have no metamorphosis, the adult form resulting from a progressive increase in size of the larval form. This is characteristic of the Apterygota and hexapods other than insects in which the larva hatches in a form essentially like the adult apart from its small size and lack of development of genitalia. At each molt the larva grows bigger and the genitalia develop progressively. Adults and larvae live in the same habitat.

In hemimetabolous insects, the larva hatches in a form which generally resembles the adult except for its small size and lack of wings and genitalia, but, in addition, usually with some other features which are characteristic of the larva but which are not present in the adult. At the final molt these features are lost. The Orthoptera, Isoptera, Hemiptera are commonly regarded as hemimetabolous. In holometabolous insects, the larvae are usually quite unlike the adult and a pupal stage is present between the last larval stage and the adult. The pupa is characteristic of holometabolous development, which occurs in all the Neuroptera, Trichoptera, Lepidoptera, Coleoptera, Hymenoptera, Diptera and Siphonaptera.

Amongst the insect groups that typically have a hemimetabolous development, a few have life histories somewhat analogous to those of holometabolous insects. Hemiptera have a typical hemimetabolous development, but in Thysanoptera, which are phylogenetically close to Hemiptera, the last two larval stages do not feed, and the final stage, which is often called a pupa, is sometimes enclosed in a cocoon. Both these stages have external wing pads, but the earlier larval stages have none; instead, some development of the wings occurs internally. Within the Hemiptera, the last two larval stages of male scale insects (Coccoidea) also do not feed. These insects clearly have a life history that can be regarded as holometabolous even though they are phylogenetically far removed from the majority of holometabolous insects.

In whiteflies (Aleyrodidae), the final larval stage feeds for a short period but then has an extended non-feeding period during which the pharate adult develops. This stage is commonly known as a pupa and some texts refer to whitefly development as holometabolous, although there is really no resemblance to the holometabolous development in other groups.

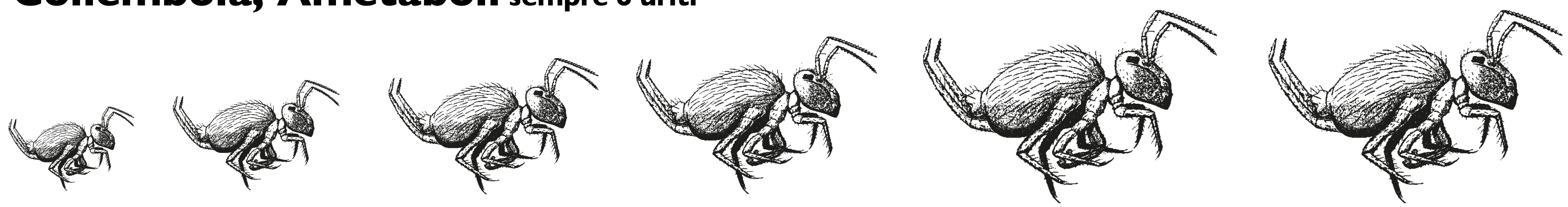
The term 'molt', as commonly used, includes two distinct processes: apolysis, the separation of the epidermis from the existing cuticle; and ecdysis, the casting of the old cuticle after the production of a new one. In the interval between apolysis and ecdysis the insect is said to be pharate. During this time the cuticle of one developmental stage conceals the presence of the next. In most hemimetabolous insects and holometabolous larval stages, the pharate period is relatively short, but it is often extended at the larval/pupal molt and pupal/adult molt (eclosion) and sometimes may be very long.



* The Ephemeroptera and the Odonata are **each** a Division of the Pterygota and together form an informal group known as the **Palaeoptera** (wings can not be folded along the body at reast). The rest of the pterygote orders form a third division, the **Neoptera,** on the basis of the shared ability to fold the wings back along the body at rest.
* The Palaeoptera is not now thought to be a monophyletic group. The Ephemeroptera is considered to be the sister group of the Odonata + Neoptera and the Odonata is the sole sister group of the Neoptera. The orders Mantodea, Blattodea and Phasmatodea (and occasionally the Grylloblattodea) have sometimes been considered as suborders of the Orthoptera. The Mantodea. Blattodea and Isoptera have been united as three suborders of the order Dictyoptera. The Phthiraptera has previously been treated as two separate orders, the Mallophaga (chewing lice) and the Anoplura (sucking lice). In some texts the Hemiptera is split into two "orders". the Hemiptera and the Homoptera. The Raphidioptera and the Megaloptera have sometimes been treated as separate suborders of the Neuroptera. T Recent reserch suggests that the Strepsiptera may be more closely related to the Diptera.

Ametabolia

Collembola, Ametaboli sempre 6 uriti

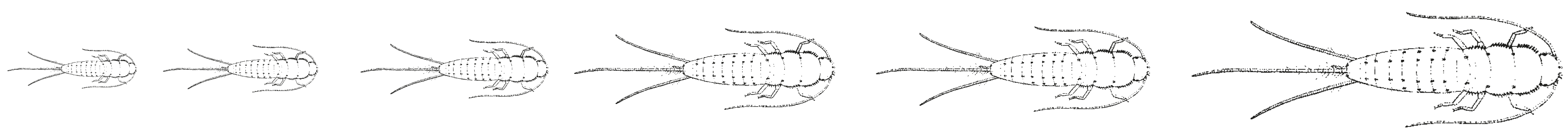


Neanide Neanide Neanide Neanide Adulto Mute post-immaginali

Diplura, Ametaboli

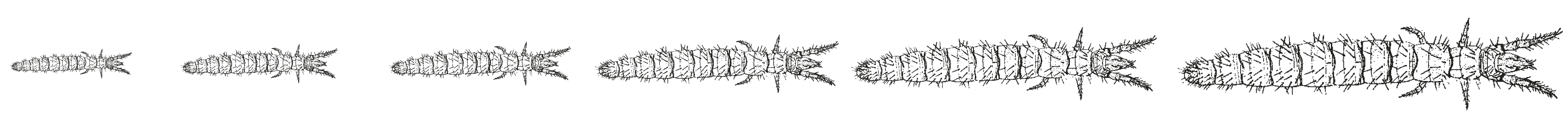
Neanide Neanide Adulto Mute post-immaginali

Tisanura, Ametaboli



Neanide Neanide Neanide Neanide Neanide Adulto

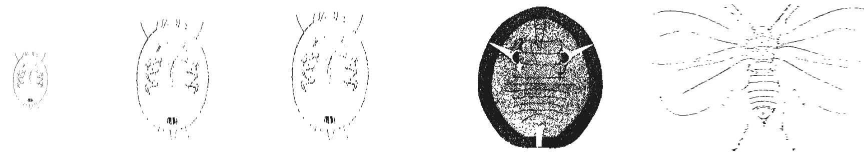
Protura, Anametaboli, Neanide (9 uriti) Adulto (12 uriti) aumento degli uriti da 8+telson a 11+telson



Neanide Neanide Neanide Neanide Neanide Adulto

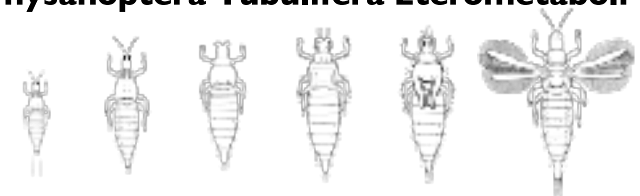
Eterometabolia

Hemiptera Aleyrodoidea Eterometaboli Neometaboli



Neanide I Neanide II Neanide III Pupa nel pupario Adulto

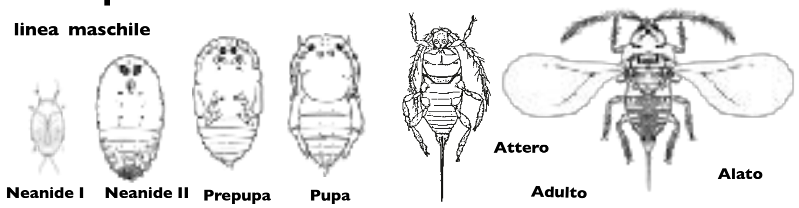
Thysanoptera Tubulifera Eterometaboli Neometaboli



Neanide I Neanide II Prepupa Pupa I Pupa II Adulto

Hemiptera Coccoidea - Eterometaboli Neometaboli

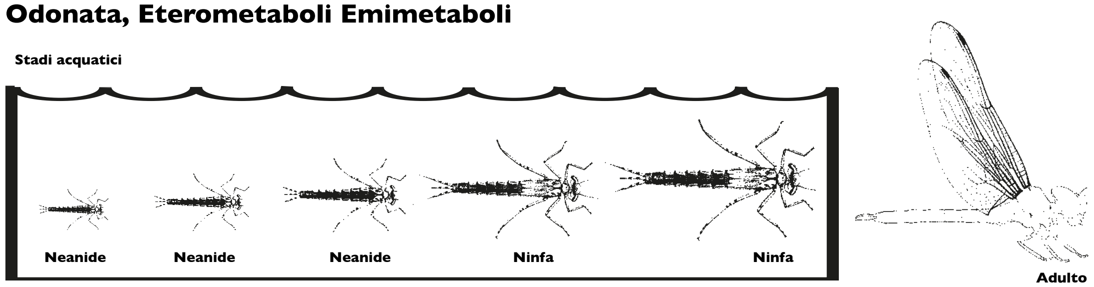
linea maschile



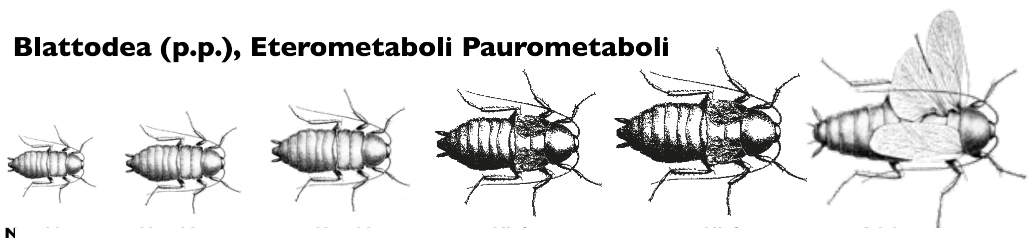
Neanide I Neanide II Prepupa Pupa Adulto

