SOME CHARACTERISTICS OF THE FIRST STAGE LARVA OF *DERMATOBIA HOMINIS* GMELIN

BY

R. NEWSTEAD, F.R.S.,

AND

W. H. POTTS, B.A.

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PLATES IV AND V.

In Central and South America there is an Oestrid Fly, *Dermatobia hominis*, whose larva is the cause of cutaneous Myiasis in man and animals. These larvae are able to penetrate the unbroken skin, and there, in the course of development to maturity, give rise to tumours similar to those produced by the larvae of the Warble Flies (*Hypoderma* spp.) of Europe and North America. They are a source of considerable loss to cattle-owners, since the hides, riddled by the holes left on the emergence of the fully-grown larvae, are often valueless. According to Da Matta (1920), the proportion of hides thus damaged may be from 5 per cent. to as much as 70 per cent. The larvae are also indirectly responsible for the death of many animals, especially calves, since the tumours caused by them are liable to secondary infection from other myiasis-producing flies, whose larvae are unable themselves to pierce the unbroken skin. There is one fly of this latter type, the ' Screw-worm ' (*Chrysomyia macellaria*), which is very abundant in the Neotropical Regions and which in this way does a great deal of damage. Lastly, the *Dermatobia* larvae are the cause of much pain and inconvenience to man when passing through infected regions, and even give rise to serious illness if present in large numbers.

This Oestrid Fly differs from all other members of its class in that, instead of laying eggs or larvae directly on the hair or skin of the host, it lays batches of its eggs on the bodies of other insects, chiefly mosquitos. The larva of *Dermatobia* does not, apparently, leave the egg until the mosquito alights on a warm-blooded animal to take a meal. Thus it would seem that the larva must be highly sensitive to a slight rise in temperature, and that the emergence from the egg must of necessity take place during the comparatively brief period in which the mosquito feeds. There is evidence to show that the larva, if unable to emerge completely from the egg during the time the mosquito is feeding, may withdraw itself into the egg and there wait until the mosquito visits another animal. This may occur several times, the larvae being capable of remaining alive for twenty days before reaching a host.

We are indebted to Dr. Nunez Tovar, who himself has done much to elucidate the remarkable life-history of the *Dermatobia*, for his gift of material which has enabled us to study these young larvae which penetrate the skin of their hosts. Before we present a detailed description of its characteristics, it has been thought well to give a short account of the life-history of this fly, as some interesting work has been done since the last comprehensive account in English was written by Sambon in 1915.

THE DISTRIBUTION OF THE FLY

According to Neiva and Gomes (1917), *Dermatobia hominis* occurs in Central and South America from Mexico to the Argentine. It appears to be absent from the United States, for, although cases infested with the larvae have been recorded from that country, it has always been found that the larvae were acquired in Central or South America. The fly seems to need a warm temperature, a certain degree of humidity, and forest country.

HOSTS OF THE FLY

The occurrence of larvae in the skin of man and various animals has long been known. The domestic animals in which they have been found are, in order of importance :—Cattle, dogs (especially hunting dogs), pigs, goats, turkeys, and, rarely, mules. There appears to be some doubt as to whether they occur in sheep, donkeys and horses. It is, in fact, sometimes stated that horses are not infested, but Neiva and Gomes (1917) give one record of the finding of larvae in a horse. The larvae have also been found in the following wild animals :—Monkeys (whence the name ' Ver Macaque,' frequently given to the larva), jaguar, tapir, coati, agouti, deer (rarely), squirrels, and even birds, e.g., toucans and the ant-thrush (*Formicarius* sp.).

DISPOSAL OF THE EGGS

Although the existence of these larvae has been known for so long, there has been considerable doubt and uncertainty as to the exact way in which they reach the skin of their hosts.

Morales (1911), in Guatemala, was the first to publish a statement to the effect that the eggs were carried, firmly attached to the abdomen of a mosquito, *Psorophora* (then *Janthinosoma*) *lutzi*. From such eggs Morales obtained a larva, which produced in man characteristic tumours, and which presented all the characters of a *Dermatobia* larva. Tovar, in Venezuela, made similar observations two months earlier, but these were not published until 1913, in an article by Gonzales Rincones in the newspaper ' El Universel ' of Caracas.

These observations have since been confirmed by other observers, different flies being found to be *involuntary carriers* of the eggs in different parts of the country. Specimens of *Dermatobia* astride other flies have been caught, and even observed in the act of siezing the flies. According to Neiva and Gomes (1917), the adult *Dermatobia* frequent horses and other animals, and sieze flies which come either to suck blood or to feed upon sweat.

