Boll. Zool. agr. Bachic.
Ser. II, 14 (1977-78): 29-93

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Some structures of various *Hymenoptera Chalcidoidea* and their functions (*)

The various actions by which a parasitic insect arrives at a choice of a suitable host have been much discussed. The last review of the subject was that of Vinson (1976), who put forward a synthesis pointing out the connections between the operations of choosing a habitat and victim, and the means with which these operations were carried out (fig. 1).

Among *Hymenoptera Chalcidoidea,* which include the smallest and most specialized insects in existence, even very accurate morphological studies suffer from the many limitations imposed by the optical microscope. In consequence, ethological research on these insects provides us with only approximate information on the use of their apparatus.

This present study wishes to draw attention to the importance of the S.E.M. (Scanning Electron Microscope) for really detailed investigation of the structures.

The exploration of the cuticle with the electron beam presents to us, in fact, a complexity of appendices, of tegumental projections and of sensory apparatus considerably greater than that previously known.

The modifications of the same structure in different species, in relation to the tasks for which it is used, often reveal extraordinary adaptations.

Examination of some species of Chalcidoidea, even if only superficial and to gain a general impression, gives us a much more adequate idea of the structural reality of the organs and appendices of the insect.

(*) This work was presented at XV International Congress of Entomology, Washington D.C., August 23, 1976, section I, Symposium on Biosystematics of parasitic Hymenoptera.

In this way the richness and range of means available to these insects clarifies their relations with their surroundings and their capacity to receive information and react to it.

Some photographs taken by the S.E.M. illustrate the subject clearly, removing the sense of the unknown that surrounded the behaviour of these insects.

Eyes

The first stimuli that reach the adult are received through the eyes. These guide the insect newly emerged from its pupal case from the usually well-hidden position where it has accomplished its metamorphosis, towards the open spaces. An investigation of the fine structure of the corneal surface of the complex eyes leads one to suppose that the various species and groups use the light waves differently.

The structural complexity of the ommatidial corneas is notable in nocturnal Lepidoptera such as *Cydia pomonella* L. where the surface is made up of regular cylindrical protuberances joined like a bunch of optic fibres (fig. 2). The function of these structures is to reduce to a minimum the reflection of light, as BERNHARD (1967) first showed by using experimental mathematical models, and CLAPHAM and HUTLEY (1973) have confirmed with other analogous proofs. Another solution presumably achieving the same effect as the above mentioned, can be seen in *Trialeurodes vaporariorum* Westw. (Homoptera Aleyrodidae), where the ommatidia have a cornea with an alveolate surface (fig. 3).

Like the diameter of the corneal protuberances in the above mentioned butterflies, that of the geometric reticle of the eyes of *T. vaporariorum* is also rather small, in comparison with the length of the visible light waves, and so cannot influence the formation of images on the part of the corneal lenses or the perception of colours. However, like the ommatidium of the Lepidoptera, it seems that here the arguments of BERNHARD are applicable, that there is a gradual transition which we verify from the refractive index of air (1) to that of the chitin (1.57): the refractive index the compact base part of the cornea presumably diminishes in the reticular relief to the point of almost reaching the refractive index of air. Although these fine structures, which appear to be complex « traps » for light, are typical of insects that are primarily nocturnal, others that are similar are found in the Chalcidoidea which are regarded as typically diurnal insects.

In *Trichogramma embryophagum* Htg., the corneas of the ommatidia are covered with small prominences (fig. 4), while in *Torymus varians* (Walker) we observe there are regular depressions, with the parallel result of increasing the surface of the cornea.

In two Eulophidae, parasites of eggs of *Cassida* spp., *Foersterella flavipes* Foerst. and *Foersterella erdoesi* Boucek, the corneas are seen to be regularly streaked.

The dimensions, distance and width of the cuticular reliefs which constitute the corneal striation (fig. 5) have analogies with the micro-protuberances indicated earlier even if only to indicate their efficiency.

In most of the Chalcidoidea the complex eyes are seen to have bristles distributed near various edges formed by more ommatidia. The histological examination of *Apis mellifera* L. has shown (SANCHEZ, 1921) that we are dealing with trichoid sensilla, and that these play a part in controlling the position of the wings during flight (NEES, 1965). In the species where the males, unlike the females, do not abandon the niche in which they have developed, the complex eyes (and the wings) are usually stunted and the ommatidial hairs are reduced in number and dimensions.

Among other examples we can mention *Blastophaga psenes* L., where the female has numerous bristles between the ommatidia, while the stunted complex eyes of the males are absolutely smooth (fig. 1); and *Tetrastichus goidanichii* Dom. where the males have thinner and smaller ocular pubescens than the females.

Antennae

The antennae constitute for the adult Chalcidoidea, as for other Pterygota, the essential means for the exploration of their environment, for the recognition of individuals of the opposite sex for stimulation to copulate, etc. Their removal, experimentally tried out on *Lariophagus distinguendus* (Foerster) (= *utibilis* Tuck.) (Hymenoptera, Pteromalidae) (MORETTI, 1940), leads to an inhibition of the search for a host, and for food, and of the laying of eggs. In the same way the male, deprived of his antennae, no longer notices the presence of a female, even when she is close to him; the characteristic manifestations of interest in the other sex, as displayed by the male, cease immediately (agitation of wings, hurried pursuit).

A greater abundance and variety of sensilla is generally found in the antennae of the female. In many taxonomic groups the apical segment of the club is richer in sensilla (figs. 6, 7); in others, more distal segments are covered in sensilla of various types (figs. 9, 10).

In some species one frequently finds a characteristic disposition of the sensilla on the ventral surfaces of the club which leads one to assume the use of the antennae on the substratum in a more or less prone position, while the concentration of the sensilla at the apex of the segment of the antennae makes one presume a touching with the tips, as is done by various species, particularly the males (fig. 8).

In *Torymus varians* (Walker) (fig. 9), which lays its eggs in the seeds of small unripe apples, we find a crown of sensilla situated on the ventral side of the club, which seems adapted for measuring the convex shape and other characteristics of the niche in which the eggs are laid. This complex of sensilla makes one think of a key that must fit into lock, or into certain features of the host or its habitat.

Unlike the female, the male has just one apex cap of sensilla, and with these he feels the body of the female; then climbing on to her back he caresses the antennae, bending them and stroking them many times between his own flagellum and the scape. The large sensillum, or number of sensilla, that in some groups of Chalcidoidea specifically characterize the ventral side of the antennal scape of the males (for example, many *Eulophidae, Aphelinidae,* etc.), could have a stimulating function in sexual approach.

The male of *Blastophaga psenes,* which, without seeing her, can fertilize the female enclosed in the same gall nut in which she has developed, has a few large sensilla situated at the apex of the club, while the rest of the antenna is almost smooth, subatrophic and largely sunk in a deep facial cavity (fig. 11).

Legs

As a result of their incessant tactile exploration of the ground surface, the antennae become covered in particles of extraneous matter which obstruct their multiple sensory activities. The task of frequent cleaning which these appendages require is usually given to the front feet. The form and dimensions of the sensilla of the antennae, as well as their disposition, are such that these can be cleaned only by means of special instruments [1].

Meeting this need we find the antenna cleaner and the internal surfaces of the upper segment of the tarsus opposite the spur, the combs and the groups of bristles and brushes variously disposed on the apex of the tibia and on the various sections of the tarsi (figs. 12, 13, 14). A particularly specialized arrangement is provided by the front feet of the male of *Blastophaga psenes* (L.), transformed into an articulated vice, which can take a firm hold of the gall-nut which encloses the female to be fertilized (fig. 15). The morphology of these parts is so complicated that an examination from different points of observation is necessary.

The feet of the 2nd and 3rd pairs of legs have, beyond the functions of locomotion and of gripping during mating or egg-laying, also clean parts of the body, and are provided with the necessary instruments (fig. 16).

It seems that greater importance can be attributed to the pretarsus which comes into direct contact with the ground surface and is adapted to gather from this information that will determine the choice of an ecological niche. This article is amongst the smallest and most delicate structures of the *Chalcidoidea*. Between the two robust retractable claws there is positioned an arolium which has various shapes but is usually well-developed, rigid and covered with hairs and bristles, or else smooth and membraneous.

A robust arolium can be observed in phytophagous species (fig. 17) or in parasites of host animals with tegument that is armour-plated or encased in strong protective layers (fig. 18); a frail vesicular arolium is present in species that are parasite eggs (figs. 19, 20).

Trichogramma embryophagum, which is not documented with photographs here, also has pretarsi similar to those of *Foersterella.*

The unguitractor frequently possesses, on the outside, a double series of lamellae which combine with the apposite posterior edge of the preceding segment of the tarsus to make an instrument for gripping: a sort of pincer, capable of gripping the tiniest support: e.g. a vegetable hair,

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[1] The cleaning of specimens of insects as a preparation for examination with an S.E.M., even when it is done with ultra sound waves or with sophisticated methods, is often so inadequate as to compel the abandonment of the study, if alternative material is lacking.

an appendix or a tegumental projection of an insect, with which phoretical relationships may be contracted.

Having at our disposal an *Ichneumonoidea,* the Braconid *Ascogaster quadridentatus* Wesm., which lays its eggs in the egg of its host, we wanted to examine and compare the pretarsi; there is present (figs. 19-20) a delicate vesicular arolium with a triangular orbicula above its.

This type of « little cushion » or pad, so widespread amond *Chalcidoidea,* is often retractable and is usually kept retracted. We observed that when beginning to lay in the eggs of *Ephestia kuehniella* the *Trichogramma* « raises » itself on its pretarsi. The arolium proves itself to be an instrument that gives the claws strength for gripping and puts the insect in the best position to observe vibrations in the ground surface and its smallest conformations.

Ovipositor

Observation of the process of host-selection by Hymenoptera Terebrantia has led us to consider the ovipositor something more than a simply a particular instrument for placing the eggs in ecological niches that are hidden, or at least removed from direct contacts.

On this subject the detailed paper of DELANOUE and ARAMBOURG (1965) on *Eupelmus urozonus* Dalm. is most valuable.

The more we analyse each operation by means of which the female reaches the conclusion of the egg-laying, the more interesting become the deductions on the capacity of the terebra to recognize each characteristic of the habitat intended for the future larvae. (cfr. SALT 1937, LAING 1937, KING and RAFAI 1970, ASKEW 1971, WESELOH 1971 and 1972, GREANY and OATMAN 1972).

The singling out of the sensilla on the valvulae, the histological study of these, and the experiments on the results of both chemical and tactile stimuli have brought out fundamental elements for evaluating the role of the terebra.

The third valvulae, which insistently feel the exact area which has previously been explored by the antennae, and which linger over it as if to circumscribe it, have sensilla over a large part of their external surfaces and in particular at the apex where they often form varied structures. But in a number of species, the inside surfaces (fig. 21) are also partially covered with tegumental projections that surround formations of a sensory type lying below the apex: lines of short bristles or cones or fine brushes (e.g. *Megastigmus aculeatus* Swed.) visible also in *Torymus varians* Walker (fig. 21).

Recently there were some investigations of the fine structure of the sensory apparatus of the stylets of *Devorgilla canescens* Grav. (GANESALINGAM, 1972) and of the first valvulae and the second valvulae of *Orgilus lepidus* Muesebeck (*Hymenoptera Braconidae*).

The authors (HAWKE, FARLEY and GREANY, 1973) distinguished sensilla of a double chemo- and mechano-reception function, and mechanoreceptors of two different types.

In Chalcidoidea there are sensilla with various forms of external apparatus (fig. 22). An important series of researches on the structure of the terebra by COPLAND and KING (1972-1976) contains much information about the presence of the sensilla on the terebra.

On the external surfaces of the apex of the two pairs of valvulae there are numerous sensilla of coeloconic type while on the internal surfaces two types of campaniform sensilla can be seen, both set out in longitudinal double file: one placodeum type and the other dome-type. It can be maintained that the dome-like sensilla, projecting from the surfaces of the stylet, are subjected to pressure when the eggs travel along the canal formed by the stylets: it thus seems likely that these sensilla give notice of the exit of the egg from the ovipositor (fig. 23).

The mechanism for sliding the stylets along the sheath by means of the « guide » (fig. 24) would seem to be highly perfected mechanical equipment, notwithstanding the minute dimensions of these insects.

As far as the sensory apparatus is concerned, it is interesting to make a comparison with the substitute ovipositor of a Diptera Trypetidae, *Rhagoletis cerasi* L., which is also equipped on the apex with campaniform sensilla and coeloconic sensilla (figs. 25, 26). An apparatus of such diverse origin but with functions analogous to those of the terebra has ended up provided with similar instruments.

ACKNOWLEDGMENTS

I am grateful to my friend Professor Minos Martelli, editor of the Bollettino di Zoologia agraria e Bachicoltura, who has generously undertaken the publication of this study.

I expresses my sincere appreciation to Dr. H.L.G. Stroyan for critical comments on the manuscript and for the correction and improvement of the English text.

In addition, I would like to express my thanks and appreciation to Ferdinando Bianchi, in charge of the Electron Microscopes of the Faculty of Agriculture of the Catholic University in Piacenza, who made the photographic documentation by means of the S.E.M. possible.

SUMMARY

The author refers to morphological observations carried out by means of a S.E.M. on some *Chalcidoidea,* concerning essential organs and appendages used for the choice of a habitat and the selection of a host.

These structures show a complexity - not visible using an optical microscope - that frequently permits an intuitive knowledge of the function which they perform.

Homologies or analogies with microstructures possessed by other Pterygota are brought out.

Of particular interest are some sensilla placed on the distal articles of the antenna, or at the apex of the stylets of the terebra which combine to form organs used to obtain diverse and to us unknown information on the ecotrophic niche.

In the adult female, the structural complexity or the richness of sensorial organs do not seem to be correlated with the entomoparassitism, but rather with the selectiveness in the choice of the substratum in which the eggs are laid.

RIASSUNTO

Su alcune strutture e loro funzione in vari Imenotteri Calcidoidei.

Si è molto discusso sulle tappe attraverso le quali un insetto parassitoide perviene alla individuazione dell'ospite. L'ultima rassegna sull'argomento si deve a VINSON (1976) che ha presentato una sintesi in cui sono indicate le connessioni tra le operazioni di selezione e i mezzi con cui esse vengono applicate.