Odonata, Eterometaboli Emimetaboli

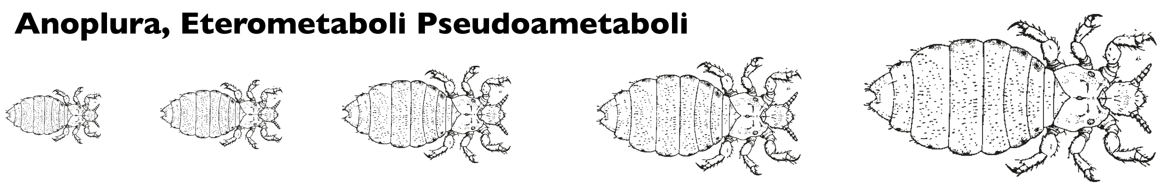
Stadi acquatici



Blattodea (p.p.), Eterometaboli Paurometaboli



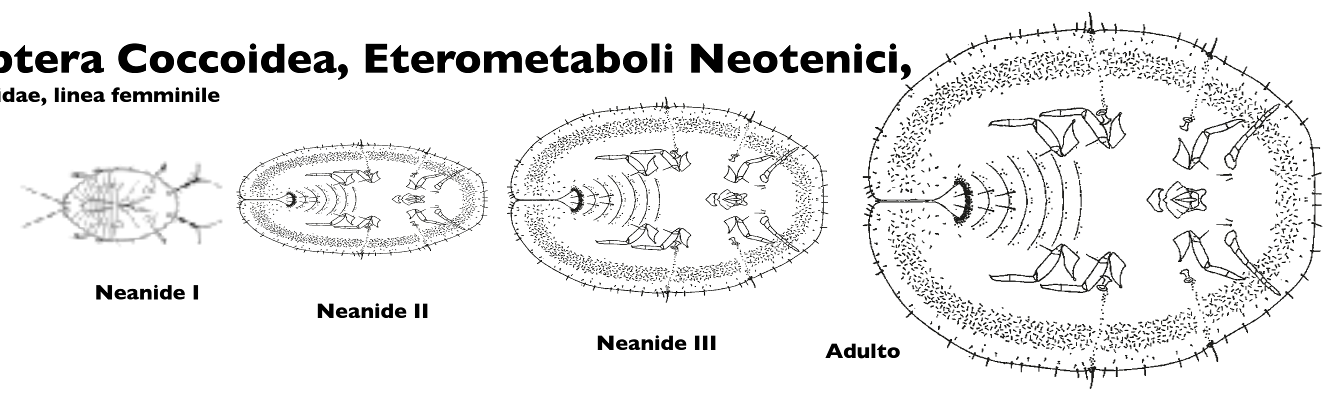
Anoplura, Eterometaboli Pseudoametaboli



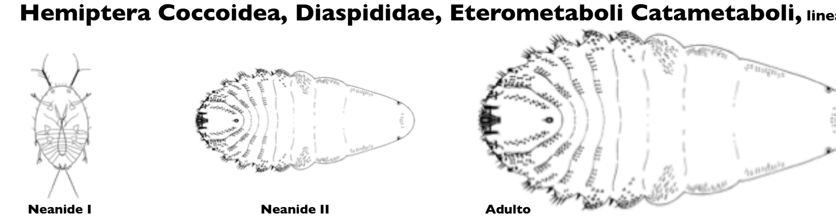
Neanide Neanide Neanide Neanide Adulto

Hemiptera Coccoidea, Eterometaboli Neotenici,

non Diaspididae, linea femminile

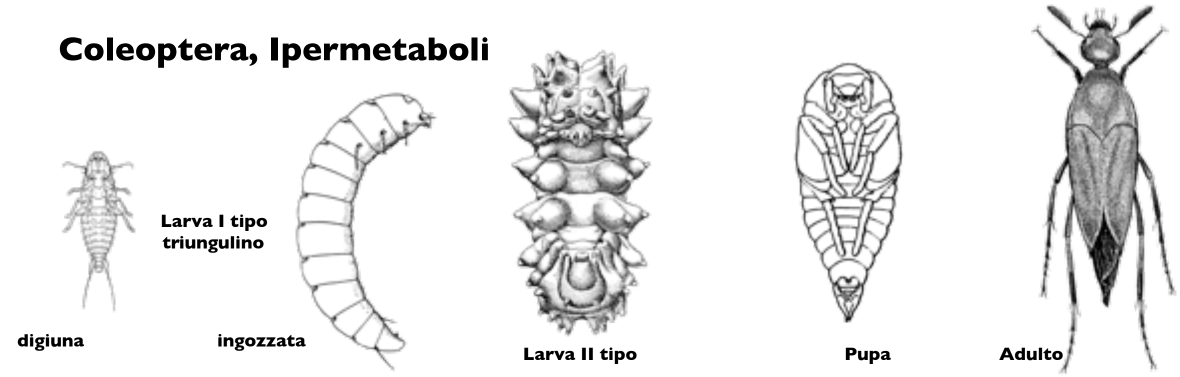


Hemiptera Coccoidea, Diaspididae, Eterometaboli Catametaboli, linea femminile

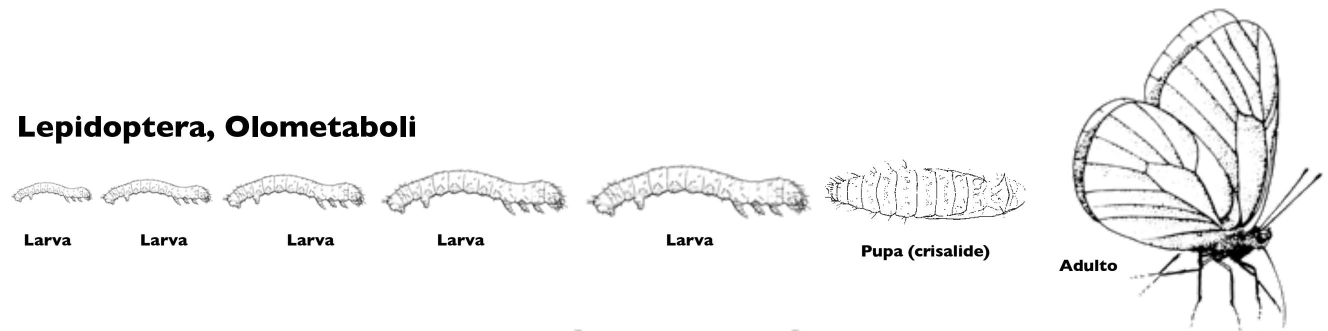


Olometabolia

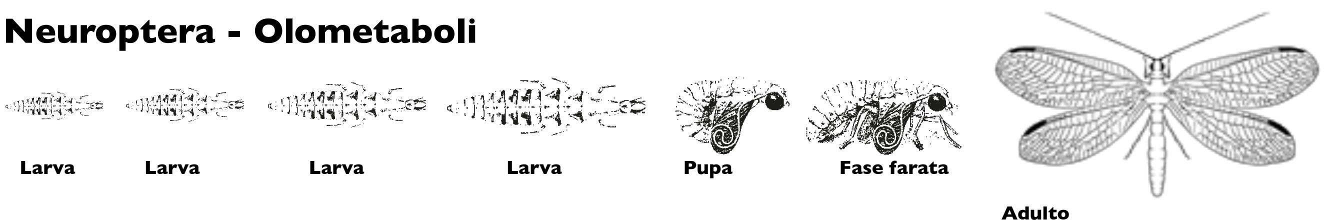
Coleoptera, Ipermetaboli



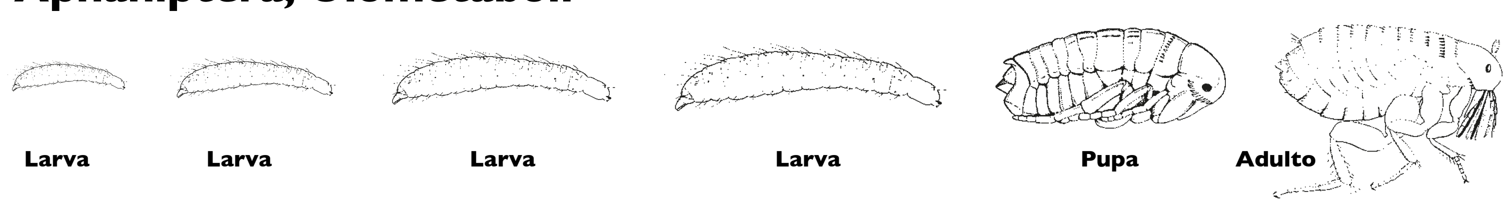
Lepidoptera, Olometaboli



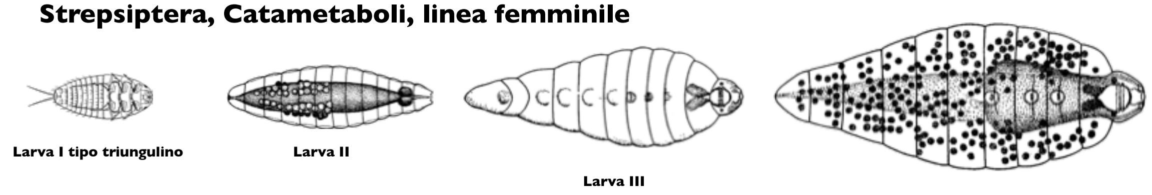
Neuroptera - Olometaboli



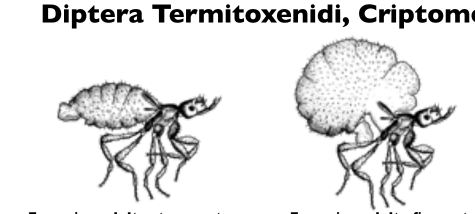
Aphaniptera, Olometaboli

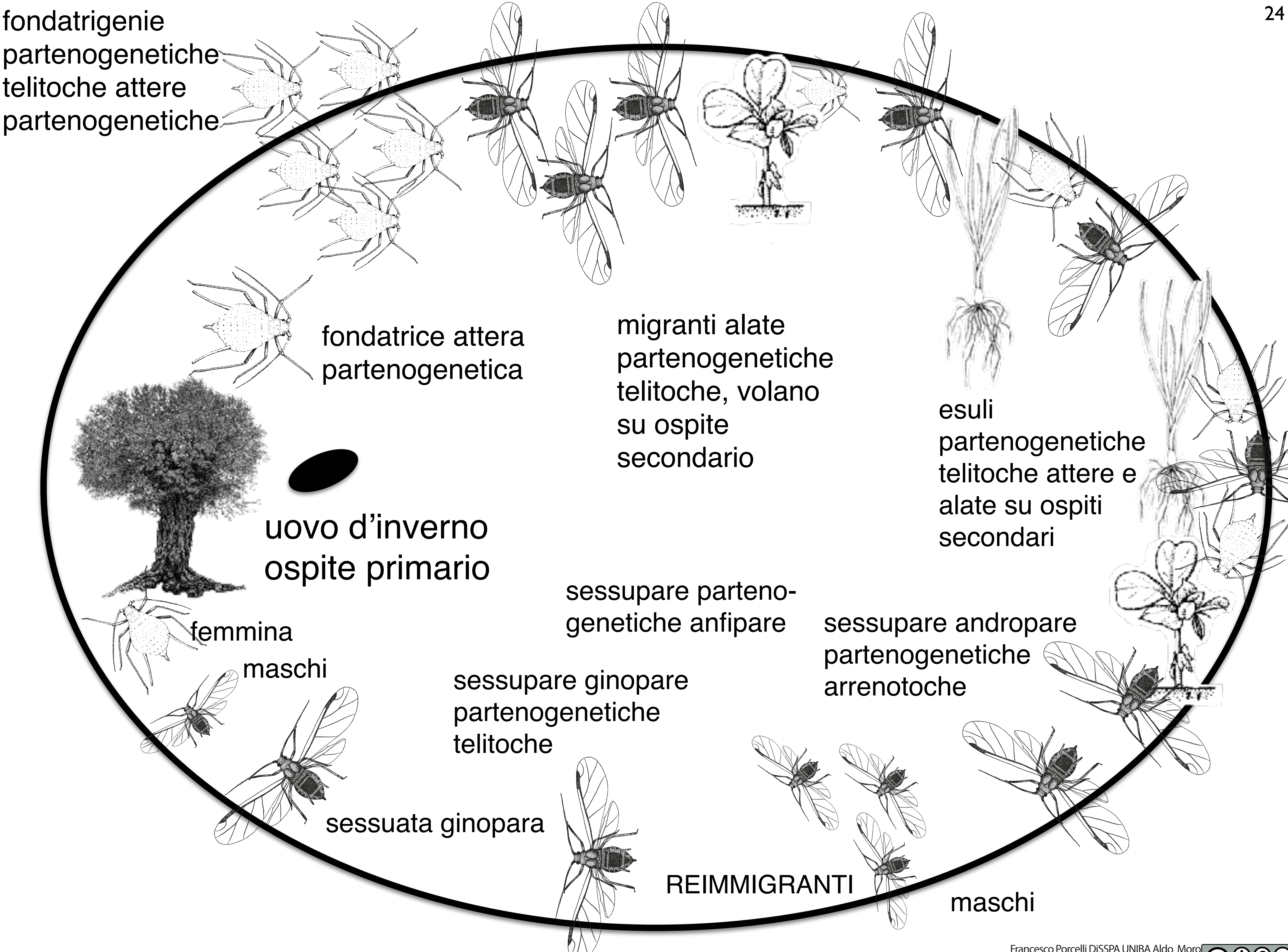


Strepsiptera, Catametaboli, linea femminile



Diptera Termitoxenidi, Criptometaboli




fondatrigenie
partenogenetiche
telitoche attere
partenogenetiche
fondatrice attera
partenogenetica
migranti alate
partenogenetiche
telitoche, volano
su ospite
secondario
esuli
partenogenetiche
telitoche attere e
alate su ospiti
secondari
uovo d'inverno
ospite primario
sessupare parteno-
genetiche anfipare
sessupare andropare
partenogenetiche
arrenotoche
femmina
maschi
sessupare ginopare
partenogenetiche
telitoche
sessuata ginopara
REIMMIGRANTI
maschi

08 Insecticide IRAC MoA classification

IRAC

Insecticide Resistance Action Committee
www.irac-online.org

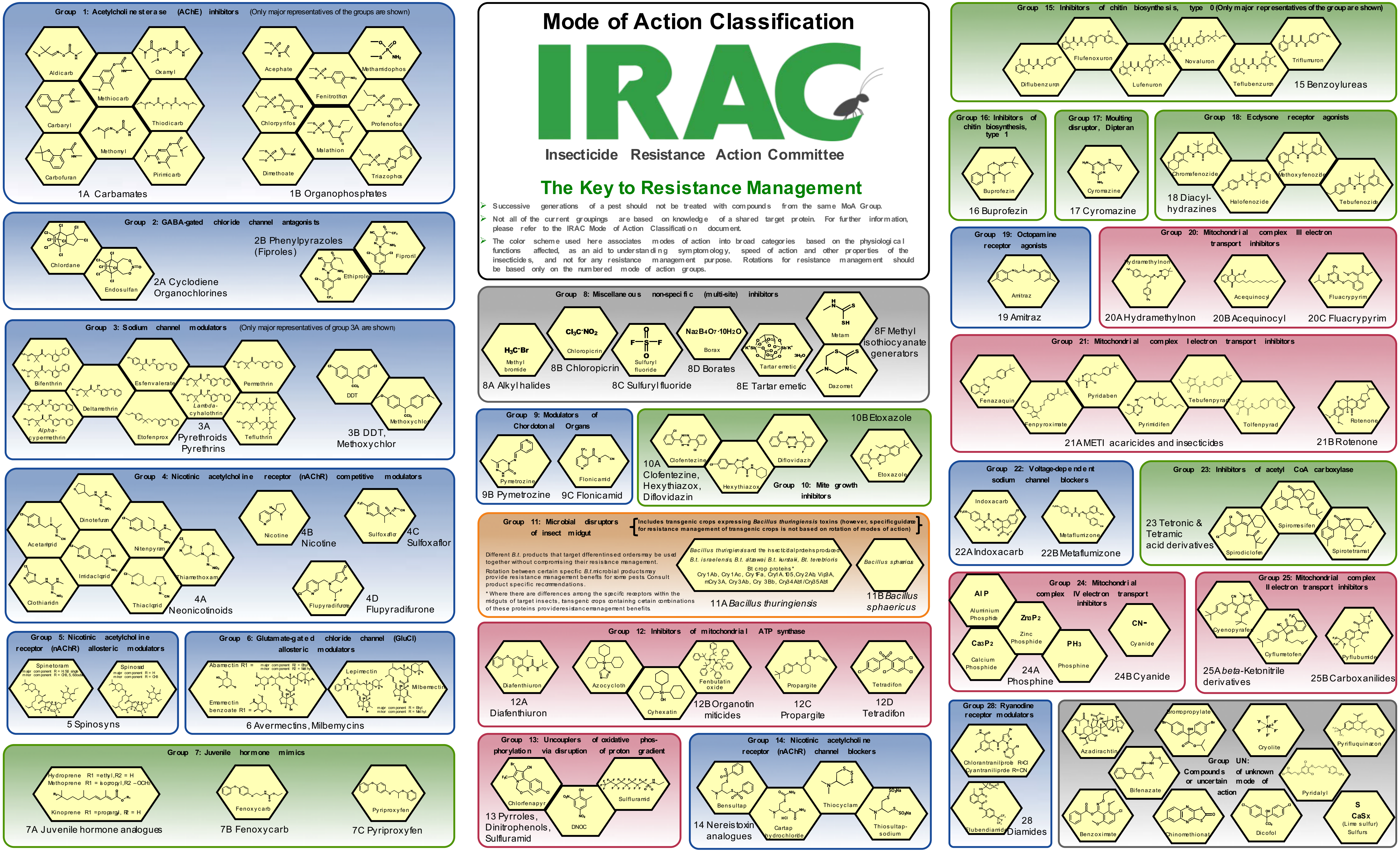
IRAC MoA Classification Scheme

Issued, April 2012 *Version 7.2*

Prepared by: IRAC International MoA Working Group

Approved by: IRAC Executive

Page 1 of 23
Further information is available at: www.irac-online.org or enquiries@irac-online.org



Targeted Physiology

- Nerve & Muscle
- Growth & Development
- Respiration
- Midgut
- Unknown or Non-specific

Use of Groups and Sub-Groups:

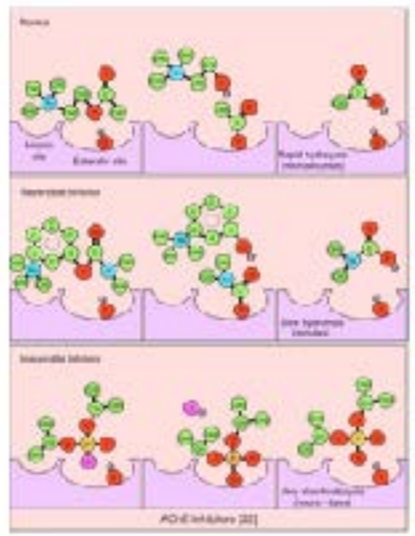