The final piece of evidence, the observation of the act of deposition of the ova by *Dermatobia*, has also been recorded. Neiva and Gomes (*loc. cit.*) enclosed adult females with various flies and found that eggs were laid on *Musca domestica*, *Stomoxys calcitrans*, and also on some Sylvan Muscoids. From these eggs larvae were obtained and were reared to the adult stage in dogs ; the whole process, from the laying of the eggs to the emergence of the adult, occupied 120 to 141 days.

Dr. N. Tovar also (1924) placed captured *Dermatobia* with specimens of the mosquitos—*Psorophora posticata*, *P. lutzi*, *P. tovari*, *Aedes trivittatus*, *Stegomyia calopus*, *Culex scapularis*, and Woodland Muscoids. Bundles of eggs were laid on all the examples of *Psorophora* (fifteen in all), irrespective of sex, whilst on none of the others (twenty specimens in all) was a single egg to be found. In fact, he stated that although the insects other than *Psorophora* were sometimes seized by the *Dermatobia*, they were treated with violence and discarded damaged, whereas the *Psorophora* were always treated gently and liberated unharmed. He also records that *Dermatobia* eggs were never found in nature save on specimens of *Psorophora* (Plate IV, fig, 1).

In view of the results of modern investigations it is interesting to record some of the names by which the natives of various parts of America referred to the fly. For instance, in Venezuela the worm was commonly known as Gusano de Zancudo, in Colombia as Gusano de Mosquito, and in Trinidad as Ver Marangouin ; all of these terms mean ‘ Mosquito worm.’ In an old book, the ‘ Historia del Nuevo Mundo,’ written in 1653 by a Jesuit, Father Bernabe Cobo, the following statement, doubtless based on information received from the natives, is found :—‘ In some of the warm lowlands there is a species of mosquito . . . somewhat reddish. In each wound produced by this mosquito, soon grows within the flesh a spine-covered worm the size of a haricot bean or even larger . . . .’ (Quoted from Sambon, 1915). Knab (1913) states that in 1905 the natives of the Isthmus of Tehuantepec, Mexico, pointed out to him certain large mosquitos (*Psorophora*) as ‘ Madre del Gusano.’ In the first reference to this fly under the binomial system of nomenclature, that of Linnaeus Junior (1781), we find :—‘ . . . . the fly deposits on a man’s skin, one after another, its eggs, or rather, its living larvae, *of which it carries about* 50 *on its hinder portion.*’ (Quoted from Sambon, *loc. cit.*).

Da Matta (1920), in his account of *Dermatobia*, states that the mode of transference of the larvae may also be by direct oviposition on the skin of animals, or by indirect methods, by their deposition on leaves, from which the larvae may be picked up by passing animals, or by deposition on sweaty garments. These have been discussed by Neiva and Gomes (1917), For the first, we have been unable to find any record of a direct observation, either of eggs being found attached to the skin of animals, or of the act of deposition on the skin, although there is a record of *Dermatobia* having been seen hovering over horses with the ovipositor extended.

As to oviposition on leaves, there appear to be no records of leaves having been found with ‘ packets ’ of eggs adhering to them. Neiva and Gomes (*loc. cit.*) record that eggs were deposited on the sides of the vessel. They offer the explanation that, at a given moment, the female feels the necessity for oviposition irrepressible ; if then the insect which she is attempting to catch escapes, she oviposits on the nearest object. They found that eggs so laid, if kept in a moist place, produced larvae ; if, however, the conditions were dry, the eggs shrivelled and perished. They suggest that this may happen in nature, but the chances of larvae so produced being picked up by appropriate hosts do not seem to be very great. Since, however, it has been shown that the larvae can remain alive for twenty days in the egg without finding a host, this may be an alternative mode of transference.

Oviposition on ‘ sweaty ’ clothes, too, seems to be supported by no direct observation. Neiva (1914) supports the hypothesis, saying that it would account for cases of infection of newly-born children who have never left the house. But he states that such cases are rare.

CARRIERS OF THE EGGS

The following insects have been found bearing batches of *Dermatobia* eggs in nature :—

BRAZIL :—*Psorophora posticata* (one example only, by Neiva and Gomes, 1917. Also by Peryassu, 1922).
Anthomyia heydenii (Lutz, 1917).
Anthomyia lindigii (Lutz, 1917).
Synthesiomyia brasiliana (Lutz, 1917).
Woodland Muscoids (on numerous occasions, Neiva and Gomes, 1917).