Negli Imenotteri Calcidoidei, che racchiudono i più piccoli e specializzati insetti esistenti, gli studi morfologici, anche quando assai accurati, risentono dei molti limiti posti dal microscopio ottico; conseguentemente anche le osservazioni etologiche su questi insetti ci forniscono notizie approssimative sull'uso dei loro apparati.

Il presente lavoro vuol richiamare l'attenzione sulla importanza del S.E.M. per indagare più intimamente sulle strutture.

L'esplorazione della cuticola con il fascio di elettroni ci rivela infatti una complessità delle appendici, delle produzioni tegumentali e dell'apparato sensorio maggiore di quanto già conosciuto.

Le modificazioni che nelle diverse specie i medesimi strumenti presentano in rapporto ai compiti a cui sono destinati, sono spesso rivelatori di straordinari adattamenti.

Così pure la ricchezza di mezzi in dotazione a questi insetti chiarisce molto dei loro rapporti con l'ambiente e delle loro capacità di ricavare informazioni e sviluppare risposte.

La presente ricerca è rivolta ad indagare su alcune delle strutture di maggior importanza per l'etologia degli Insetti ed in particolare degli Imenotteri Calcidoidei soprattutto per quanto riguarda la selezione dell'ambiente e della nicchia ecotrofica destinata alla prole.

Nelle femmine adulte la complessità di strutture o la ricchezza di sensilli non sembrano correlabili con l'entomoparassitismo quanto piuttosto con la selettività per il substrato in cui sono deposte le uova.

Occhi

Le cornee degli ommatidi di *Trichogramma embryophagum* Htg. presentano minuscole convessità, o minute concavità in *Torymus,* che accrescono la superficie esposta alla luce che ricordano le protuberanze corneali cilindriche di Lepidotteri notturni come *Cydia molesta* Busk aventi l'effetto di ridurre al minimo la riflessione luminosa.

Una soluzione diversa per effetti analoghi è individuabile negli adulti di *Trialeurodes vaporariorum* Westw. (*Homoptera Aleyrodidae*) i cui ommatidi presentano cornea a scultura alveolare. Come il diametro delle protuberanze e delle fossette corneali anche il reticolo dell'ommatidio nell'Aleurodide è così minuto rispetto alla lunghezza d'onda luminosa da non poter influire sulla formazione dell'immagine o la percezione dei colori.

Come nell'ommatidio dei Lepidotteri anche in quello di *T. vaporariorum* Westw. sembrano applicabili le argomentazioni di BERNHARD (1967) sulla transizione graduale dell'indice di rifrazione dell'aria (1) a quello della chitina (1, 57): la differenza tra l'indice di rifrazione dell'aria e quella della parte compatta sottostante della cornea va presumibilmente riducendosi nei rilievi sporgenti soprastanti fino ad avvicinarsi all'indice di rifrazione dell'aria.

Tali strutture appaiono come complesse trappole per la luce tipiche di insetti a prevalente attività notturna; altre di più dubbio significato funzionale si riscontrano in *Foersterella flavipes* (Foerster) e *F. erdoesi* Boucek entrambe che presentano cornee a striature parallele.

Frequente la presenza di setole interommatidiali, mancanti o ridotte nei maschi non volatori: circa la loro funzione vengono ricordate per *Apis mellifera* L. quelle di sensibilità al flusso d'aria e di contribuire alla regolazione del volo.

Antenne

Notevole interesse assume nella femmina la disposizione e l'associazione di sensilli sul lato ventrale della clava disposti a costituire complessi organi sensori che fanno pensare ad un calco per saggiare un certo modello di substrato (*Torymus varians* Walker, *Anastatus bifasciatus* Fonsc., *Pteromalus puparum* L., *Ooencyrtus* sp.).

Nei maschi vi sono casi in cui vi è una concentrazione dei sensilli all'apice della clava (*Ooencyrtus* sp., *Blastophaga psenes* L.) mentre in taluni gruppi particolari tipi di sensilli sono notoriamente disposti solo sul lato ventrale della clava.

Zampe

Numerose formazioni tibio-tarsali appaiono specializzate nella pulizia delle antenne e del corpo come in *Torymus varians* Walker, *Ooencyrtus* sp., *Foersterella flavipes* (Foerster), *F. erdoesi* Boucek. Più modificati all'ambiente ed alle esigenze etologiche sono i pretarsi. Nei Calcidoidei i pretarsi sono per lo più rispondenti al tipo diffuso negli Imenotteri. Una coppia di unghie semplici, un unguiretrattore, un arolio sul cui dorso non sempre è differenziata la placca detta orbicula.

L'arolio è membranoso, estroflettibile per una porzione distale di varia entità: interamente membranoso e costituente una sorta di cuscinetto di notevoli proporzioni in talune specie (*Trichogramma embryophagum* Htg., *Foersterella flavipes* (Foerster) e *F. erdoesi* Boucek) o in gran parte sclerificata e pelosa con una più modesta parte distale glabra raramente estroflessa (*Torymus varians* Walker, *Pteromalus puparum* L., *Blastophaga psenes* L. femmina).

Un Braconide parassita oolarvale, l'*Ascogaster quadridentatus* Wesm. presenta un arolio dall'aspetto di una grande vescica bilobata, pressata sul substrato da una triangolare, ampia orbicula.

Nel maschio di *Blastophaga psenes* L. l'arolio è ridotto ad una sporgenza callosa, sormontato alla base da una forte setola, mentre due unghie robuste formano con gli altri tarsomeri e con la produzione unguiforme all'apice delle tibie un eccezionale mezzo di attacco alla galla in cui è racchiusa la femmina.

Ovopositore

L'esistenza di sensilli sugli stiletti della terebra attraverso gli studi più recenti con i microscopi elettronici si è andata confermando.

La cautela nell'indicarne la presenza sulla base di dati morfologici o di deduzioni sperimentali è derivata in passato dalla natura stessa degli stiletti, lunghe appendici cuticolari trasparenti e apparentemente amorfe.

Sensilli di varia struttura sono riscontrati sia sulla superficie esterna delle valve e degli stiletti sia su quella interna (*Torymus varians*). Analoga presenza di sensilli viene osservata all'apice dell'ovopositore di sostituzione di un Dittero Tripetide *Rhagoletis cerasi* L.

EXPLANATION OF FIGURES

FIG. 1 - *Torymus varians* (Walk.) (Hymenoptera Torymidae).
Top left: the female, having reached the small unripe fruit, cleans the flagellum of the antennae with which it sets out to explore the surface.
Top right: having found a fruit answering to its needs, after it has felt the surface with the third valvulae, the insect begins drilling with the stylets of the terebra; the feet are spread apart and the abdomen curved because of the initial thrust.
Bottom: three moments in the laying of the eggs, during which the abdomen is rolled up and the stylets, already disconnected from the third valvulae are pushed in to an increased depth so as to reach one of the seeds of the apple. The narrowing of the angle between the femurs and tibiae will be noted, together with the curving of the third valvulae, while the stylets steadily sink into the mesocarp. During the entire operation the antennae are held vertical and almost immobile, as if tensed to perceive vibrations or any other occurrence.

Torymus varians (Walk.). A sinistra: la femmina, pervenuta su di un piccolo frutto acerbo, si pulisce il funicolo antennale con cui inizia ad esplorare la superficie.
A destra: dopo aver tastato la superficie del frutto con le terze valve e avendolo trovato rispondente alle sue necessità, l'insetto inizia a trivellarlo con gli stiletti della terebra; le zampe sono tenute allargate e l'addome curvato per iniziare la perforazione.
In basso: tre momenti nella deposizione delle uova durante i quali l'addome viene fatto ruotare e gli stiletti, sempre separati dalle terze valve, sono spinti a crescente profondità fino a raggiungere un seme lattescente della mela. Si osservi il restringersi degli angoli formati dalle articolazioni femori-tibie insieme con il curvarsi delle terze valve, mentre gli stiletti si affondano progressivamente nel mesocarpo.
Durante l'intera operazione le antenne sono tenute verticali e quasi immobili, come tese a percepire vibrazioni o altri eventi.

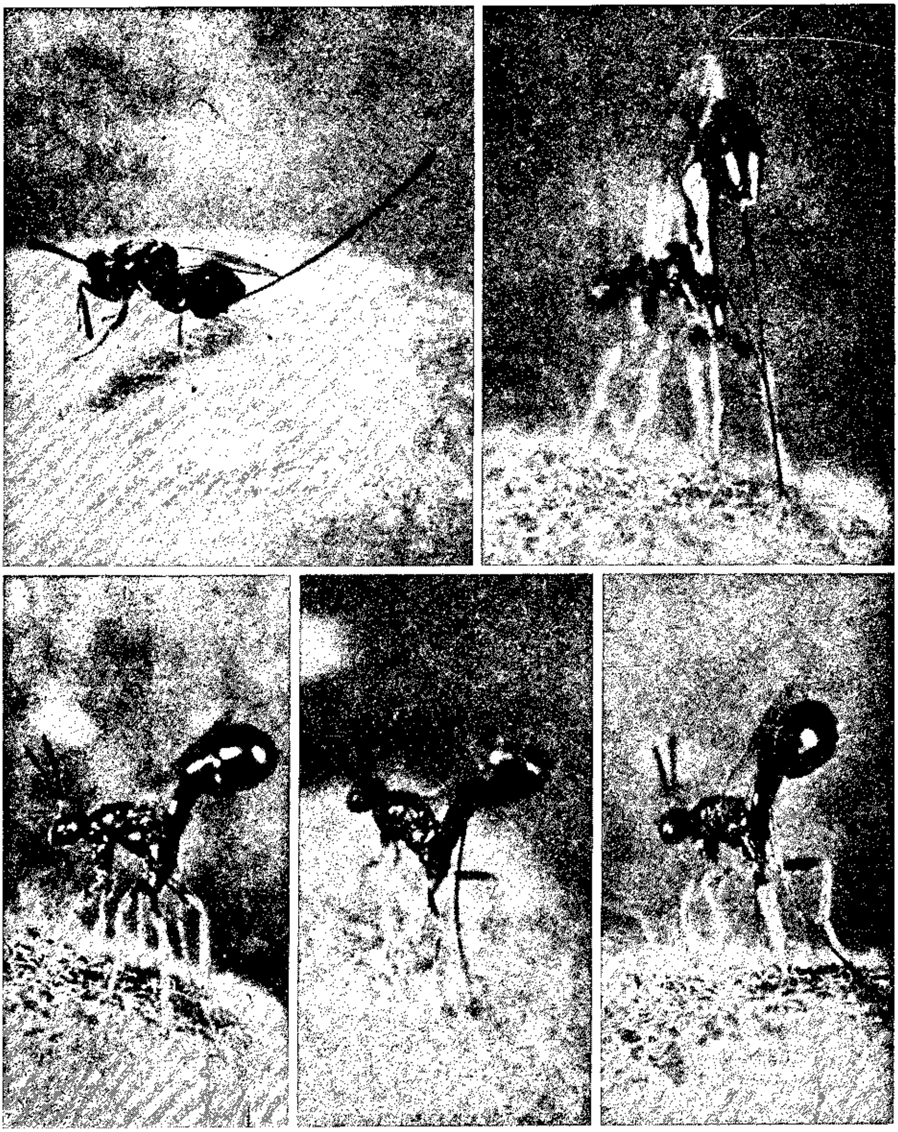


FIG. 2 - *Cydia pomonella* (L.) (Lepidoptera Tortricidae). Female. Ommatidia seen from the front (top) and from three-quarters (below, on the left). Below, at the right, detail of an ommatidial cornea (x 10000).

Cydia pomonella (L.) (Lepidoptera Tortricidae). Femmina. Ommatidi visti di fronte (in alto) e di tre quarti (in basso a sinistra). Jn basso a destra, particolare della cornea di un ommatidio (x 10.000).

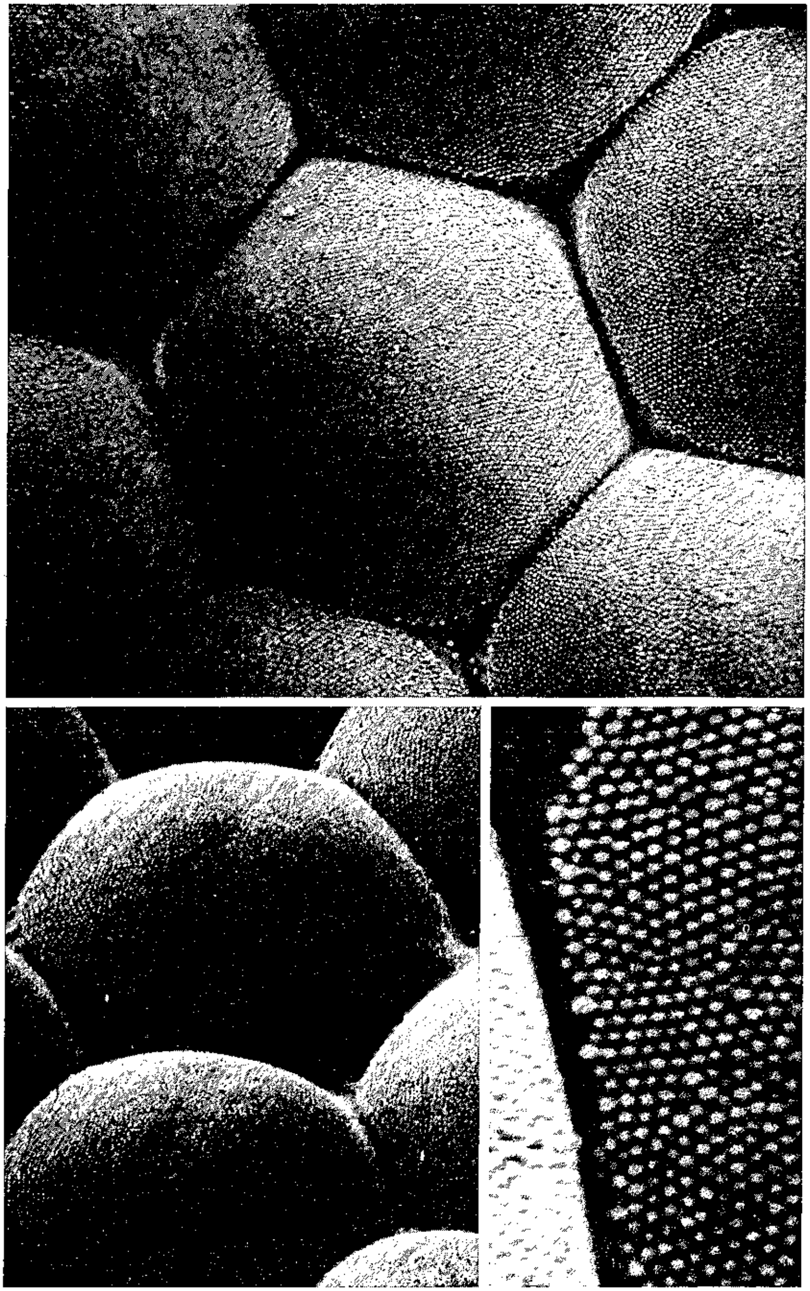


FIG. 3 - *Trialeurodes vaporariorum* (Westw.) (Homoptera Aleyrodidae). Female. Ommatidia seen at different enlargements (x 2800, top; x 6000, below on the left). Below on the right, corneal surface of an ommatidium (x 10000). In the top photograph, groups of glandular hairs are evident, they are similar to those that cover a large part of the body. A small globule of wax is emitted from the apex of hairs.