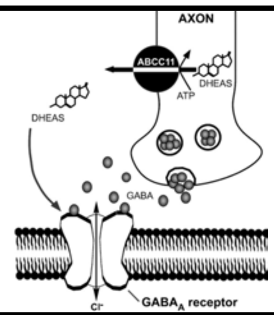
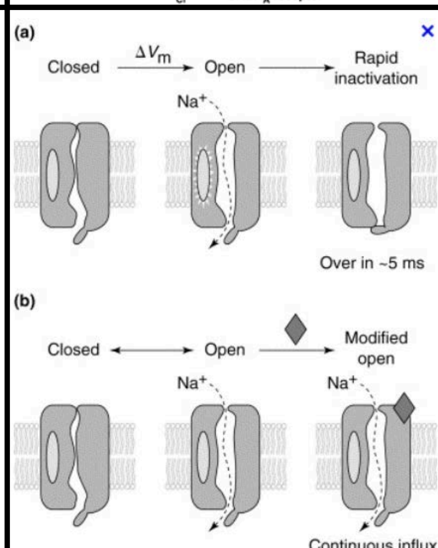
- Alternations, sequences or rotations of compounds between MoA groups reduces selection for target site resistance.
- Applications are arranged into MoA spray windows defined by crop growth stage and pest biology.
- Several sprays of a compound may be possible within each spray window, but successive generations of a pest should not be treated with compounds from the same MoA group.
- Local expert advice should always be followed with regard to spray windows and timing.
- Actives in groups 8 (Miscellaneous non-specific multi-site inhibitors), 13 (Uncouplers) and UN are thought not to share a common target site and therefore may be freely rotated with each other unless there is reason to expect cross-resistance.
- Sub-groups represent distinct structural classes believed to have the same mode of action.
- Sub-groups provide differentiation between compounds that may bind at the same target site but are structurally different enough that risk of metabolic cross-resistance is lower than for close chemical analogs.
- Cross-resistance potential between sub-groups is higher than between groups, so rotation between sub-groups should be considered only when there are no alternatives, and only if cross-resistance does not exist, following consultation with local expert advice. These exceptions are not sustainable, and alternative options should be sought.
- Sub-group 3B: DDT is no longer used in agriculture and therefore this is only applicable for the control of insect vectors of human disease, such as mosquitoes, because of a lack of alternatives.
- Sub-group 10A - Hexythiazox is grouped with clofentezine because they exhibit cross-resistance even though they are structurally distinct, and the target site for these compounds is unknown. Diflovidazin has been added to this group because it is a close analogue of clofentezine and is expected to have the same mode of action.