GUATEMALA :—*Culex* sp. unknown (Morales, 1911).

PANAMA :—*Goeldia longipes* (a non-bloodsucking mosquito, Shannon, 1925).

TRINIDAD :—*Psorophora* (then *Janthinosoma*) sp. (collected by Mr. F. Urich. Knab, 1913).

VENEZUELA :—*Psorophora lutzi*, *Psorophora posticata* (Tovar, 1924).

In captivity, *Dermatobia* has laid packets or batches of eggs on the following insects :—*Musca domestica*, *Stomoxys calcitrans*, Woodland Muscoids. (Neiva and Gomes, 1917). *Psorophora posticata*, *P. lutzi*, and *P. tovari* (Tovar, 1924).

Blanchard (1896) was sent the following flies by Da Silva Araujo in 1893, as being incriminated by the natives as ' parents of the Berne ' (*Dermatobia* larva) :— *Lucilia ruficornis* Macq., *Sarcophaga chrysostoma* Wd., *S. plinthopyga* Wd., and an *Hystricia.*

Neiva (1910) states that in Brazil nearly all species of *Tipulidae, Volucella obesa,* and a species of *Mesembrinella,* are accused of producing the warbles, whilst in Matto Grosso, several species of *Echinomyia,* and in Mexico, the beetle *Atractoceros brasiliensis* were also suspected. He, however, considered these popular beliefs to be erroneous.

Finally, Dunn (1918) has suggested the possibility of a tick (probably *Amblyomma cajannense*) being a carrier. The evidence is as follows :—Dr. Clark, in the course of two trips into the interior of Panama, discovered larvae of *Dermatobia* five times in wounds in man caused by tick bites. *Psorophora* were not obtained in collections of mosquitos from the places at that time, and besides, four out of the five sites were protected by clothing so that subsequent infestation of the wound seems improbable.

GENERAL DESCRIPTION OF FIRST INSTAR LARVA (Plate IV)

The general outline is somewhat elliptical, bluntly rounded anteriorly, and gradually attenuated posteriorly, the width of the last two segments being approximately half the width of the mid-thoracic segment, as seen in profile, after maceration in caustic potash (See fig. 1).

The cephalic segment is scantily clothed with very minute spines ; these appear to be more numerous dorsally and bilaterally (fig. 3A). The first thoracic segment bears a continuous band of relatively small and closely set black spines. The second and third thoracic segments are completely clothed with similar spines (figs. 3B and C). First, second and third abdominal segments show a double transverse series of large spines dorsally, and a single series ventrally ; the interspaces are set with smaller spines which are much more numerous in the posterior series than in the anterior one. The fourth to sixth segments inclusive are spineless. The seventh segment is clothed with long and slender, translucent spines (fig. 3D). The terminal segment is almost covered with relatively large strongly hooked and translucent spines (fig. 3E).

The spines on the thoracic and first three abdominal segments are directed backwards, whilst those of the last two segments are directed forwards. This arrangement of the posterior groups of spines enables the larva to retain a firm hold of the inner walls of the egg-shell after partial emergence.

The main tracheal tubes of the respiratory system, which resist the action of caustic potash, show very clearly (fig. 2). On the other hand the posterior stigmata are minute and not very clearly defined ; they communicate with the tracheal trunks by two long and slightly narrower felt chambers which extend to the middle of the penultimate segment.

The antennal organs (fig. 2), presumably corresponding to the antenno-maxillary organs of other Dipterous larvae as described by Keilin (1915), are placed well forward in the cephalic segment in a dorso-lateral position ; the proximal portion of the organ is strengthened with an incomplete band of dark chitin, the terminal portion being translucent.

THE MOUTH PARTS (Plate V)

The mouth parts consist of the following paired appendages :—

(1) Mouth hooks (*mh* in all figures).
(2) ' Prestomal sclerites ' (*ps* in all figures).
(3) Stomal plates (*sp* in all figures).
(4) Membranous bands (*mb* in all figures).
(5) Rudimentary Hypo-pharyngeal sclerite (fig. 1C, *hs*).
(6) Cephalo-pharyngeal sclerites (*cs* in all figures).