Trialeurodes vaporariorum (Westw.) (Homoptera Aleyrodidae). Femmina. Ommatidi visti a ingrandimenti diversi (x 2.800, in alto, x 6.000 in basso a sinistra). In basso a destra, superficie corneale di un ommatidio (x 10.000). Nella foto in alto, si evidenziano gruppi di peli ghiandolari sormontati apicalmente da una goccia di materiale ceroso; peli ghiandolari simili ricoprono gran parte del corpo.

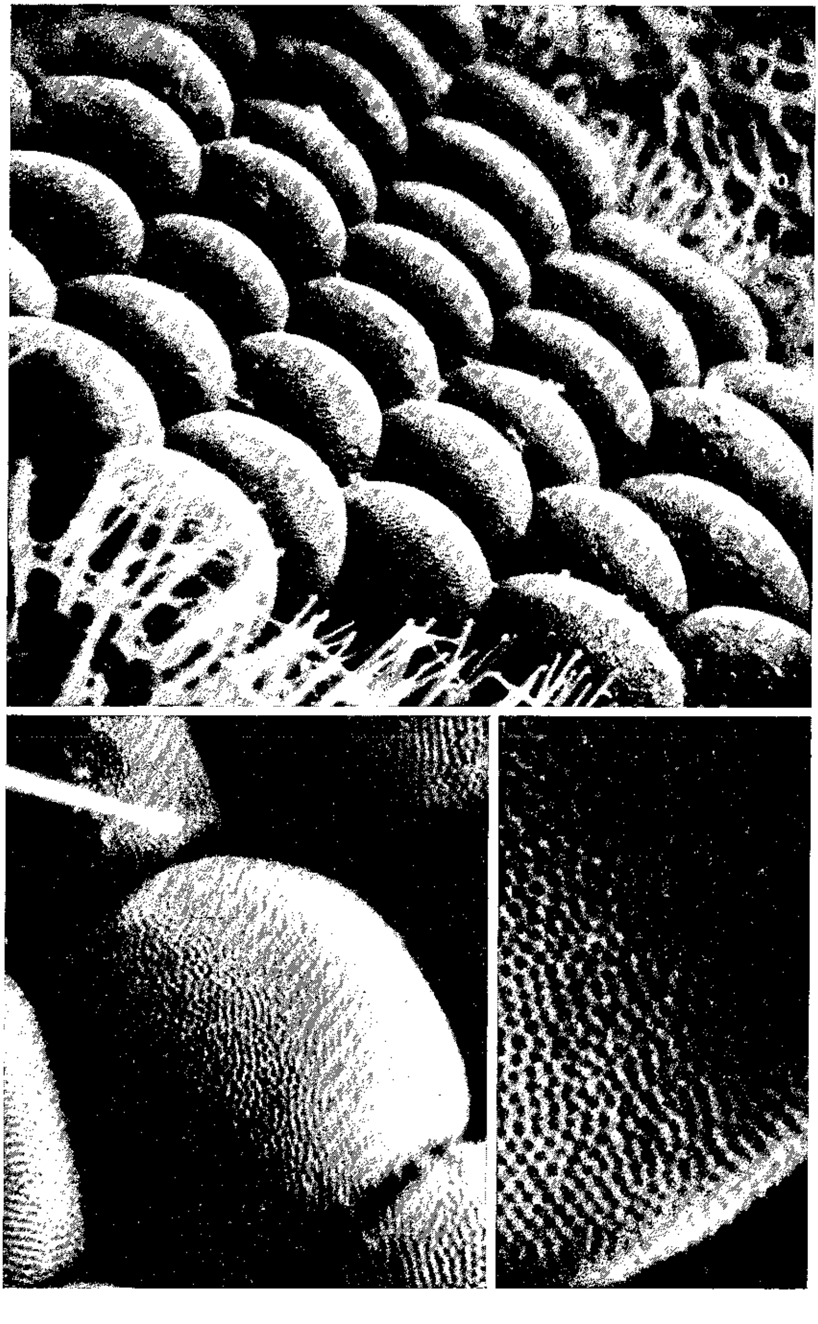


FIG. 4 - *Trichogramma embryophagum* Hart. (Hymenoptera Trichogrammatidae). Female. Top: part of a complex eye (x 2000). Below: corneal surface of an ommatidium (x 10000, on the left and x 28000, on the right).

Trichogramma embryophagum Hart. (Hymenoptera Trichogrammatidae). Femmina. In alto: parte di un occhio composto (x 2.000). In basso: superficie corneale di un ommatidio (x 10.000, a sinistra e x 28.000 a destra).

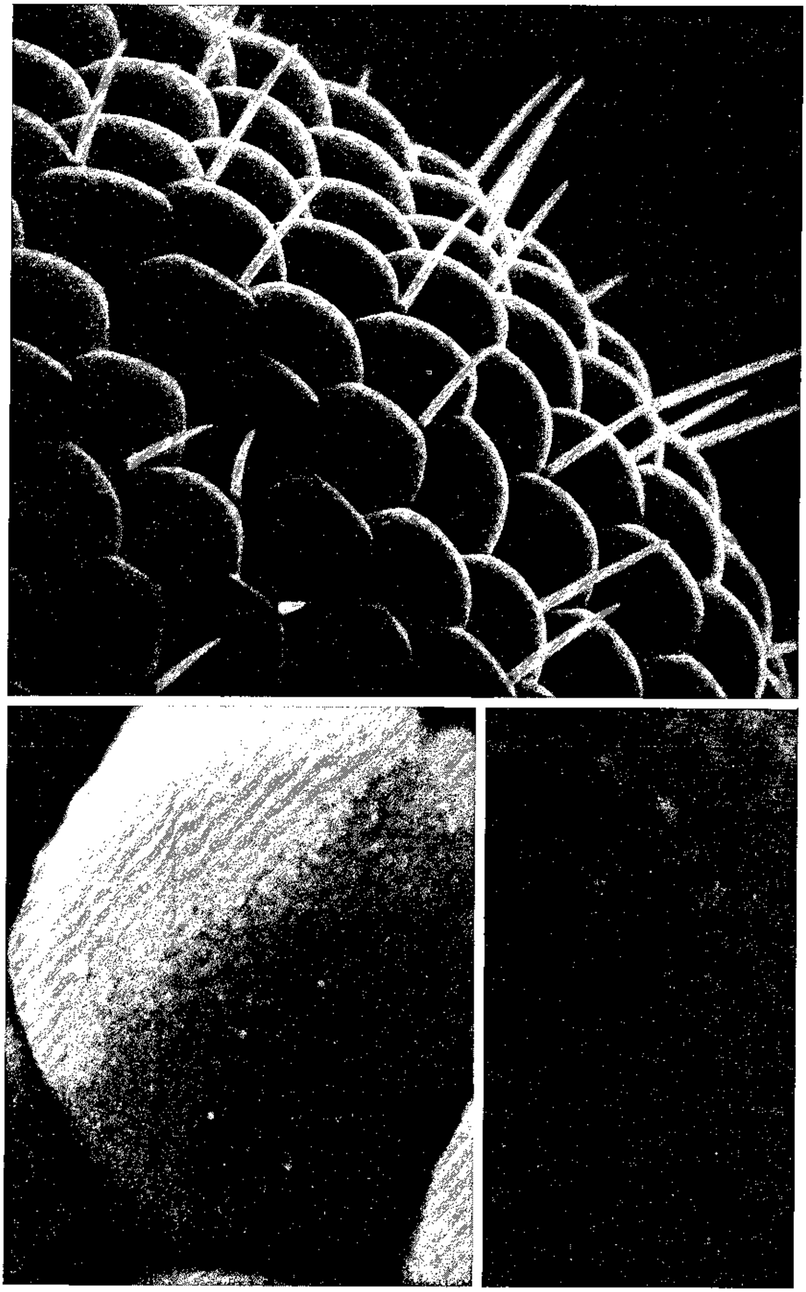


FIG. 5 - *Foersterella flavipes* (Foerst.) (Hymenoptera Tetracampidae). Female. Ommatidia at different enlargements (top, x 2800 below, x 6000).

Foersterella flavipes (Foerst.) (Hymenoptera Tetracampidae). Femmina. Ommatidi a ingrandimenti diversi (x 2.800 in alto e x 6.000 in basso).

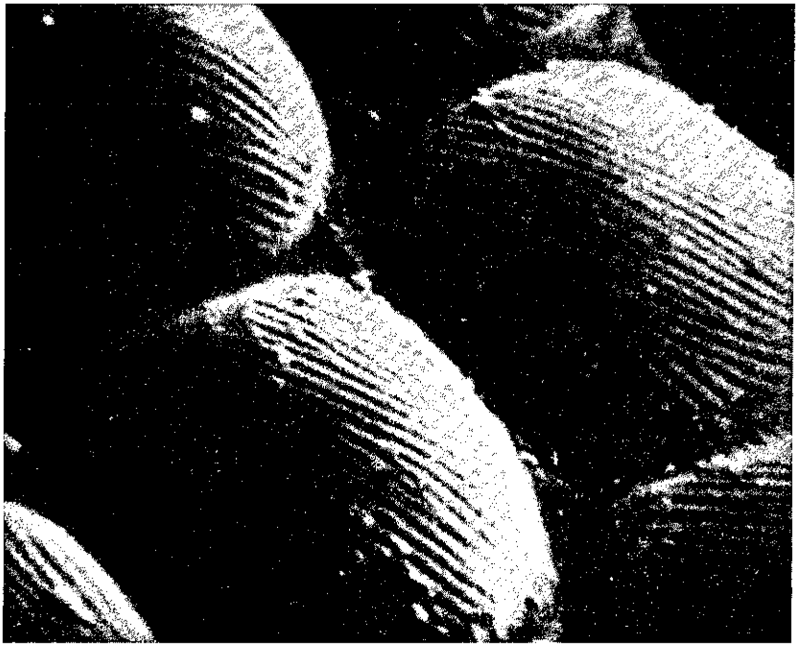
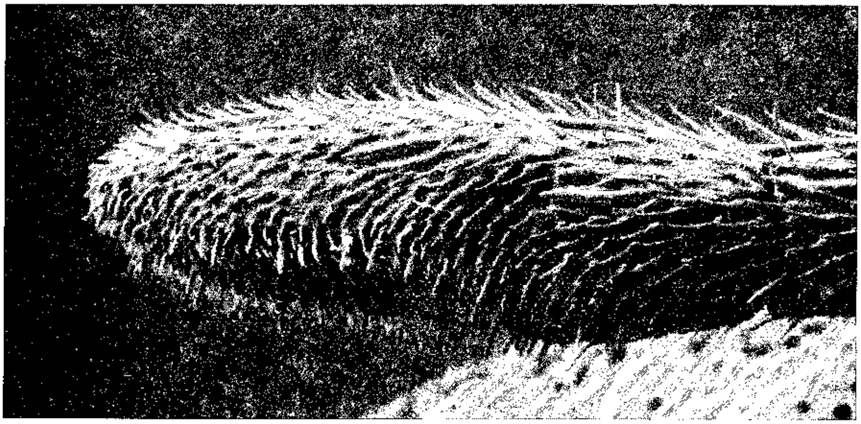


FIG. 6 - *Ooencyrtus* sp. (Hymenoptera Encyrtidae). Female. Antennal club seen from profile view (top, x 400) and from the apex and slightly from the ventral angle (below, x 1000).

Ooencyrtus sp. (Hymenoptera Encyrtidae). Femmina. Clava antennale vista di profilo (in alto, x 400) ed apicalmente e un poco ventralmente (in basso, x 1.000).