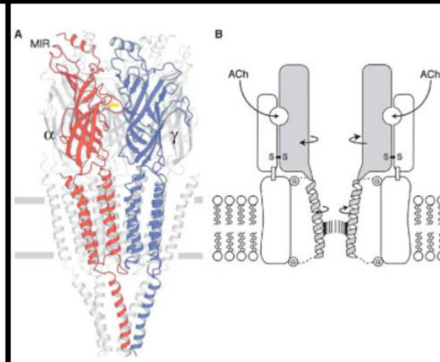
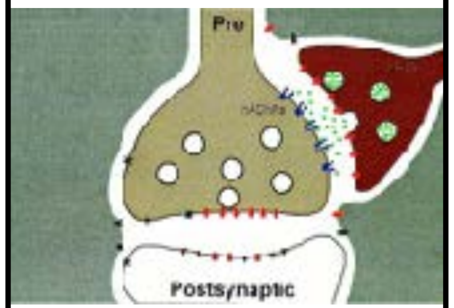
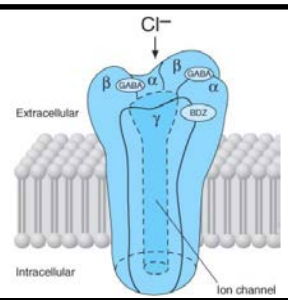
Poster Notes:

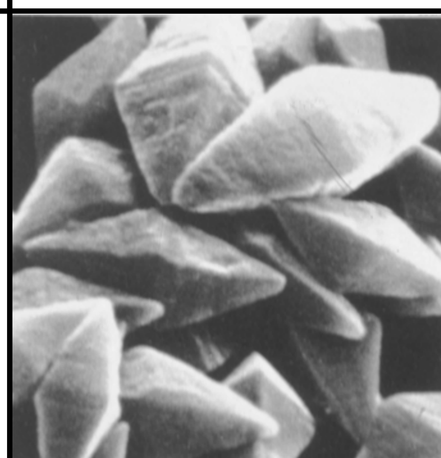
- Groups 26 and 27 are unassigned.
- The poster is for educational purposes only. Information presented is accurate to the best of our knowledge at the time of publication, but IRAC or its member companies cannot accept responsibility for how this information is used or interpreted. Advice should always be sought from local experts or advisors, and health and safety recommendations followed.
- Representative compounds are shown. Please visit www.irac-online.org for the complete IRAC classification.

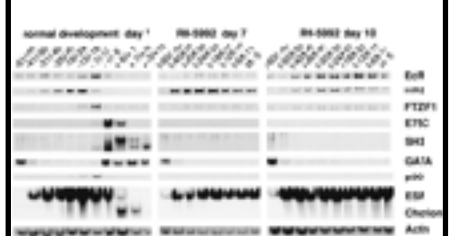
CropLife INTERNATIONAL

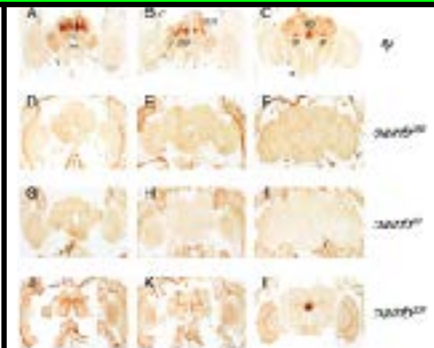
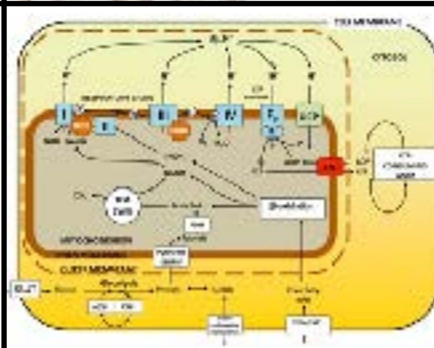
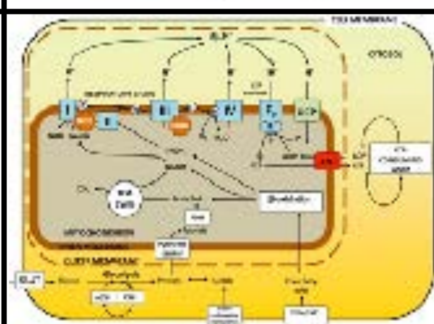
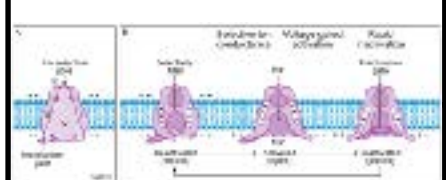
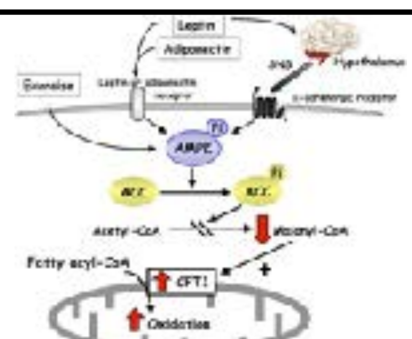
Poster Edition 5, June 2015. Based on the MoA Classification Version 7.4

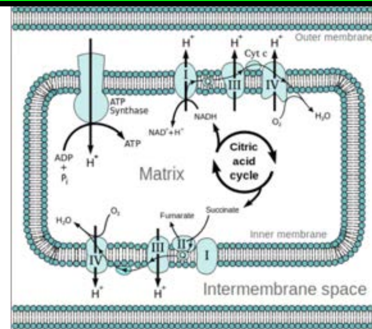
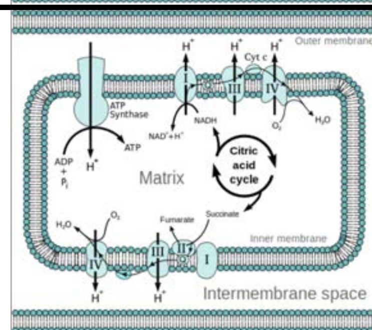
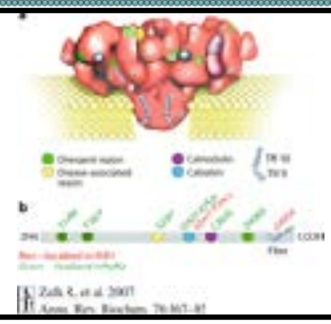
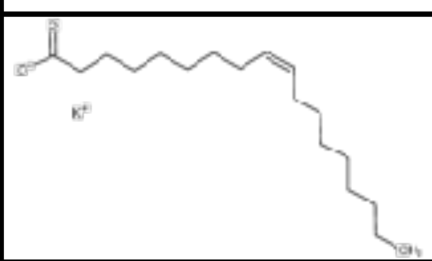
<table>
<tr><th colspan="2">Main Group and Primary Site of Action</th><th>Chemical Sub-group or exemplifying Active Ingredient</th><th>Active Ingredients</th></tr>
<tr><td rowspan="2">1 Acetylcholinesterase (AChE) inhibitors
Nerve action
there is a strong evidence that action at this protein is responsible for insecticidal effects</td><td rowspan="2"></td><td>1A Carbamates</td><td>Alanycarb, Aldicarb, Bendiocarb, Benfuracarb, Butocarboxim, Butoxycarboxim, Carbaryl, Carbofuran, Carbosulfan, Ethiofencarb, Fenobucarb, Formetanate, Furathiocarb, Isoprocarb, Methiocarb, Methomyl, Metolcarb, Oxamyl, Pirimicarb, Propoxur, Thiodicarb, Thiofanox, Triazamate, Trimethacarb, XMC, Xylylcarb</td></tr>
<tr><td>1B Organophosphates</td><td>Acephate, Azamethiphos, Azinphos-ethyl, Azinphos- methyl, Cadusafos, Chlorethoxyfos, Chlorfenvinphos, Chlormephos, Chlorpyrifos, Chlorpyrifos-methyl, Coumaphos, Cyanophos, Demeton-S-methyl, Diazinon, Dichlorvos/ DDVP, Dicrotophos, Dimethoate, Dimethylvinphos, Disulfoton, EPN, Ethion, Ethoprophos, Famphur, Fenamiphos, Fenitrothion, Fenthion, Fosthiazate, Heptenophos, Imicyafos, Isofenphos, Isopropyl O- (methoxyaminothio-phosphoryl) salicylate, Isoxathion, Malathion, Mecarbam, Methamidophos, Methidathion, Mevinphos, Monocrotophos, Naled, Omethoate, Oxydemeton-methyl, Parathion, Parathion-methyl, Phenthoate, Phorate, Phosalone, Phosmet, Phosphamidon, Phoxim, Pirimiphos- methyl, Profenofos, Propetamphos, Prothiofos, Pyraclofos, Pyridaphenthion, Quinalphos, Sulfotep, Tebupirimfos, Temephos, Terbufos, Tetrachlorvinphos, Thiometon, Triazophos, Trichlorfon, Vamidothion</td></tr>
<tr><td rowspan="2">2 GABA-gated chloride channel antagonists
Nerve action
there is a strong evidence that action at this protein is responsible for insecticidal effects</td><td rowspan="2"></td><td>2A Cyclodiene organochlorines</td><td>Chlordane, Endosulfan</td></tr>
<tr><td>2B Phenylpyrazoles (Fiproles)</td><td>Ethiprole, Fipronil</td></tr>
<tr><td rowspan="2">3 Sodium channel modulators
Nerve action
there is a strong evidence that action at this protein is responsible for insecticidal effects</td><td rowspan="2"></td><td>3A Pyrethroids Pyrethrins</td><td>Acrinathrin, Allethrin, d-cis-trans Allethrin, d-trans Allethrin, Bifenthrin, Bioallethrin, Bioallethrin S- cyclopentenyl isomer , Bioresmethrin, Cycloprothrin, Cyfluthrin, beta-Cyfluthrin, Cyhalothrin, lambda- Cyhalothrin, gamma-Cyhalothrin, Cypermethrin, alpha-Cypermethrin, beta-Cypermethrin, theta-cypermethrin, zeta-Cypermethrin, Cyphenothrin , (1R)- trans- isomers], Deltamethrin, Empenthrin (EZ)- (1R)- isomers], Esfenvalerate, Etofenprox, Fenpropathrin, Fenvalerate, Flucythrinate, Flumethrin, tau- Fluvalinate, Halfenprox, Imiprothrin, Kadethrin, Permethrin, Phenothrin [(1R)-trans-isomer], Prallethrin, Pyrethrins (pyrethrum), Resmethrin, Silafluofen, Tefluthrin, Tetramethrin, Tetramethrin [(1R)-isomers], Tralomethrin, Transfluthrin,</td></tr>
<tr><td>3B DDT Methoxychlor</td><td>DDT Methoxychlor</td></tr>
</table>