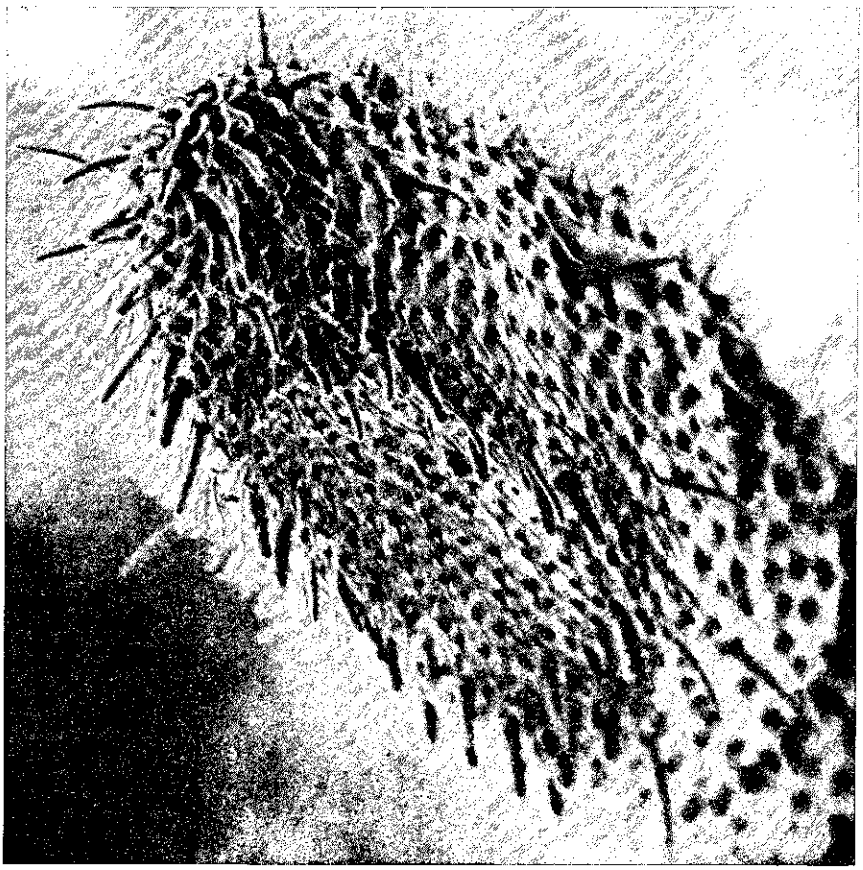
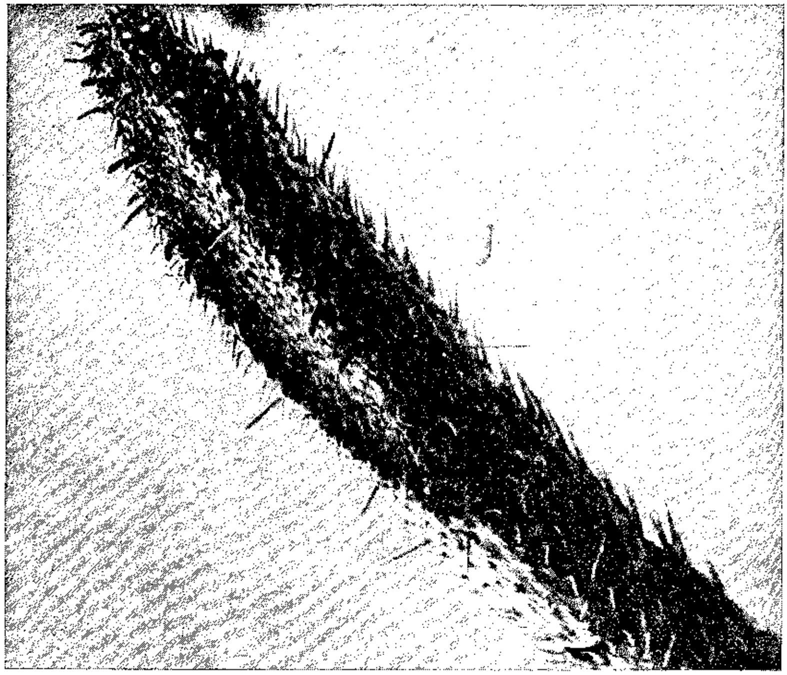


FIG. 7 - *Ooencyrtus* sp. (Hymenoptera Encyrtidae). Female. Antennal club, seen from the ventral angle (top, x 600). Below, detail of the top photograph (x 1850).

Ooencyrtus sp. (Hymenoptera Encyrtidae). Femmina. Clava antennale, vista dal ventre (in alto, x 600). In basso, particolare della foto precedente (x 1.850).



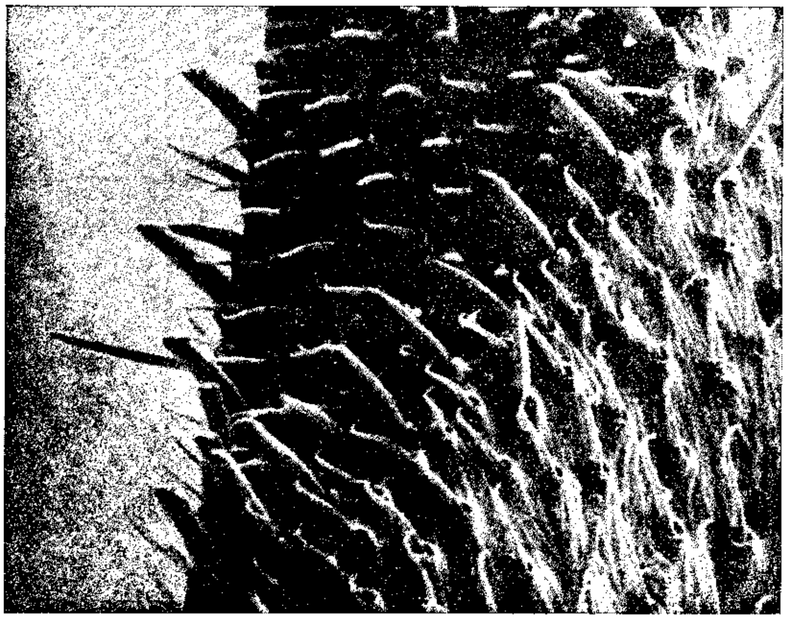
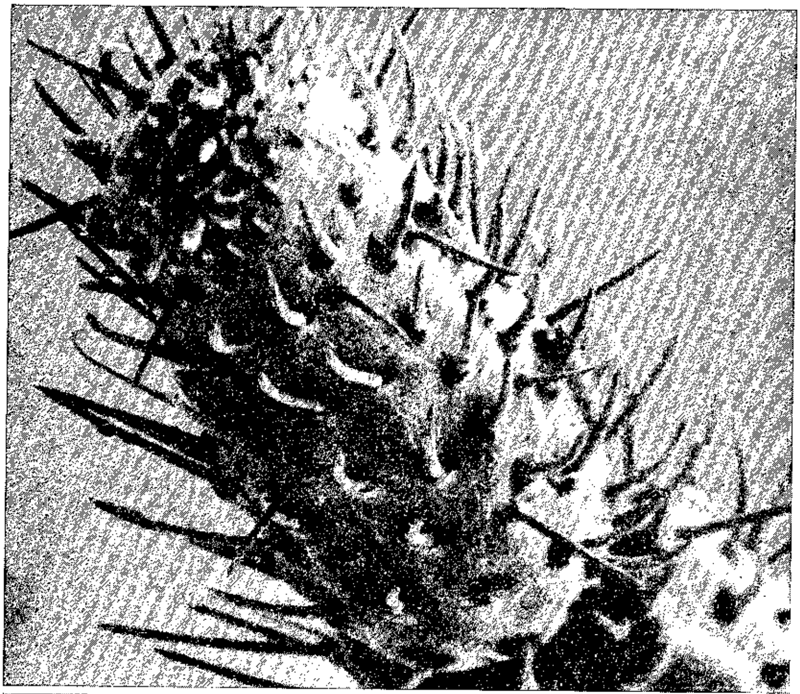


FIG. 8 - *Ooencyrtus* sp. (Hymenoptera Encyrtidae). Male. Antennal club seen from the ventral angle (top, x 1000). The same seen from the apex (below, x 1100).

Ooencyrtus sp. (Hymenoptera Encyrtidae). Maschio. Clava antennale vista ventralmente (in alto, x 1.000). La stessa vista apicalmente (x 1.100).



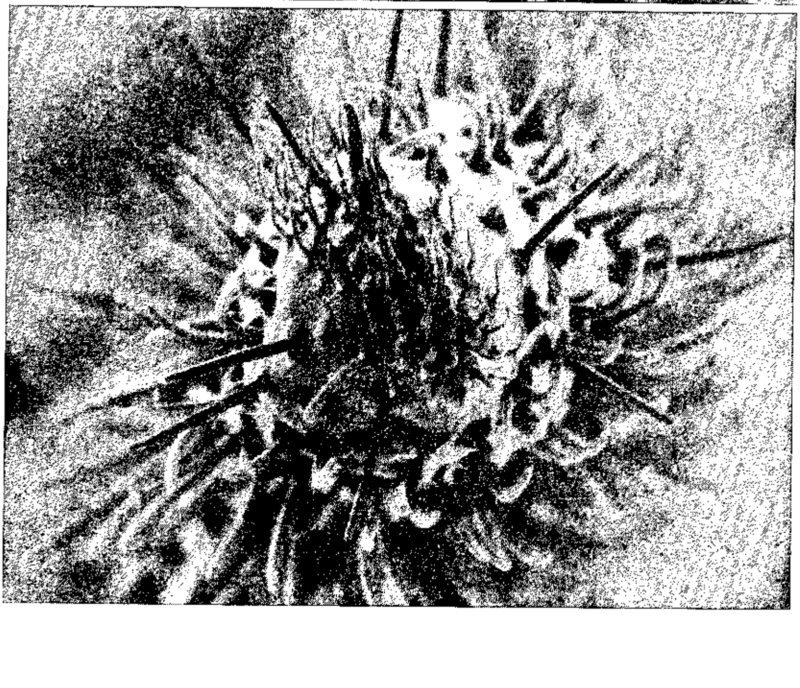


FIG. 9 - *Torymus varians* (Walker) (Hymenoptera Torymidae). Female. Top: ventral surface of the antennal club (x 600). Below: pre-apex group of sensilla of the antennal club (x 3000).

Torymus varians (Walker). (Hymenoptera Torymidae). Femmina. In alto: superficie ventrale della clava antennale (x 600). In basso: gruppo preapicale di sensilli della clava antennale (x 3.000).

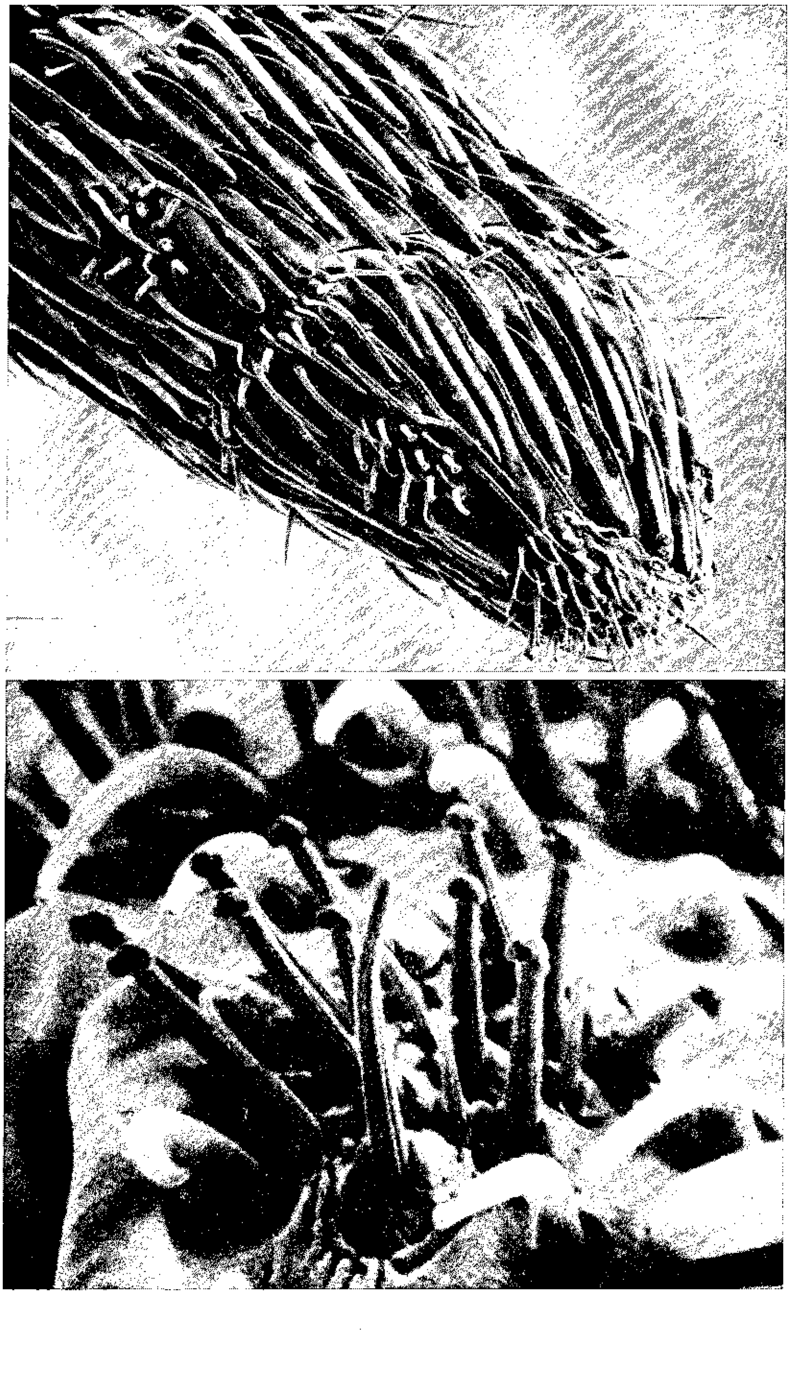
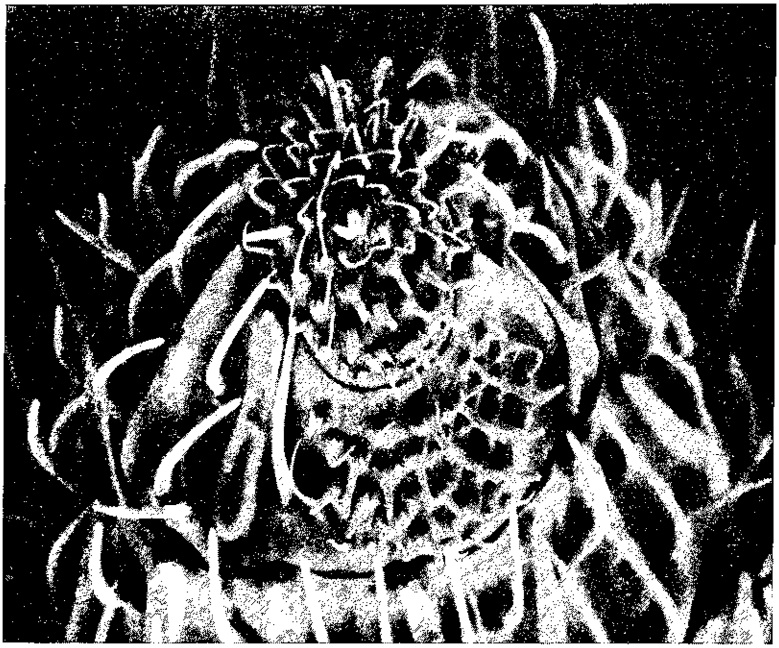


FIG. 10 - Top: *Pteromalus puparum* L. (Hymenoptera Pteromalidae). Female. Antennal club seen from the apex and slightly from the ventral angle (x 1100).

Below: *Anastatus bifasciatus* Fonsc. (Hymenoptera Eupelmidae). Female. Antennal club seen from the apex and slightly from the ventral angle (x 2300).

In alto: *Pteromalus puparum* L. (Hymenoptera Pteromalidae). Femmina. Clava antennale vista apicalmente e un poco ventralmente (x 1.100).

In basso: *Anastatus bifasciatus* Fonsc. (Hymenoptera Eupelmidae). Femmina. Clava antennale, vista apicalmente e un poco ventralmente (x 2.300).



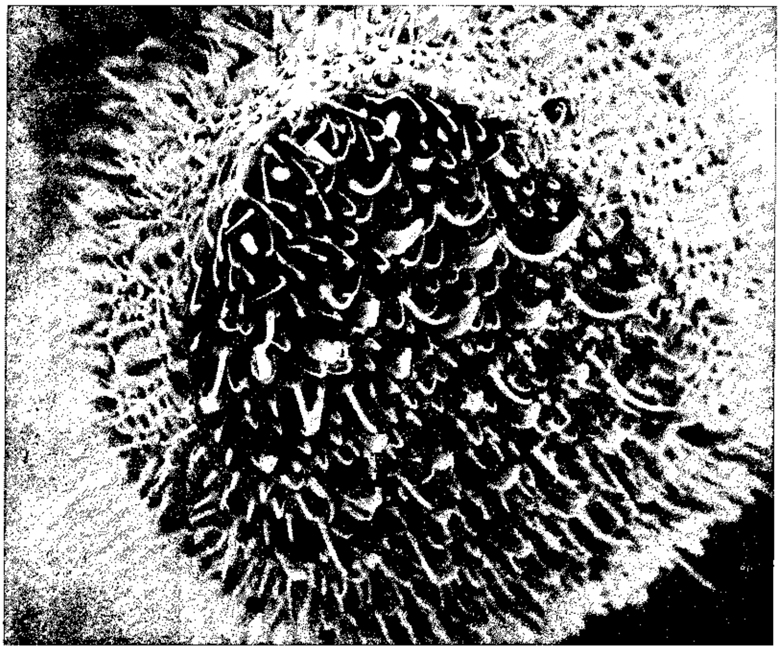


FIG. 11 - *Blastophaga psenes* L. (Hymenoptera Agaonidae). Male. Head and part of the prothorax, seen from the abdomen (x 200). The complex eyes can be seen, without the hairs that we usually find between the ommatidia. In the cavities there can be seen numerous clumps of pollen coming from the receptacle of the *Ficus carica* in which the insect developed. Bottom: the antenna funiculus seen from the apex (x 1000). In both the photographs the terminal article of the club has collapsed, but this is only as a result of preparation.

Blastophaga psenes L. (Hymenoptera Agaonidae). Maschio. Capo e parte del protorace, visti dal ventre (x 200). Si notano gli occhi composti privi dei peli che usualmente sono collocati fra gli ommatidi. Nelle cavità sono presenti numerose masserelle di polline proveniente dal ricettacolo del *Ficus carica* in cui l'insetto si è sviluppato. In basso, funicolo antennale visto apicalmente (x 1.000); in entrambe le foto, l'articolo apicale della clava è afflosciato, anomalo, per effetto della preparazione.

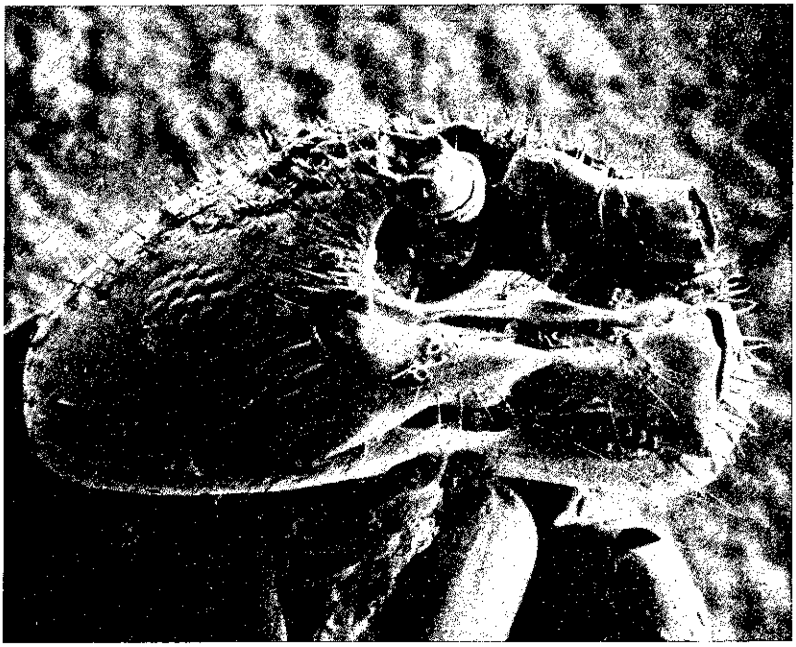


FIG. 12 - Top: *Foersterella flavipes* (Foerster) (Hymenoptera Tetracampidae). Male. Head and prothorax seen from the front slightly ventrally. The specimen is in the act of cleaning the left antennal club with the antenna cleaner of its front foot on the same side (x 250). Bottom: *Ooencyrtus* sp. (Hymenoptera Encyrtidae). Male. Distal apex of the front tibia and first segment of the tarsus, profile view (x 1000).

In alto: *Foersterella flavipes* (Foerster) (Hymenoptera Tetracampidae). Maschio. Capo e protorace visti frontalmente e un poco ventralmente. L'individuo è in atto di pulire la clava antennale sinistra con la stregghia della zampa anteriore (x 250) del medesimo lato.

In basso: *Ooencyrtus* sp. (Hymenoptera Encyrtidae). Maschio. Apice distale della tibia anteriore e primo tarsomero visti di profilo, dal lato interno (x 1.000).

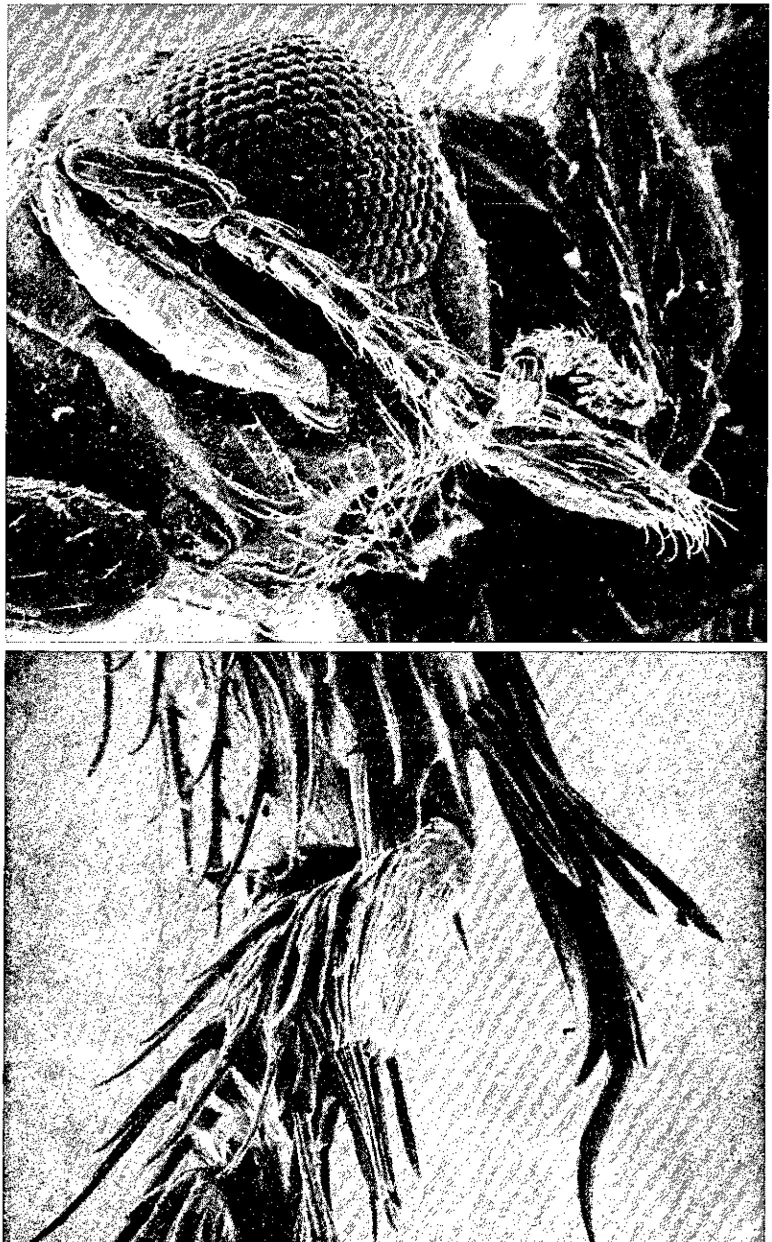
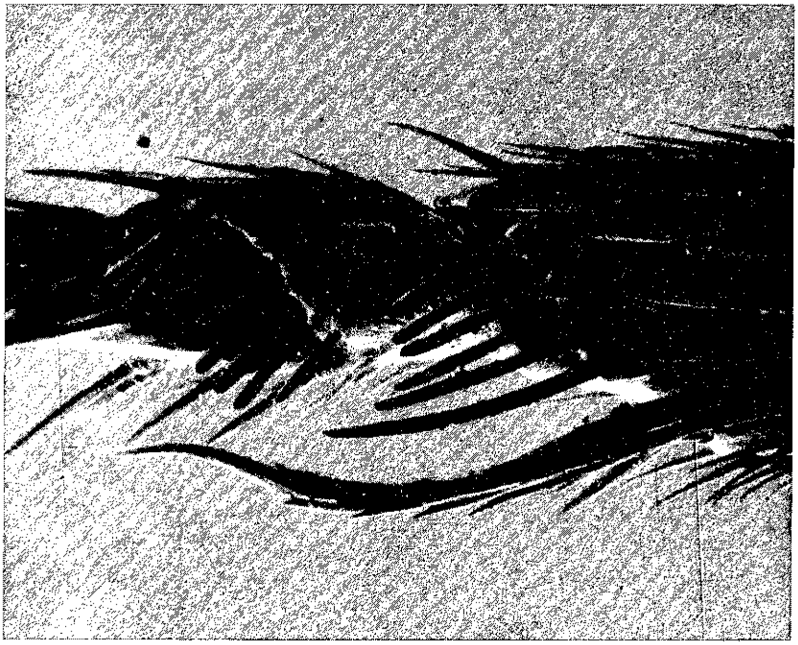


FIG. 13 - Top: *Ooencyrtus* sp. (Hymenoptera Encytidae). Male. Distal apex of the tibia and first segment of the tarsus, seen from profile view and outside (x 900). Below: *Foersterella erdoesi* Boucek (Hymenoptera Tetracampidae). Male. Distal apex of the front tibia and first segment of the tarsus, seen from profile view and outside (x 1100).

In alto: *Ooencyrtus* sp. (Hymenoptera Encyrtidae). Maschio. Apice distale della tibia e primo tarsomero, visti di profilo e dal lato esterno (x 900).

In basso: *Foersterella erdoesi* Boucek (Hymenoptera Tetracampidae). Maschio. Apice distale della tibia anteriore e primo tarsomero, visti di profilo, dal lato esterno (x 1.100).



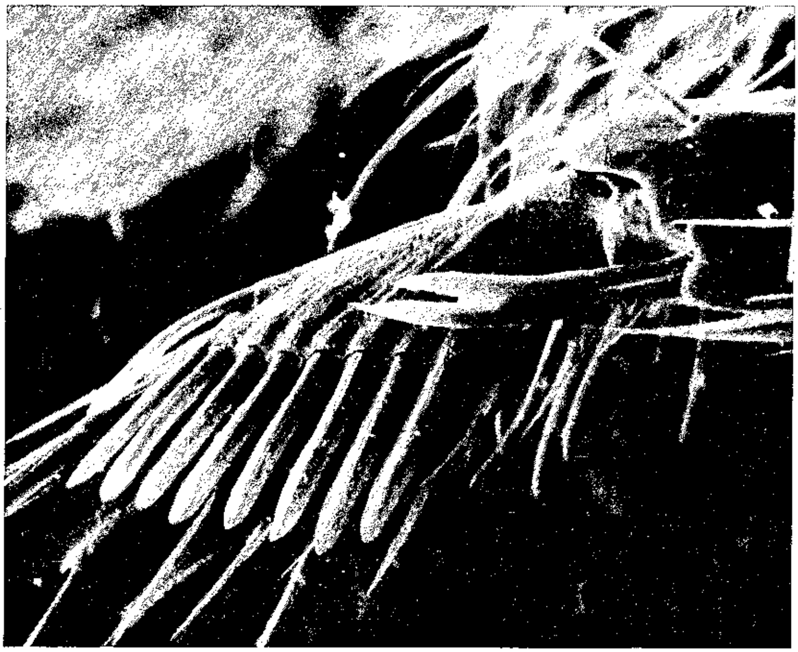


FIG. 14 - *Torymus varians* (Walker) (Hymenoptera Torymidae). Female. Top: distal apex of the front tibia and part near the first segment of the tarsus seen from the inside (x 350). Below: the same parts of the former photograph seen from three-quarters and from the front (x 650).

Torymus varians (Walker) (Hymenoptera Torymidae). Femmina. In alto: apice distale della tibia anteriore e parte prossimale del primo tarsomero visti dal lato interno (x 350). In basso: le stesse parti della fotografia che precede, viste anteriormente e di tre-quarti (x 650).