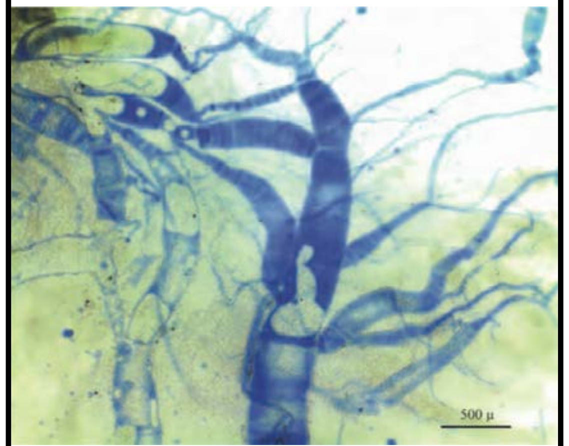
Main Group and Primary Site of Action		Chemical Sub-group or exemplifying Active Ingredient	Active Ingredients
4 Nicotinic acetylcholine receptor (nAChR) agonists **Nerve action** there is a strong evidence that action at one or more of this class of protein is responsible for insecticidal effects		**4A Neonicotinoids**	Acetamiprid, Clothianidin, Dinotefuran, Imidacloprid, Nitenpyram, Thiacloprid, Thiamethoxam,
		4B Nicotine	Nicotine
		4C Sulfoxaflor	Sulfoxaflor
5 Nicotinic acetylcholine receptor (nAChR) allosteric activators **Nerve action** there is a strong evidence that action at one or more of this class of protein is responsible for insecticidal effects		**Spinosyns**	Spinetoram, Spinosad
6 Chloride channel activators **Nerve and muscle action** there is a strong evidence that action at one or more of this class of protein is responsible for insecticidal effects		**Avermectins, Milbemycins**	Abamectin, Emamectin benzoate, Lepimectin, Milbemectin
7 Juvenile hormone mimics **Growth regulation** The target protein responsible for biological activity is unknown, or uncharacterized		**7A Juvenile hormone analogues**	Hydroprene, Kinoprene, Methoprene
		7B Fenoxycarb	Fenoxycarb
		7C Pyriproxyfen	Pyriproxyfen
8 Miscellaneous non-specific (multi-site) inhibitors		**8A Alkyl halides**	Methyl bromide and other alkyl halides
		8B Chloropicrin	Chloropicrin
		8C Sulfuryl fluoride	Sulfuryl fluoride
		8D Borax	Borax
		8E Tartar emetic	Tartar emetic

Main Group and Primary Site of Action		**Chemical Sub-group or exemplifying Active Ingredient**	**Active Ingredients**
9 Selective homopteran feeding blockers **Nerve action** The target protein responsible for biological activity is unknown, or uncharacterized		**9B Pymetrozine**	Pymetrozine
		9C Flonicamid	Flonicamid
10 Mite growth inhibitors **Growth regulation** The target protein responsible for biological activity is unknown, or uncharacterized		**10A Clofentezine Hexythiazox Diflovidazin**	Clofentezine Hexythiazox Diflovidazin
		10B Etoxazole	Etoxazole
11 Microbial disruptors of insect midgut membranes (includes transgenic crops expressing *Bacillus thuringiensis* toxins, however specific guidance for resistance management of transgenic crops is not based on rotation of modes of action)		**11A Bacillus thuringiensis and the insecticidal proteins they produce**	*Bacillus thuringiensis* subsp. *israelensis* *Bacillus thuringiensis* subsp. *aizawai* *Bacillus thuringiensis* subsp. *kurstaki* *Bacillus thuringiensis* subsp. *tenebrionis*
		11B Bacillus sphaericus	Bacillus sphaericus
12 Inhibitors o f mitochondrial ATP synthase **Energy metabolism** Several compounds affect the function of this protein, but it is not clear that this is what leads to biological activity		**12A Diafenthiuron**	Diafenthiuron
		12B Organotin miticides	Azocyclotin, Cyhexatin, Fenbutatin oxide
		12C Propargite	Propargite
		12D Tetradifon	Tetradifon
13 Uncouplers of oxidative phosphorylation via disruption of the proton gradient **Energy metabolism**		**Chlorfenapyr** **DNOC** **Sulfluramid**	Chlorfenapyr DNOC Sulfluramid

Main Group and Primary Site of Action		**Chemical Sub-group or exemplifying Active Ingredient**	**Active Ingredients**
14 Nicotinic acetylcholine receptor (nAChR) channel blockers **Nerve action** Several compounds affect the function of this protein, but it is not clear that this is what leads to biological activity		**Nereistoxin analogues**	Bensultap, Cartap hydrochloride, Thiocyclam, Thiosultap-sodium
15 Inhibitors of chitin biosynthesis, type 0 **Growth regulation** The target protein responsible for biological activity is unknown, or uncharacterized		**Benzoylureas**	Bistrifluron, Chlorfluazuron, Diflubenzuron, Flucycloxuron, Flufenoxuron, Hexaflumuron, Lufenuron, Novaluron, Noviflumuron, Teflubenzuron, Triflumuron
16 Inhibitors of chitin biosynthesis, type 1 **Growth regulation** The target protein responsible for biological activity is unknown, or uncharacterized		**Buprofezin**	Buprofezin
17 Moulting disruptor, Dipteran **Growth regulation** The target protein responsible for biological activity is unknown, or uncharacterized		**Cyromazine**	Cyromazine
18 Ecdysone receptor agonists **Growth regulation** There is a strong evidence that action at this protein is responsible for insecticidal effects		**Diacylhydrazines**	Chromafenozide, Halofenozide, Methoxyfenozide, Tebufenozide

Main Group and Primary Site of Action		**Chemical Sub-group or exemplifying Active Ingredient**	**Active Ingredients**
19 Octopamine receptor agonists **Nerve action** There is a good evidence that action at one or more of this class of protein is responsible for insecticidal effects		**Amitraz**	Amitraz
20 Mitochondrial complex III electron transport inhibitors **Energy metabolism** There is a good evidence that action at this protein complex is responsible for insecticidal effects		**20A Hydramethylnon**	Hydramethylnon
		20B Acequinocyl	Acequinocyl
		20C Fluacrypyrim	Fluacrypyrim
21 Mitochondrial complex I electron transport inhibitors **Energy metabolism** There is a good evidence that action at this protein complex is responsible for insecticidal effects		**21A METI acaricides and insecticides**	Fenazaquin, Fenpyroximate, Pyrimidifen, Pyridaben, Tebufenpyrad, Tolfenpyrad
		21B Rotenone	Rotenone (Derris)
22 Voltage-dependent sodium channel blockers **Nerve action** There is a good evidence that action at this protein complex is responsible for insecticidal effects		**22A Indoxacarb**	Indoxacarb
		22B Metaflumizone	Metaflumizone
23 Inhibitors of acetyl CoA carboxylase. **Lipid synthesis, growth regulation** There is a good evidence that action at this protein is responsible for insecticidal effects		**Tetronic and Tetramic acid derivatives**	Spirodiclofen, Spiromesifen, Spirotetramat

Main Group and Primary Site of Action		Chemical Sub-group or exemplifying Active Ingredient	Active Ingredients
24 Mitochondrial complex IV electron transport inhibitors **Energy metabolism** There is a good evidence that action at this protein complex is responsible for insecticidal effects		**24A Phosphine**	Aluminium phosphide, Calcium phosphide, Phosphine, Zinc phosphide
		24B Cyanide	Cyanide
25 Mitochondrial complex II electron transport inhibitors **Energy metabolism** There is a good evidence that action at this protein complex is responsible for insecticidal effects		**Beta-ketonitrile derivatives**	Cyenopyrafen, Cyflumetofen
28 Ryanodine receptor modulators **Nerve and muscle action** There is a good evidence that action at this protein complex is responsible for insecticidal effects		**Diamides**	Chlorantraniliprole, Cyantraniliprole, Flubendiamide
un **Compounds of unknown or uncertain MoA** The target protein responsible for biological activity is unknown, or uncharacterized		**Azadirachtin**	Azadirachtin
		Benzoximate	Benzoximate
		Bifenazate	Bifenazate
		Bromopropylate	Bromopropylate
		Chinomethionat	Chinomethionat
		Cryolite	Cryolite
		Dicofol	Dicofol
		Pyridalyl	Pyridalyl
		Pyrifluquinazon	Pyrifluquinazon
Pesticide soaps Membrane disrupting function. Inactivation in hard water, need for buffering and conditioning. Phytotoxicity? Known pest target, Soap spray during the growing season.		**Potassium fatty acid soaps**	Oleic acid potassium salt $C_{18}H_{34}KO_2$

<table>
<tr><th colspan="2">Main Group and Primary Site of Action</th><th>Chemical Sub-group or exemplifying Active Ingredient</th><th>Active Ingredients</th></tr>
<tr><td>Petroleum Distilled Spray (mineral) Oils: PDSOs)
Cuticle corrosion & softening; teratogenic effects on the epidermis; spiracle, trachea and tracheole blockage & coating; disruption of tracheal & cuticle waxes; host location failures, repellence & deterrence; accumulation in lipophilic tissue: fat bodies & nerve cells; neurotoxicity; demes growth rate.</td><td></td><td>Aromatics and other unsaturated hydrocarbons should be reduced to levels as low as possible (preferably < 8%). Molecular weight more than 290 with high paraffinicity have best insecticide action. Narrow-distillation-range products are desirable.</td><td>California grade standards for distinguishing types of petroleum spray oils based on unsulfonated residue (UR) and distillation properties
<table>
<tr><th>Grade</th><th>Minimum UR (%) (ASTM D 483)</th><th>Distilled at 335.6° C (ASTM D 447)</th><th>Viscosity (SUS) at 37.8° C (ASTM D 446)</th></tr>
<tr><td>Light</td><td>90</td><td>64–79</td><td>55–65</td></tr>
<tr><td>Light-medium</td><td>92</td><td>52–61</td><td>60–75</td></tr>
</table></td></tr>
<tr><td>Copper sulphate
The toxic action of copper is attributed to its ability to denature cellular proteins and to deactivate enzyme systems in bacteria, fungi and algae. For fungicidal use, more effective when either mixed with liming agents or placed in a basic solution.</td><td></td><td>$CuSO_4.5H_2O$</td><td>Copper sulphate is a very basic cellular poison basing its activity on Copper (CU), a well known biologically-active heavy metal.</td></tr>
<tr><td rowspan="2">Inert powders
They are assumed to have a disturbing physico-chemical action on soft bodied insect or other arthropods. Diatomaceous earth is suggested in stored grains, mills and stores, empty rooms and home gardening (soil treatment) pest control. Kaolin is suggested against several pests, mainly in biologically managed orchards.</td><td rowspan="2"></td><td>Diatomaceous earth</td><td>It consists mainly of silicon dioxide. It should be noted that another active substance, quartz sand, also consists mainly of silicon dioxide.</td></tr>
<tr><td>Kaolin, $Al_2Si_2O_5(OH)_4$</td><td>It is actually a mixing of amorphous silica (SiO_2) and alumina (Al_2O_3) but the nature of metakaolin phase shows a very complex interactions between main components.</td></tr>
<tr><td colspan="2" rowspan="2">Adjuvant
An agricultural adjuvant is broadly defined by the as "any substance (other than water) that is added to an agricultural chemical product to alter its physico-chemical properties and/or improve its efficacy".
Adjuvants may: destroy, stupefy, repel, inhibit the feeding of, or prevent infestation by any pest in relation to a plant, a place or thing; modify the physiology of a pest so as to alter its natural development or fitness; modify the effect of another agricultural chemical product, or attract a pest for the purpose of destroying it.</td><td colspan="2">Adjuvants that enhance product efficacy
Wetters/spreaders: non-ionic surfactants; Anionic, cationic & amphoteric, organo-silicate and acidified surfactants; Stickers: latex-, terpene/pinolene-, pyrrolidone-based; Penetrants: mineral & (esterified) vegetable oil, organo-silicate & acidified surfactants; Extenders: ammonium sulphate, menthene-based; Humectants: glycerol, propylene glycol, diethyl glycol;</td></tr>
<tr><td colspan="2">Adjuvants that improve ease of application
Acidifying/buffering agents; Anti-foaming/de-foaming agents, which may include: dimethopolysiloxane; Compatibility agents, which may include: ammonium sulphate; Drift-reducing agents, which may include: polyacrylamides; polysaccharides; Dyes; Water conditioners, which may include: ammonium sulphate.</td></tr>
</table>

Come distinguere predatori, parassitoidi e parassiti

uno proposta basata sul comportamento

Si tratta di comportamento, premesso che:

- Le simbiosi considerate non sono mutualistiche;
- nelle simbiosi considerate **alcune specie sono attive altre passive**;
- non consideriamo canoni come ecto/endo, idio/koino, i Taxa di appartenenza, l'esistenza di cicli, etc. etc.