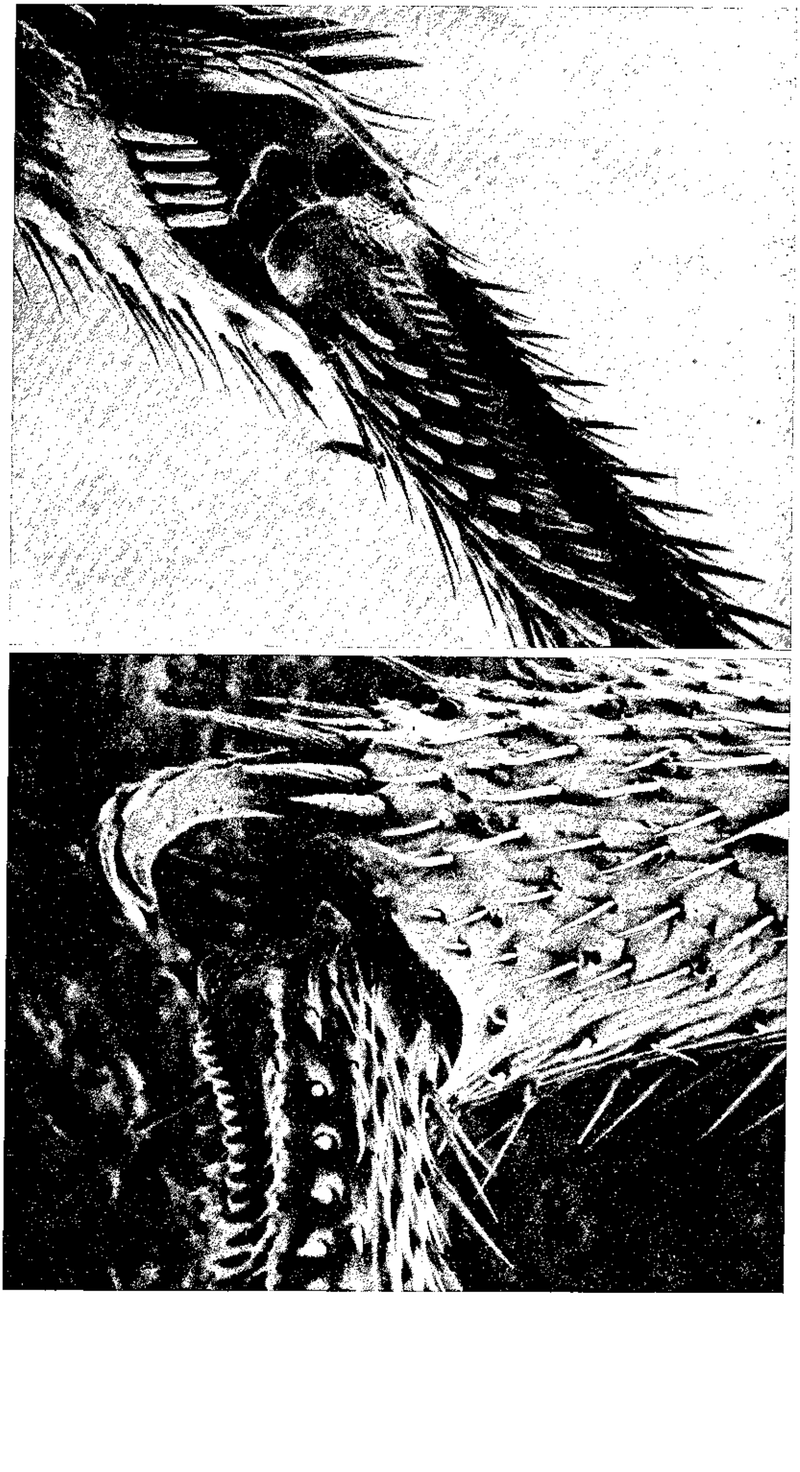


FIG. 15 - *Blastophaga psenes* L. (Hymenoptera Agaonidae). Male. Top: distal apex of the tibia and front segments of the tarsus seen ventrally (x 550). Bottom: apex of the front metatarsus and pretarsus seen from the apex (x 1400). Two grains of pollen will be noticed in the cavities between metatarsus and pretarsus.

Blastophaga psenes L. (Hymenoptera Agaonidae). Maschio. In alto: apice distale della tibia e tarsomeri anteriori visti ventralmente (x 550). In basso: apice del metatarso e pretarso anteriori visti apicalmente (x 1.400). Si notino nelle cavità tra metatarso e pretarso due granuli di polline.

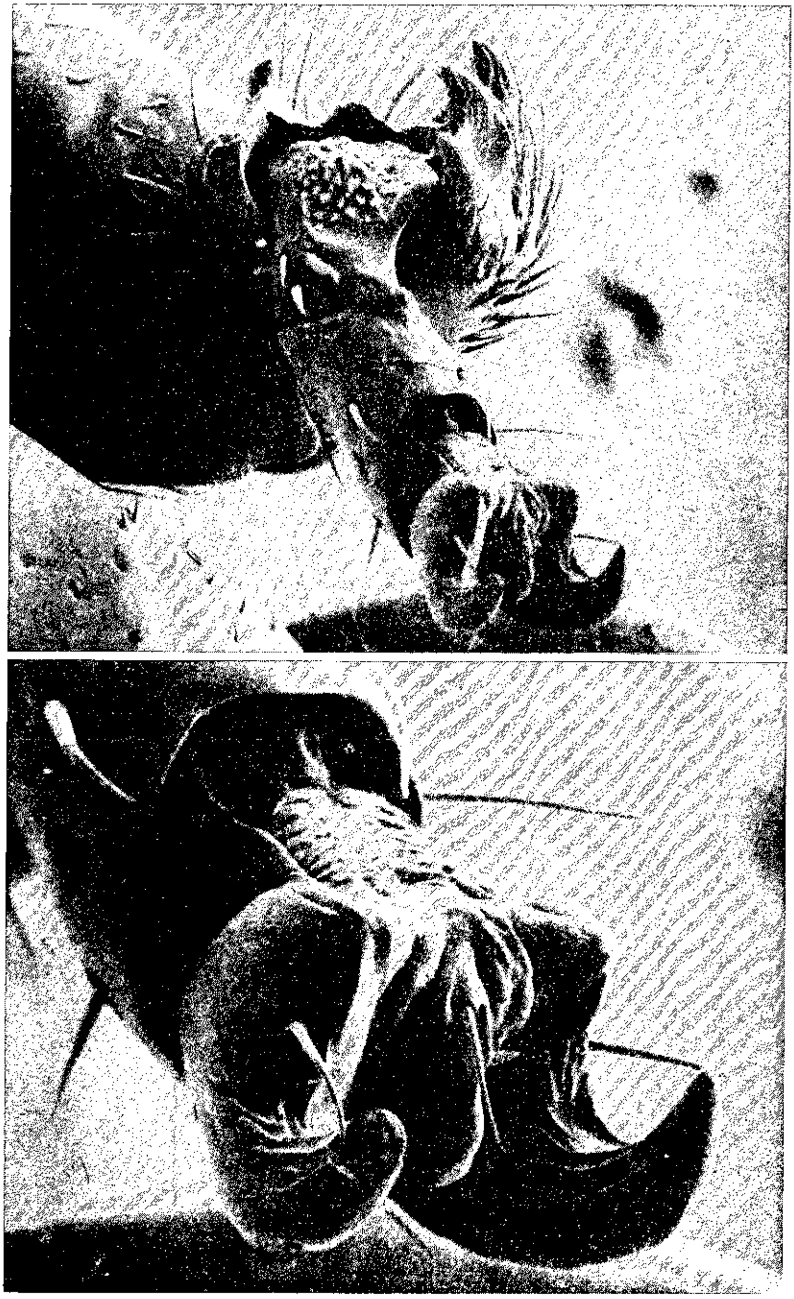


FIG. 16 - *Torymus varians* (Walker) (Hymenoptera Torymidae). Female. Top: distal apex of the median tibia and part near the first segment of the tarsus seen from the inside and from the front (x 600). Below: distal apex of the back tibia and part near the first segment of the tarsus, seen from the front (x 300).

Torymus varians (Walker) (Hymenoptera Torymidae). Femmina. In alto: apice distale della tibia media e parte prossimale del primo tarsomero, visti dal lato interno e anteriormente (x 600). In basso: apice distale della tibia posteriore e parte prossimale del primo tarsomero, visti anteriormente (x 300).

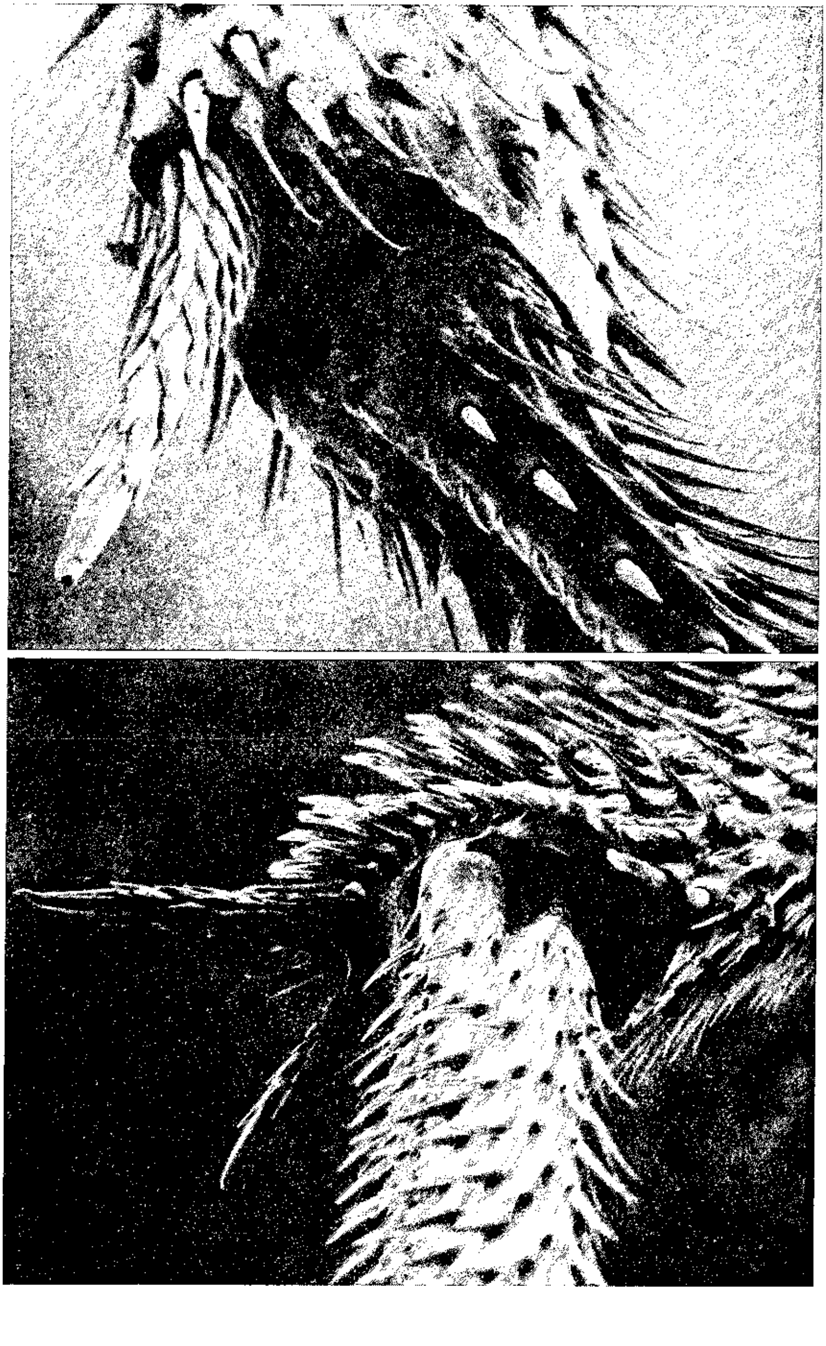
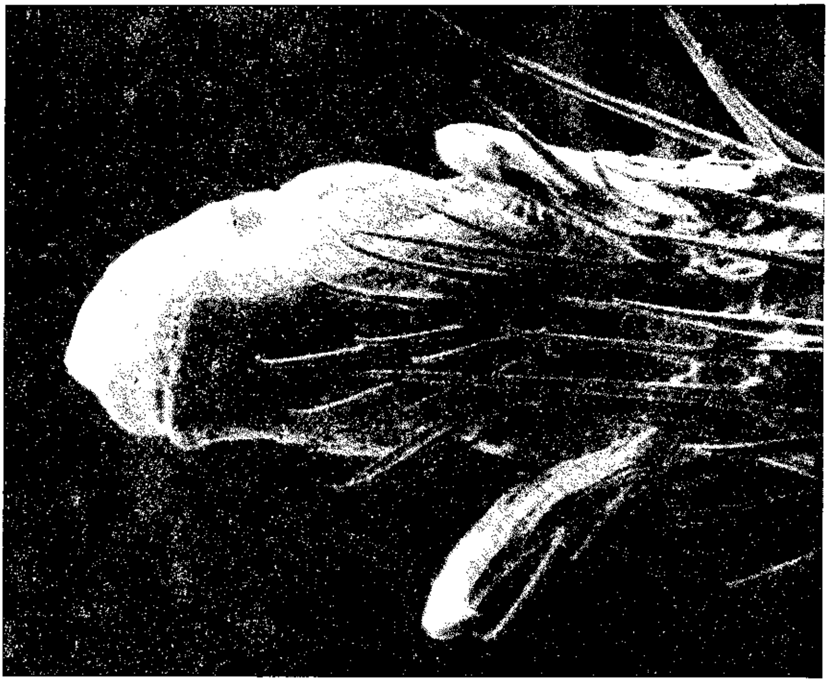


FIG. 17 - *Torymus varians* (Walker) (Hymenoptera Torymidae). Female. Top: apex of the front metatarsus and pretarsus seen from the ventral angle (x 600). Below: *Blastophaga psenes* L. (Hymenoptera Agaonidae). Female. Apex of the back metatarsus and pretarsus, seen from the ventral angle (x 1100).

Torymus varians (Walker) (Hymenoptera Torymidae). Femmina. In alto: apice del metatarso e pretarso anteriori visti ventralmente (x 600).

In basso: *Blastophaga psenes* L. (Hymenoptera Agaonidae). Femmina. Apice del metatarso e pretarso posteriori, visti ventralmente (x 1.100).



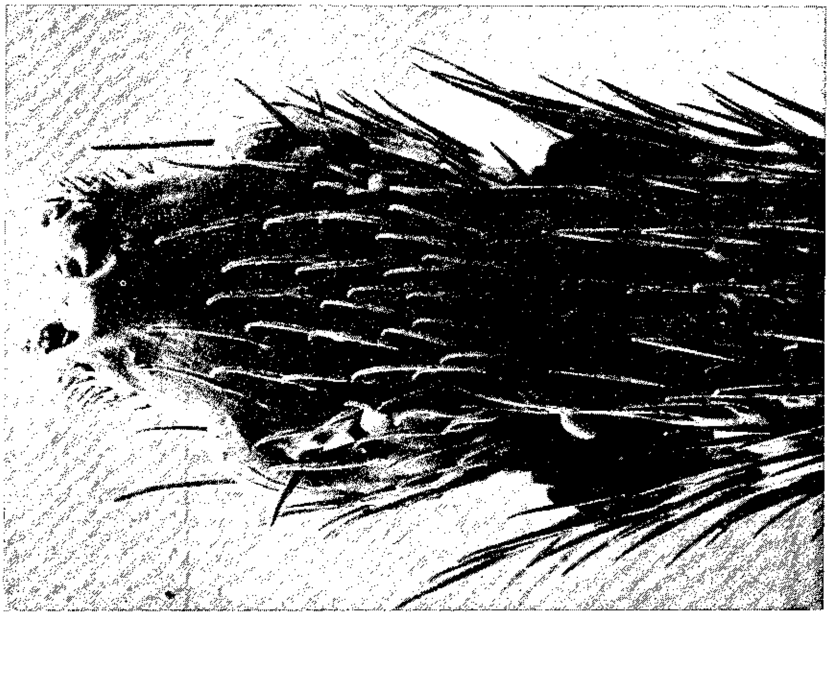


FIG. 18 - *Pteromalus puparum* L. (Hymenoptera Pteromalidae). Female. Top: apex of the back metatarsus and pretarsus, seen from three-quarters and slightly ventrally (x 900). Below: pretarsus of the middle leg seen from the ventral angle (x 1400).

Pteromalus puparum L. (Hymenoptera Pteromalidae). Femmina. In alto: apice del metatarso e pretarso posteriori, visti di tre-quarti e un poco ventralmente (x 900). In basso: pretarso della zampa mediana vista ventralmente (x 1.400).

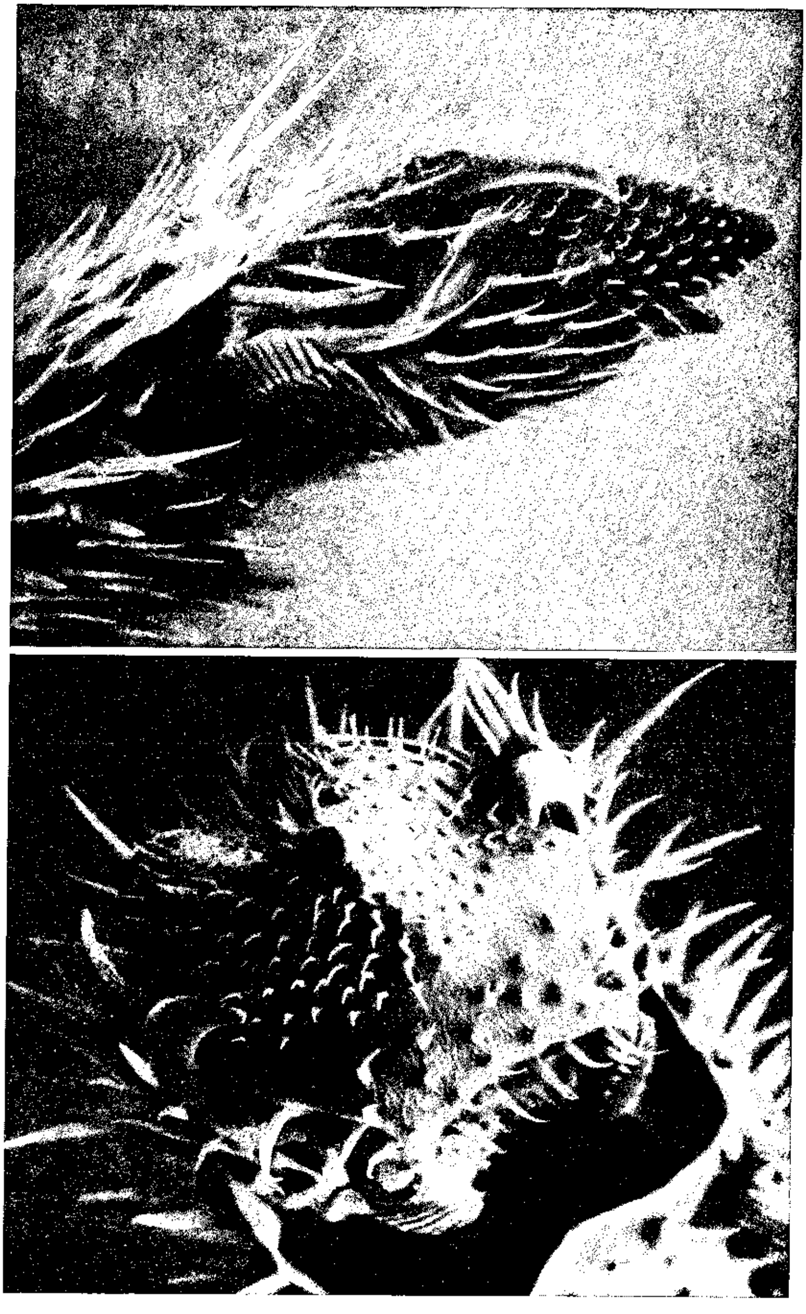


FIG. 19 - *Ascogaster quadridentatus* Wesm. (Hymenoptera Braconidae). Female. Apex of the metatarsus and pretarsus seen from three-quarters, slightly dorsally (top, x 600) and ventrally (below, x 600).

Ascogaster quadridentatus Wesm. (Hymenoptera Braconidae). Femmina. Apice del metatarso e pretarso visti di tre-quarti, un poco dorsalmente (sopra x 600) e ventralmente (sotto x 600).

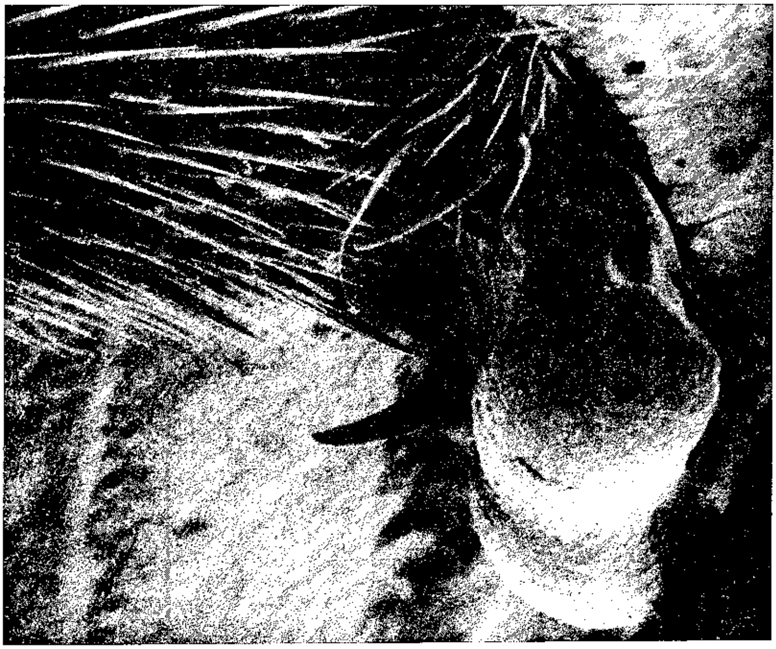


FIG. 20 - Top: *Ascogaster quadridentatus* Wesm. (Hymenoptera Braconidae). Female. Apex of the median metatarsus and pretarsus seen ventrally (x 650).

Bottom: *Foersterella flavipes* Foerter (Hymenoptera Tetracampidae). Female. Apex of the front metatarsus and pretarsus, seen from three-quarters and pretarsus, seen from three-quarters and slightly from the ventral angle (x 200).

Sopra: *Ascogaster quadridentatus* Wesm. (Hymenoptera Braconidae). Femmina. Apice del metatarso e pretarso mediani, visti ventralmente (x 650).

Sotto: *Foersterella flavipes* Foerster (Hymenoptera Tetracampidae). Femmina. Apice del metatarso e pretarso anteriori, visti di tre-quarti e un poco ventralmente (x 200).

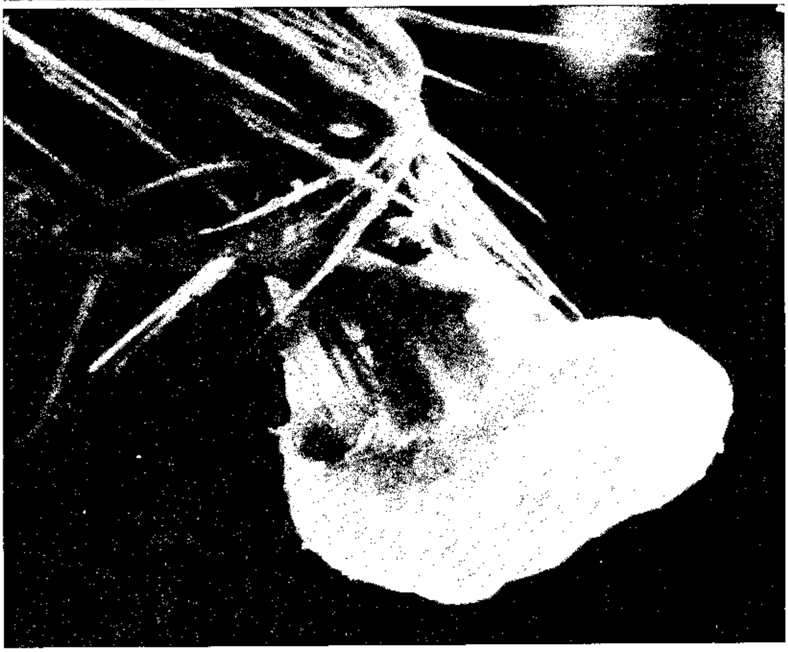


FIG. 21 - *Torymus varians* (Walker) (Hymenoptera Torymidae).
Third valvulae of the right side of the terebra, seen from the inside in two tracts, one proximal (bottom) and one below the apex (top) to show the hollow surface (x 900).

Torymus varians (Walker) (Hymenoptera Torymidae). Terza valva del lato destro della terebra, vista dall'interno in due tratti, uno prossimale (in basso) ed uno subapicale (in alto) per mostrarne la superficie concava (x 900).

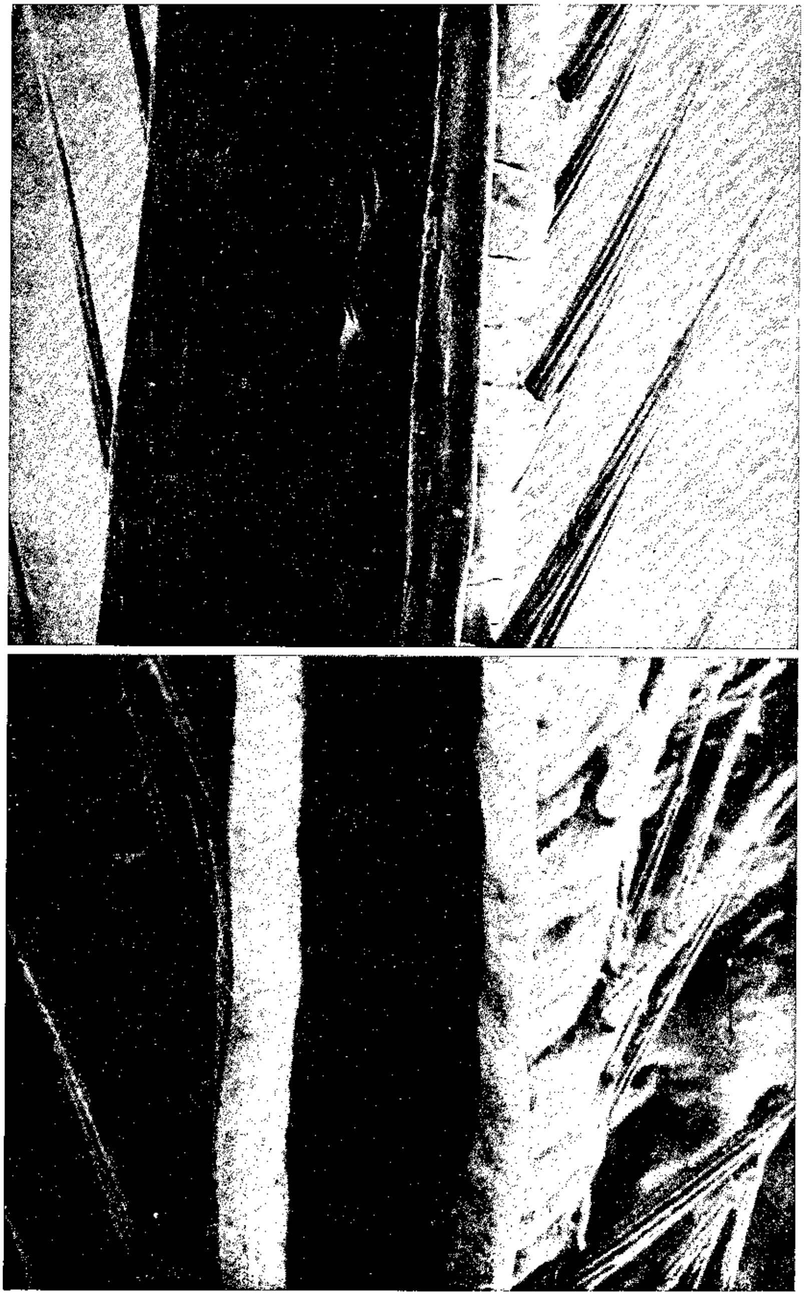


FIG. 22 - *Torymus varians* (Walker) (Hymenoptera Torymidae). Top: distal extremity of the terebra of the ovipositor seen slightly from the apex and ventral angle. Between the two teeth on the left and on the back of the terebra (situated above the stylets, deliberately spread apart), one of the sensilla is visible. Other sensilla of the same type are present on the stylets (x 900). Below: detail of the top photograph, with the part below the apex of a stylet on which are situated two sensilla (x 3000).