Si tratta di comportamento, premesso che:

- La specie attiva usa quella passiva come cibo;
- utilizziamo il **momento della riproduzione/moltiplicazione** della specie attiva rispetto alla vitalità dell'individuo della specie passiva usato, come primo canone di distinzione;
- utilizziamo il **numero di individui** della specie passiva usati da ciascun "individuo" della specie attiva come secondo canone di distinzione

Il comportamento sarà da:

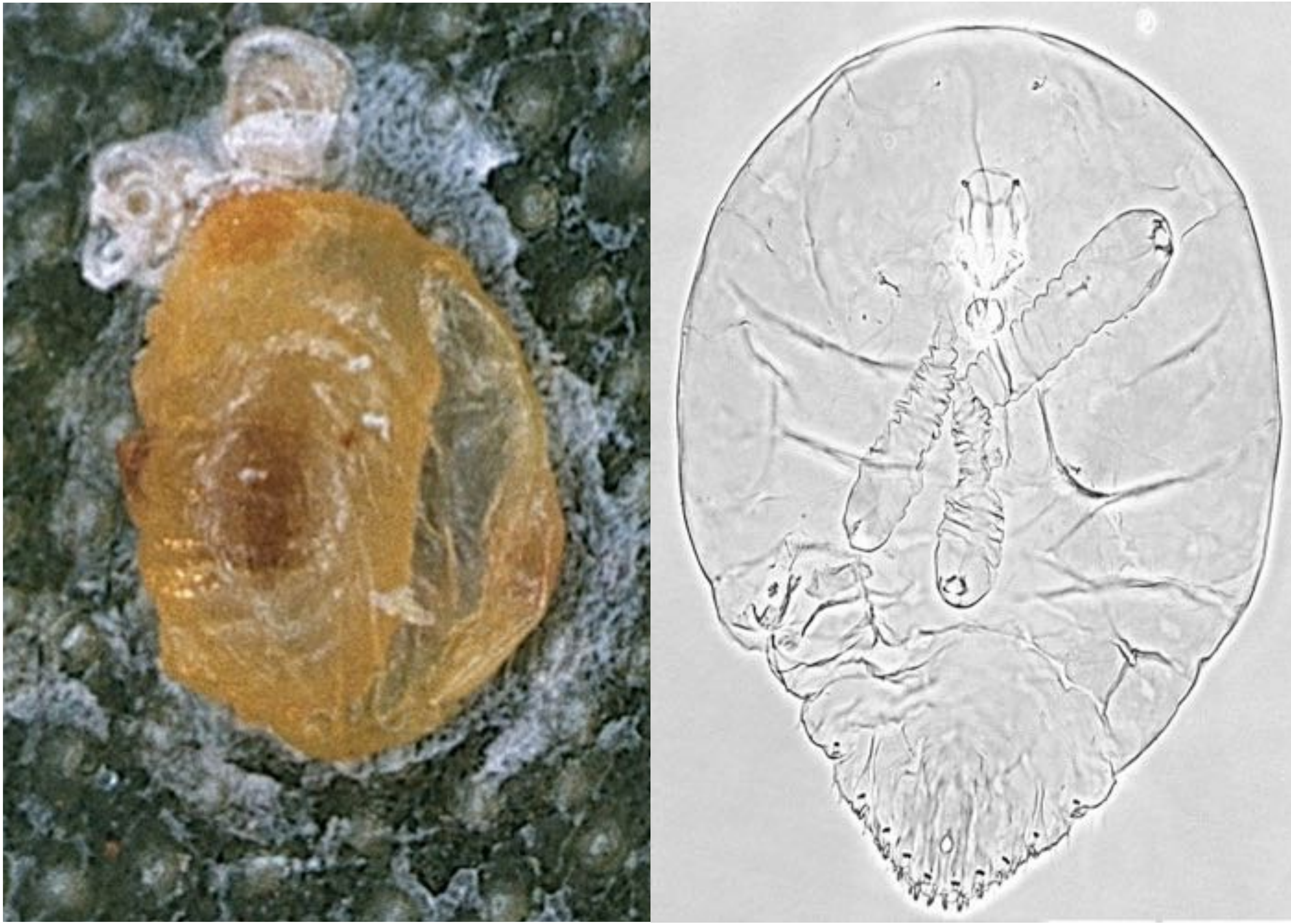
- **parassita** quando la specie attiva si riproduce/moltiplica **prima della morte degli individui della specie passiva utilizzati**;
  - il parassita **induce sempre malattia** che sia conclamata o silente;
  - corollario: il **parassita** è anche **patogeno**;

Il comportamento sarà da:

- **predatore o parassitoide** quando la specie attiva si riproduce/moltiplica **dopo la morte degli individui della specie passiva utilizzati**;
  - **predatore** quando **un individuo** della specie attiva **utilizza più di un individuo** della specie passiva per diventare adulto;
  - **parassitoide** quando **un individuo** della specie attiva **utilizza un solo individuo** della specie passiva per diventare adulto;

Si tratta di comportamento:

La stessa specie attiva può comportarsi come predatore, parassitoide o parassita a seconda dei momenti della propria biologia;



A: PROTOPOD, quite specialized larvae

1 Cyclopiform
2 Eucoiliiform
3 Teleaform
4 Uncommon

Usually 1st instar larvae, very small to microscopic, hypermetabolic belonging to insects parasitoids

Hymenoptera:
Apocrita:Terebrantia, Chalcidoidea and allied

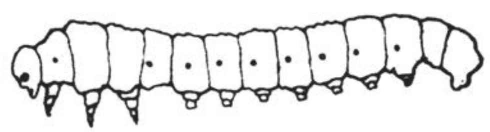
B: ERUCIFORM (POLYPOD) literally "caterpillar-shaped" with thoracic legs and abdominal prolegs

1 Prolegs from I to VIII urite and pygopode on X urite

Mecoptera

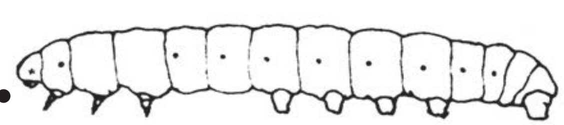
2 Prolegs from II to VIII urite and on X urite
Prolegs from II to VII urite and on X urite
Prolegs from II to VI urite and on X urite
Furthermore, one ocellus per side, sericiparous outlet as an opening in inferior labium

Hymenoptera:
Hymenoptera Symphyta, Hoplocampa



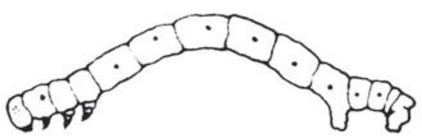
3 Prolegs from III to VI urite and on X urite
Ocelli (6 per side) present or not, sericiparous papilla present

Lepidoptera:
(most)

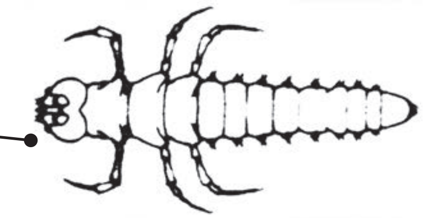
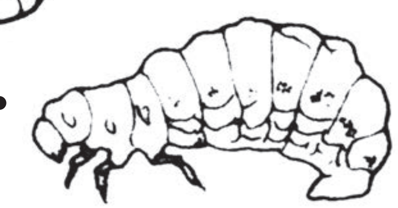
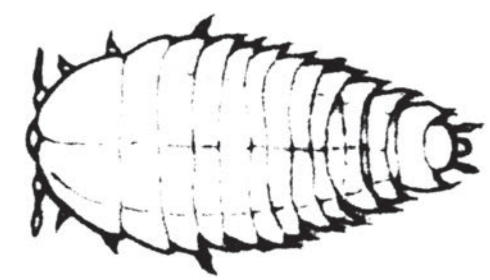
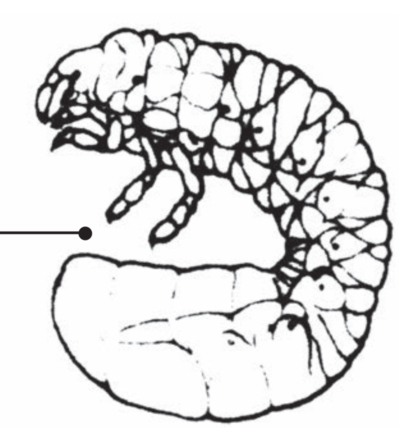


Prolegs on VI and X urite only

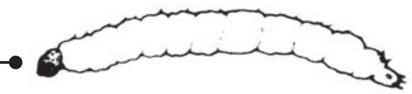
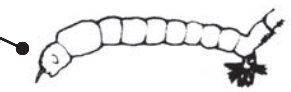
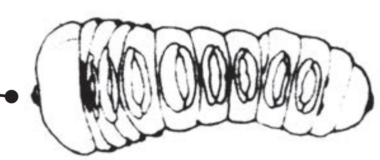
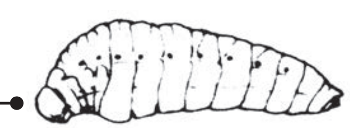
Geometridae (Loopers)



C: OLIGOPOD, only thoracid legs present

1 Campodea-like	Fast runner, predators	**Coleoptera:** Carabidae	
		Neuroptera: Chrysopidae	
	Slower, phytophagous or euryphagous	**Coleoptera:** Chrysopidae, Tenebrionidae, Chrysomelidae (with pygopode)	  
2 Oniscus-like	Self-rolling larvae	**Coleoptera:** Silphidae	
3 Scarabaeiform	"C" shaped posterior end more or less swollen	**Coleoptera:** Scarabaeidae	