Torymus varians (Walker) (Hymenoptera Torymidae). In alto: estremità distale della terebra dell'ovopositore visto un poco ventralmente e apicalmente. Tra i due denti visibili a sinistra e dorsalmente sulla terebra (situata sopra gli stiletti, divaricati ad arte) è visibile uno dei sensilli. Altri sensilli dello stesso tipo sono presenti sugli stiletti (x 900). Sotto: particolare della foto in alto, con la parte subapicale di uno stiletto su cui sono situati due sensilli (x 3.300).

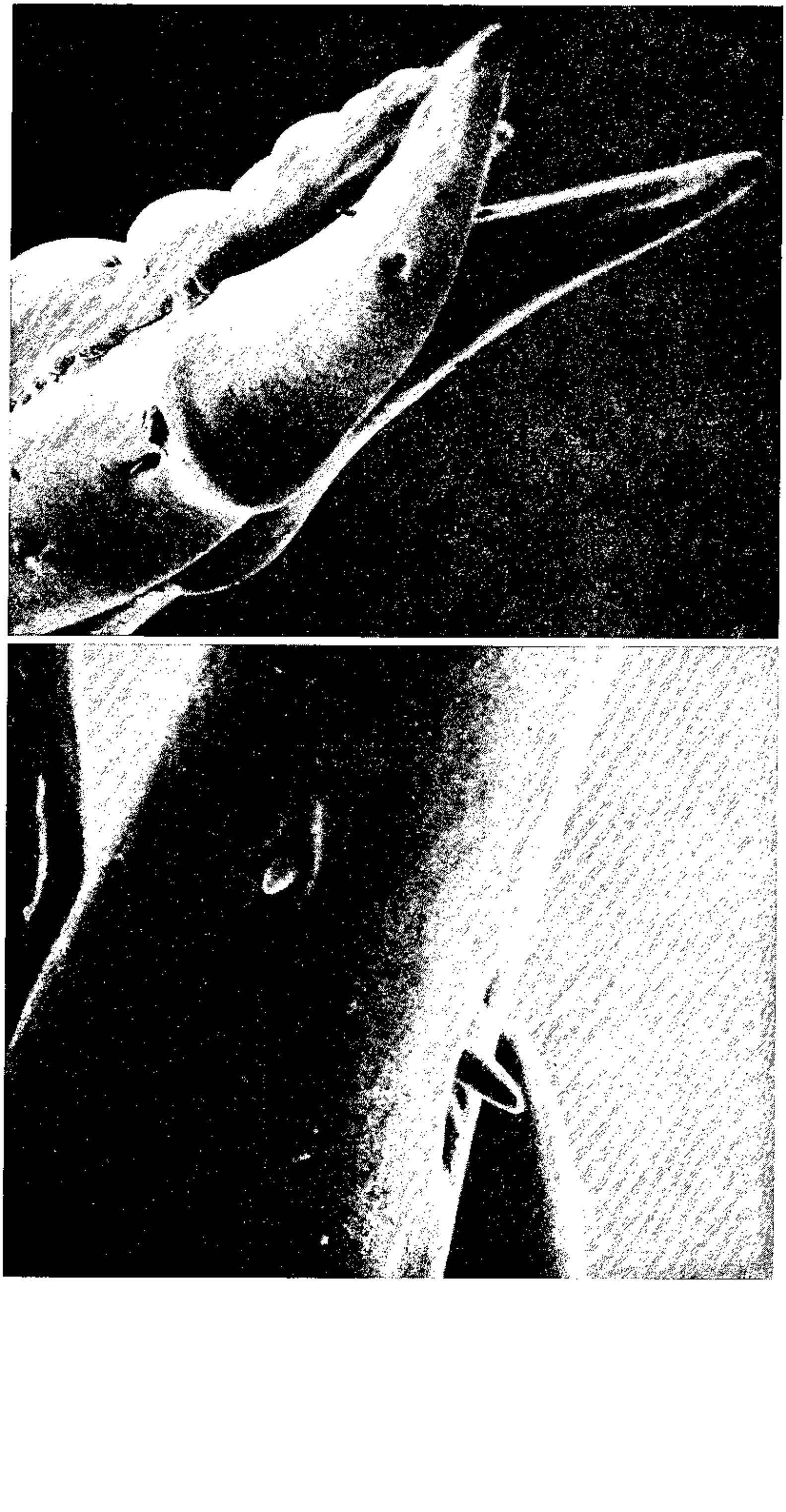


FIG. 23 - *Torymus varians* (Walker) (Hymenoptera Torymidae). Top: valve of the terebra and stylets (slightly spread apart for this photograph) seen from the back and from the front.
On the outer surface of each stylet one of the coeloconic sensilla and, on the inner surface, a longitudinal double line of campalunate sensilla (x 1850) are clear. Below: detail of the stylet of the top right photograph, that shows the longitudinal double line of campanulate sensilla (x 10000).

Torymus varians (Walker) (Hymenoptera Torymidae). In alto: valve della terebra e stiletti (leggermente divaricati per la fotografia) visti posteriormente.
Sulla superficie esterna di ciascun stiletto sono visibili uno dei sensilli celoconici e, sulla superficie interna, una doppia fila longitudinale di sensilli campaniformi (x 1.850). Sotto: particolare dello stiletto di destra della foto in alto che mostra la doppia linea longitudinale di sensilli campaniformi (x 10.000) sui quali viene a premere l'uovo in uscita.

FIG. 24 - *Torymus varians* (Walker) (Hymenoptera Torymidae). Top: section of the terebra of the ovipositor for about half its length to show the mechanism of connection between the terebra 2nd valvulae) and the underlying stylets (1st valvulae) (x 2000). Below: detail of the top photograph to show the guide which is of a reversed T shape protruding from the terebra and the corresponding groove in the stylet. The poison channel is visible, and on the left, the tegumental (sensory) projection, grooved in the terebra and hairy on the stylets.

Torymus varians (Walker) (Hymenoptera Torymidae). In alto: sezione della terebra dell'ovopositore a circa metà della sua lunghezza a mostrare il meccanismo di connessione tra la terebra (2e valve) e gli stiletti (1e valve) sottostanti (x 2.000). In basso: particolare della foto in alto a mostrare la guida a T rovesciata sporgente dalla terebra e la corrispettiva scanalatura nello stiletto; è evidente il canale del veleno e, a sinistra, le produzioni tegumentali (sensoriali) scanalate della terebra e quelle villose degli stiletti.

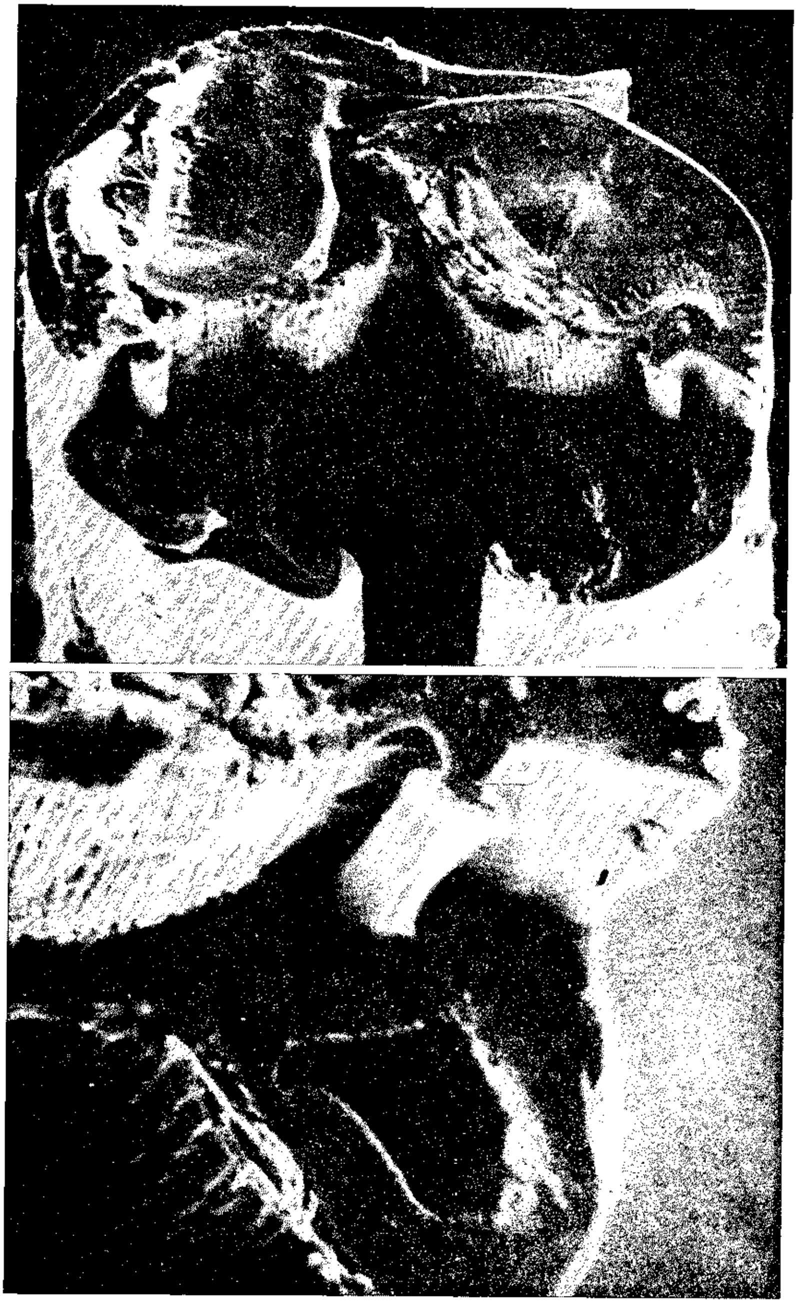
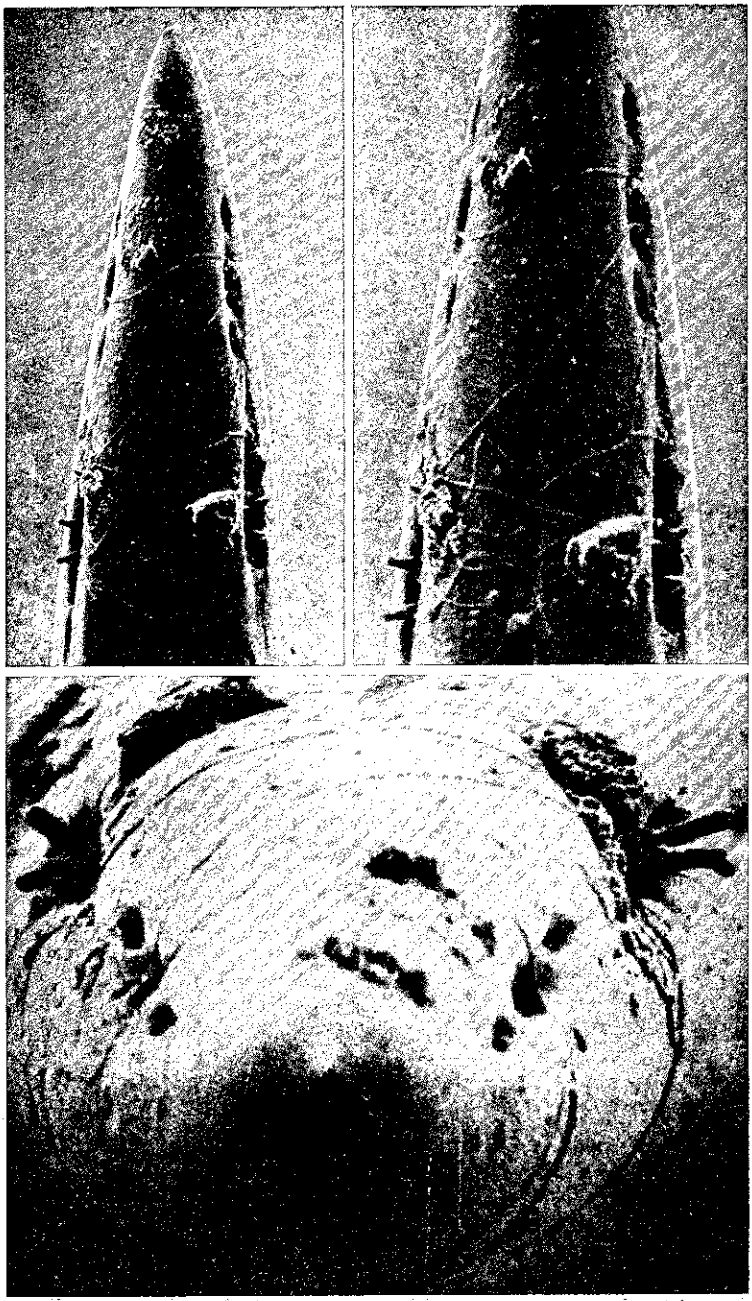


FIG. 25 - *Rhagoletis cerasi* L. (Diptera Trypetidae). Top: penultimate distal segment of the abdomen and ovipositor seen from the back and from three-quarters (x 300). Below: distal extremity of the penultimate segment of the abdomen and the part near the ovipositor seen from the ventral angle (x 500). Numerous sensilla on the ovipositor are evident in both the photographs.

Rhagoletis cerasi L. (Diptera Trypetidae). In alto: penultimo segmento distale dell'addome ed ovopositore di sostituzione visti posteriormente e di tre-quarti (x 300).
In basso: parte distale del penultimo segmento dell'addome e parte prossimale dell'ovopositore di sostituzione visti ventralmente (x 500).
In entrambe le foto sono evidenti sull'ovopositore numerosi sensilli.

FIG. 26 - *Rhagoletis cerasi* L. (Diptera Trypetidae). Top: distal extremity of the ovipositor seen from the centre (x 1300). Below: distal apex of the ovipositor seen caudally: the sensilla of different shape situated at the sides of the segment (x 3000) are evident.

Rhagoletis cerasi L. (Diptera Trypetidae). In alto: parte distale dell'ovopositore di sostituzione, visto ventralmente (x 1.300). In basso: apice distale dell'ovopositore di sostituzione visto caudalmente: risultano evidenti i sensilli celoconici di diversa lunghezza posti ai lati del segmento (x 3.000).



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Ricevuto il 1° luglio 1978; pubblicato il 10 dicembre 1978.