D: APODOUS, larvae devoid of legs

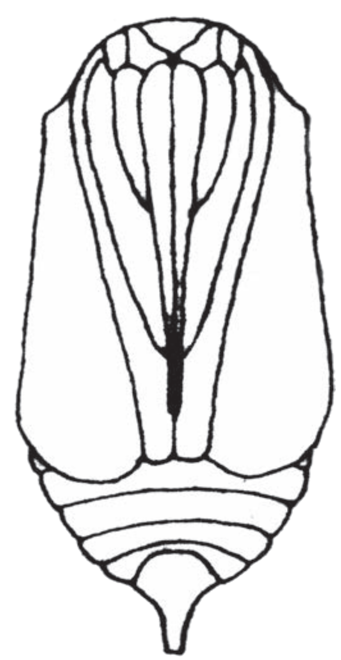
1 Larvae with 3 thoracic and 8-9 abdominal seg-ments	Eucephalous, head free, cephalic capsule evident		**Diptera:** Bibionidae, Culicidae (Mosquitoes)	 
	Emicephalous, head free, cephalic capsule reduced		**Diptera:** Cecidomyiidae (sternal spatula)	
	Microcephalous, head free, cephalic capsule unapparent, maggots		**Diptera:** Tephritidae (Fruit flies)	
2 Larvae with 3 thoracic and 10 abdominal seg-ments	Specialized larvae, usullay endophyte	Club-like larvae, head capsule immersed in thorax that is swollen,	**Coleoptera:** Cerambycidae,	
			Buprestidae	
		"C"-shaped, posterior end more or less tapered	**Coleoptera:** Curculionidae, Scolytidae	 
			Hymenoptera: Apocrita	

PUPAE

Exarate: with appendages in high relief

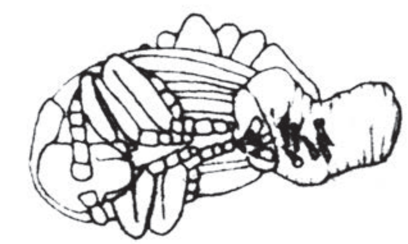
- Decticous, possess movable mandibles — Neuroptera, Mecoptera, Tricoptera, Lepidoptera (early)
- Adecticous, does not possess movable mandibles — Diptera, Coleoptera, Hymenoptera

Obtect: Appendages in bas-relief, fused or glued to the body



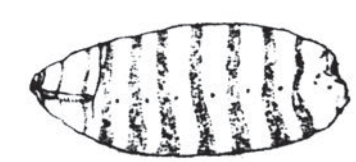
Not protected
- Free 
- Hanging 
- Cingolate 

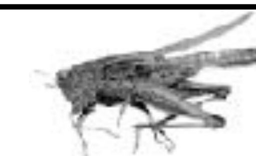
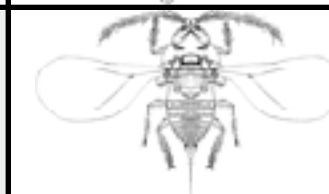
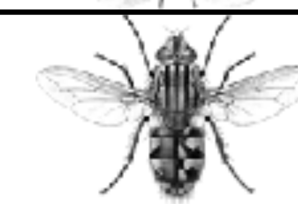
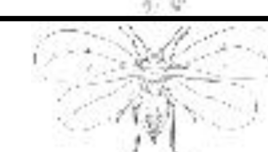
Partially protected (exuvia)

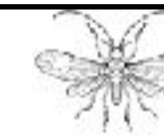
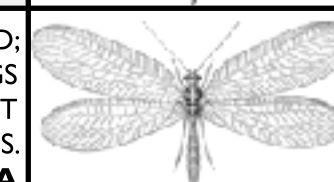


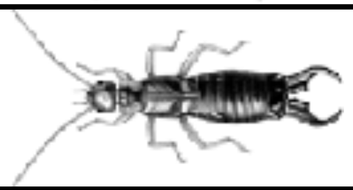
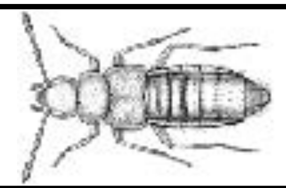
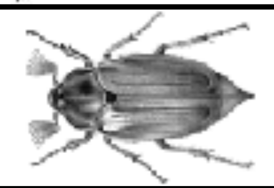
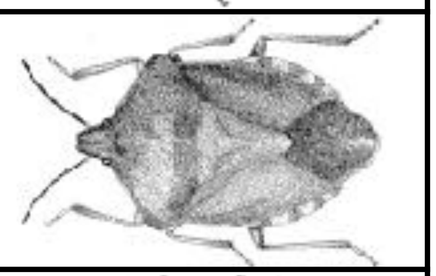
Protected into a cocoon (silk wowened) or into a pupal case (debris or remains)

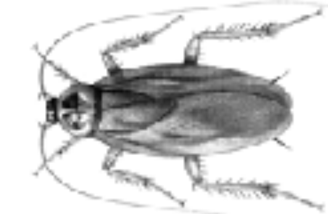
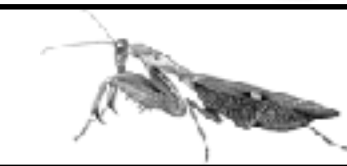
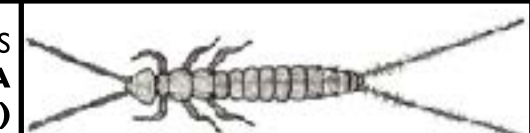
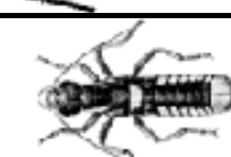
Coarctate into a Puparium, a hardened, barrel-like third larval instar integument within which Pupa and adult forms.

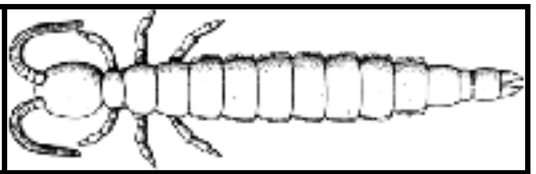
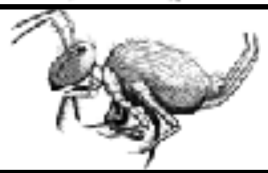
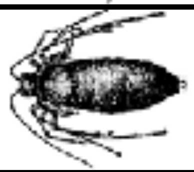
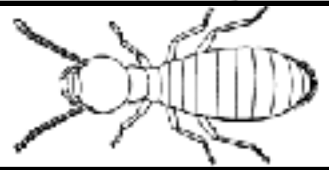
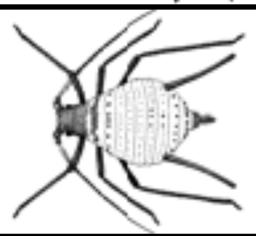
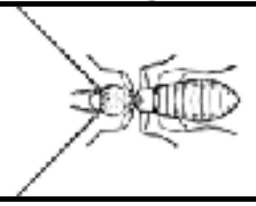


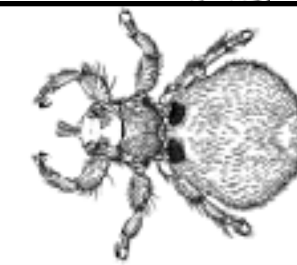
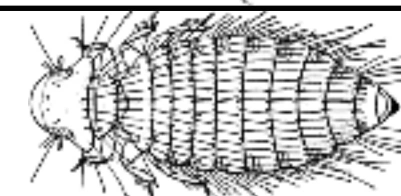
1) INSECT WITH WINGS (This includes the beetles and other insects with hard and smooth forewings, although these might appear wingless at first sight)				
	2) ALL WINGS MEMBRANOUS	A) ONE PAIR OF WINGS	GRASSHOPPER-LIKE, WITH LONG BACK LEGS: PRONOTUM EXTENDS BACK OVER THE ABDOMEN **ORTHOPTERA TETRIGIDAE**	
			2 OR 3 LONG "TAILS" AT END OF ABDOMEN; WINGS HELD VERTICALLY AT REST; VERY SMALL ANTENNAE. **EPHEMEROPTERA (PART)**	
			MINUTE INSECTS (<5MM LONG) WITH ONLY ONE FORKED VEIN IN THE WING; ONE OR MORE SHORT "TAILS"; ANTENNAE MUCH LONGER THAN THE HEAD; RARE. **RHYNCHOTA MALE SCALE INSECTS**	
			LARGE FAN-SHAPED HINDWINGS: FOREWINGS IN THE FORM OF TWISTED CLUBS (HALTERES). **STREPSIPTERA MALE**	
			FOREWINGS NORMAL; HINDWINGS IN THE FORM OF TINY, PIN-LIKE STRUCTURES (HALTERES) ALTHOUGH THESE MAY BE HIDDEN UNDER FLAPS IN THE STOUTER SPECIES; ANTENNAE OFTEN SHORT AND BRISTLE-LIKE. **DIPTERA (PART)**	
		B) TWO PAIRS OF MEMBRANOUS WINGS	MINUTE INSECTS WITH FEATHERY WINGS WHICH ARE USUALLY FOLDED TIGHTLY OVER THE BODY. **THYSANOPTERA**	
		C) WING MEMBRANE CLOTHED WITH MINUTE SCALES OR HAIRS	WINGS CLOTHED WITH SCALES, OFTEN VERY COLOURFUL; USUALLY A COILED PROBOSCIS FOR SIPPING NECTAR. **LEPIDOPTERA**	
			WINGS HAIRY, USUALLY YELLOW, BROWN, OR BLACK, AND HELD ROOFWISE OVER THE BODY AT REST WITH ANTENNAE POINTING FORWARD; FEW CROSS-VEINS; HINDWING NORMALLY BROADER THAN FOREWING; NO COILED PROBOSCIS. **TRICHOPTERA**	
			WINGS HAIRY AND ALL ALIKE; FRONT TARSI SWOLLEN; (MORE OFTEN SEEN IN WINGLESS FORM). **EMBIOPTERA**	
			TINY INSECTS CLOTHED WITH WHITE POWDER. WINGS + FLAT AT REST **RHYNCHOTA ALEYRODIDAE**	

			WINGS HELD ROOFWISE AT REST **NEUROPTERA CONIOPTERYGIDAE**	
		D) WING MEMBRANE WITHOUT A NOTICEABLE COATING OF HAIRS OR SCALES, ALTHOUGH VEINS MAY BE HAIRY; USUALLY COLOURLESS AND TRANSPARENT, BUT MAY BE COLOURED	ALL WINGS ALIKE, VERY FLIMSY AND +/-VEINLESS; USUALLY IN SWARMS; SOUTHERN EUROPE. **ISOPTERA**	
			HEAD EXTENDED DOWNWARDS TO FORM A STOUT BEAK; WINGS USUALLY MOTTLED AND +/- ALIKE; MALES MOSTLY WITH UPTURNED, SCORPION-LIKE ABDOMEN. **MECOPTERA (PART)**	
			HINDWINGS SIMILAR TO OR BROADER THAN FOREWINGS; WINGS HELD FLAT OR ROLLED ROUND BODY AT REST; OFTEN 2 FAIRLY STOUT 'TAILS', NO LONGER THAN THE BODY AND USUALLY MUCH SHORTER. **PLECOPTERA**	
		E) WINGS WITH MANY CROSS-VEINS FORMING A DENSE NETWORK	2 OR 3 “TAILS”, AS LONG AS OR LONGER THAN THE BODY; ANTENNAE MINUTE; WINGS HELD VERTICALLY AT REST HINDWING MUCH SMALLER THAN FOREWING. **EPHEMEROPTERA (PART)**	
			ANTENNAE SHORT AND BRISTLE-LIKE (SHORTER THAN WIDTH OF HEAD); BODY AT LEAST 25 MM LONG, OFTEN VERY SLENDER; WINGS NEVER HELD ROOFWISE OVER BODY. **ODONATA**	
			ANTENNAE RELATIVELY LONG, SOMETIMES CLUBBED; WING VEINS USUALLY FORK AT THE MARGINS; WINGS HELD ROOFWISE OVER THE BODY AT REST; FLIGHT SLOW IN MOST SPECIES EXCEPT ASCALAPHIDS. **NEUROPTERA**	
		F) WINGS WITH FEW CROSS-VEINS	VERY SMALL INSECTS, OFTEN WITH HAIRY WING VEINS AND SOMETIMES WITH A FEW SCALES ON THE WING MEMBRANE: VENATION CHARACTERISTIC; WINGS HELD ROOFWISE AT REST; RELATIVELY LONG ANTENNAE WITH AT LEAST 12 SEGMENTS. **PSOCOPTERA**	
			VERY SMALL INSECTS, OFTEN PEAR-SHAPED, WITH A SLENDER, NEEDLE-LIKE BEAK; WINGS NORMALLY HELD ROOFWISE AT REST, BUT SOMETIMES FLAT; ANTENNAE NEVER WITH MORE THAN 10 SEGMENTS; OFTEN IN MASSES ON PLANTS **RHYNCHOTA APHIDIDAE**	

			STOUT-BODIED INSECTS WITH A CLEAR, SHINY, AND QUITE STIFF WING MEMBRANE; WINGS HELD ROOFWISE AT REST; A LONG, SLENDER BEAK FOR SUCKING SAP FROM TREES AND SHRUBS; ANTENNAE SHORT AND BRISTLE-LIKE **RHYNCHOTA CICADIDAE**	
			MINUTE TO QUITE LARGE INSECTS WITH HINDWING VERY MUCH SMALLER THAN FOREWING AND LINKED TO IT BY A ROW OF MICROSCOPIC HOOKS; WINGS TYPICALLY WITH A SMALL NUMBER OF LARGE CELLS, BUT VENATION IS MUCH REDUCED IN MANY OF THE SMALLER SPECIES: WINGS NEVER HELD ROOFWISE. WITH A DISTINCT 'WAIST'. **HYMENOPTERA APOCRITA**	
			MINUTE TO QUITE LARGE INSECTS WITH HINDWING VERY MUCH SMALLER THAN FOREWING AND LINKED TO IT BY A ROW OF MICROSCOPIC HOOKS; WINGS TYPICALLY WITH A SMALL NUMBER OF LARGE CELLS, BUT VENATION IS MUCH REDUCED IN MANY OF THE SMALLER SPECIES: WINGS NEVER HELD ROOFWISE. WITHOUT A 'WAIST' **HYMENOPTERA SYMPHYTA**	
	3) FOREWINGS AT LEAST PARTLY HORNY OR LEATHERY; HINDWINGS MEMBRANOUS OR SOMETIMES ABSENT	G) FOREWINGS VEINLESS AND MEETING IN THE MID-LINE WITHOUT OVERLAP	FOREWINGS SHORT AND SQUARE, LEAVING MOST OF THE ABDOMEN UNCOVERED: PINCERS AT THE REAR. **DERMAPTERA**	
			FOREWINGS SHORT AND SQUARE, LEAVING MOST OF THE ABDOMEN UNCOVERED: NO PINCERS **COLEOPTERA STAPHYLINIDAE**	
			FOREWINGS OFTEN VERY HARD AND USUALLY COVERING ALL OF THE ABDOMEN, ALTHOUGH SOME ABDOMINAL SEGMENTS MAY BE EXPOSED. **COLEOPTERA**	
		H) FOREWINGS WITH VEINS AND NORMALLY OVERLAPPING TO SOME EXTENT AT REST OR ELSE HELD DISTINCTLY ROOFWISE	FOREWINGS WITH MEMBRANOUS TIPS AND LAID FLAT OVER BODY AT REST; A SLENDER PIERCING BEAK FOR SUCKING PLANT AND ANIMAL FLUIDS. **RHYNCHOTA ETEROPTERA**	
			FOREWINGS OF UNIFORM TEXTURE THROUGHOUT AND USUALLY OPAQUE, ALTHOUGH NOT ALWAYS MUCH TOUGHER THAN THE HINDWINGS; HELD ROOFWISE AT REST; A SLENDER BEAK FOR SUCKING PLANT JUICES; INSECTS OFTEN LEAP WHEN DISTURBED. **RHYNCHOTA HOMOPTERA**	

			BODY BULLET-SHAPED, WITH WINGS WRAPPED TIGHTLY AROUND IT AT REST; HIND LEGS ENLARGED FOR JUMPING. **ORTHOPTERA**	
			ALL 3 PAIRS OF LEGS LONG AND SPIKY; FAST-RUNNING; WINGS LAID FLAT OVER BODY AT REST; PRONOTUM BROAD AND ALMOST COVERING THE HEAD. **BLATTODEA**	
			FRONT LEGS ENLARGED AND VERY SPINY FOR CATCHING PREY; HEAD VERY MOBILE ON A LONG NECK. **MANTODEA**	
2) INSECTS WITHOUT WINGS OR WITH JUST VERY SMALL FLAPS				
	4) FREE-LIVING INSECTS, ON VEGETATION OR IN SOIL AND LEAF LITTER		BODY LONG AND STICK-LIKE. **FASMATODEA**	
			BODY BULLET-LIKE, OFTEN WITH SMALL WING FLAPS JUST BEHIND THE HEAD; HIND LEGS ENLARGED FOR JUMPING. **ORTHOPTERA**	
		I) INSECTS WITH LONG, SLENDER “TAILS” AT THE REAR	SMALL SOIL-DWELLING CREATURES WITH 2 “TAILS”. **DIPLURA (CAMPODEIDAE)**	
			3 “TAILS”; BODY USUALLY CLOTHED WITH SHINING SCALES; OFTEN FOUND INDOORS. **THYSANURA**	
		L) INSECTS WITH PINCERS AT THE REAR	SLENDER, PALE SOIL-DWELLING INSECTS WITH JUST ONE TARSAL SEGMENT. **DIPLURA (JAPYGIDAE)**	
			STOUTER, OFTEN DARK BROWN INSECTS WITH 3 TARSAL SEGMENTS; OFTEN UNDER STONES. **DERMAPTERA**	
		M) INSECTS WITH SHORT 'TAILS' OR NONE AT ALL	SLENDER, SOFT-BODIED SOIL-DWELLERS WITH 2 SHORT TAILS; FRONT TARSI SWOLLEN **EMBIOPTERA**	

			PALE, SLENDER SOIL-DWELLERS WITH 2 SHORT TAILS: FRONT TARSI NOT SWOLLEN **DIPLURA (PROJAPYGIDAE)**	
			FLATTENED INSECTS WITH SPIKY LEGS AND A BROAD PRONOTUM ALMOST COVERING THE HEAD; 2 STUMPY TAILS USUALLY VISIBLE. **BLATTODEA**	
			ELONGATE INSECTS WITH LARGE SPINY FRONT LEGS FOR CATCHING PREY; LONG NECK; 2 SHORT TAILS USUALLY VISIBLE. **MANTODEA**	
			SMALL LEAPING INSECTS WITH VESTIGIAL WINGS AND HEAD EXTENDING DOWNWARDS TO FORM A STOUT BEAK. **MECOPTERA (PART)**	
			SMALL LEAPING CREATURES WITH NO SIGN OF WINGS; A FORKED 'SPRING' AT THE REAR (USUALLY TUCKED UNDER BODY); MAINLY IN SOIL AND LEAF LITTER. **COLLEMBOLA**	
			BODY CLOTHED WITH SCALES OR FLATTENED HAIRS; WING VESTIGES PRESENT **LEPIDOPTERA (PART)**	
			BODY WITH A MARKED 'WAIST', OFTEN BEARING SMALL LOBES OR SCALES, AT FRONT OF ABDOMEN; ANTENNAE OFTEN ELBOWED **HYMENOPTERA FOEMICIDAE**	
			SLENDER, SOFT-BODIED AND PALE INSECTS, NORMALLY WITH 4 TARSAL SEGMENTS; USUALLY IN COLONIES IN DEAD WOOD; SOUTHERN EUROPE ONLY. **ISOPTERA**	
			SMALL, PEAR-SHAPED INSECTS WITH HEAD MUCH NARROWER THAN BODY; A NEEDLE-LIKE BEAK UNDER THE HEAD; OFTEN A PAIR OF TUBULAR OUTGROWTHS NEAR THE REAR END; ON GROWING PLANTS. **RHYNCHOTA APHIDIDAE**	
			FLATTENED INSECTS WITH RELATIVELY BROAD HEAD; ANTENNAE LONG AND SLENDER; HIND FEMUR OFTEN BROAD; COMMONLY FOUND INDOORS AMONG DRIED MATERIALS. **PSOCOPTERA**	

	4) PARASITIC INSECTS LIVING ON BIRDS AND MAMMALS	N) INSECTS FLATTENED LATERALLY	JUMPING INSECTS WITH LONG BACK LEGS; FLATTENED FROM SIDE TO SIDE; USUALLY BROWN. **SIPHONAPTERA**	
		O) INSECTS FLATTENED DORSO-VENTRALLY HEAD PARTLY SUNK INTO THORAX	ANTENNAE MORE OR LESS CONCEALED IN GROOVES; LEGS RELATIVELY STOUT, USUALLY WITH 2 STRONG CLAWS TO GRIP HOST; A PIERCING BEAK, ALTHOUGH NOT ALWAYS OBVIOUS **DIPTERA NYCTERIBIIDAE**	
			ANTENNAE CLEARLY VISIBLE; LEGS MORE SLENDER AND CLAWS LESS PROMINENT; A SLENDER, PIERCING BEAK. **RHYNCHOTA CIMICIDAE**	
		O) INSECTS FLATTENED DORSO-VENTRALLY HEAD NOT SUNK INTO THORAX	VERY SMALL, OVAL OR ELONGATE INSECTS; HEAD NEARLY AS WIDE AS BODY; PROTHORAX DISTINCT; TARSI WITH 1 OR 2 CLAWS; BITING MOUTHS. **MALLOPHAGA**	
			VERY SMALL, PEAR-SHAPED.INSECTS; HEAD MUCH NARROWER THAN BODY; THORACIC SEGMENTS FUSED INTO ONE UNIT; TARSI EACH WITH 1 LARGE CLAW; SUCKING MOUTHS **ANOPLURA**