(1) *The Mouth Hooks.*

These are highly chitinised, blackish and strongly falciform structures, the inner edge being finely though somewhat irregularly serrated. Proximally the anterior portion is strongly produced (figs. 1A, *mh*, and 1D). There are two centrally placed foramina.

(2) *The ' Prestomal sclerites.'*

These appear to consist of very thinly chitinised, translucent plates, which may act as a sheath to the tips of the mouth hooks. They are not apparent in fig. 1A, being hidden by the stomal plates, but they are indicated in fig. 1C, *ps*.

(3) *The Stomal Plates.*

These are relatively large cone-like processes, converging distally, and with longitudinal but somewhat indefinite ridges ; proximally these structures are partly surrounded by a strongly chitinised plate, which is toothed on its distal or anterior margin (figs. 1A and B, *sp*.1, and fig. 1E). Below the cones is a mass of tissue with an irregular outline, portions of which seem to bear chitinous bodies, possibly muscle attachments.

(4) *Membranous Bands.*

These very thin and very slightly chitinised structures appear to arise towards the base of the mouth hooks ; they are curved, and directed outwards and slightly backwards, the tips in some cases being slightly curved inwards, and somewhat strongly chitinsed.

(5) *Hypo-pharyngeal Sclerite.*

This consists of a median and very thinly chitinised plate with a pair of sub-median foramina, and lies between the anterior processes of the cephalo-pharyngeal sclerite, at the articulation with the mouth-hooks.

(6) *Cephalo-pharyngeal Sclerites.*

These consist of two plates, which are free dorsally, each consisting of three processes : a long, fairly heavily chitinised, anterior, inferior one, a short, fairly heavily chitinised, dorsal one, and a ventral one so lightly chitinised that it is difficult to see how far it extends into the thoracic region.

SOME AFFINITIES AND RELATIONSHIPS WITH OTHER FORMS

The most marked characteristics of the buccal organs of the first instar of *Dermatobia hominis*, are the presence of—

(1) the paired and well-developed mouth hooks (*mh*) ;
(2) the cone-shaped stomal plates (*sp* and *sp*1)

Another noteworthy feature is the absence of an unpaired median tooth, such as is found in most other first stage larvae, and is shown in *Hypoderma bovis* (Plate V, fig. 3, *mt*).

In his extensive paper on the larvae of Cyclorhaphous Diptera, Keilin (1915) states that in certain Acalyptrates, especially those with carnivorous larvae, one finds a precocious development of the paired mouth hooks of later stages. This condition also obtains in the first stage larva of *Calliphora*, where, however, as generally, a median tooth is present as well; *Hypoderma bovis* (Pl. V, fig. 3, *mt*, *mh*) shows both paired hooks and median tooth. No trace of the latter structure is to be seen either in *Dermatobia hominis* or in *Cordylobia anthropophaga* (Plate V, 2A-C), and this is paralleled in a figure given by Keilin of *Onesia sepulchralis* (*loc. cit.*, Pl. X, fig. 49C).

The paired mouth hooks of *Cordylobia anthropophaga* (' median buccal spine ' of Blacklock, 1923, fig. 1, 3C and D) show a very remarkable modification. These structures, of which four aspects are shown in our illustration (Plate V, figs. 2A-D) are broadly dilated unilaterally at the tips and strongly toothed on the distal margin (figs. 2A-C, *mh*, and fig. 2D). Seen in profile (fig. 2B) they are strongly directed upwards, and according to Blacklock lie, when at rest, at right angles to the cephalo-pharyngeal sclerite. These processes are also very strongly developed dorsally (figs. 2B and C, *mh* 3) and bilaterally are broadly expanded (fig. 2A, *mh*1). Further, ventrally there is a thin and broadly dilated flange (figs. 2A and C, *mh* 2) which appears to be connected with the finely spinose lower lip of the buccal cavity (fig. 2C, *bs*).

In the larva of *Hypoderma bovis*, which shows both median unpaired spines (fig. 3, *mt*) and paired mouth hooks (fig. 3, *mh*), the latter, as Carpenter and Hewitt (1914) have pointed out, are remarkable for being widely separated, directed laterally, and pointing outwards instead of upwards as in *Cordylobia anthropophaga*, or downwards and normally, as in *Dermatobia hominis*.

The peculiar form and high development of the structures we have called the stomal plates seem to be without exact parallel in other first stage larvae. They may be represented in a rudimentary form by some of the accessory pieces which Keilin has described (*loc. cit.*). For instance, there is an appendage which Keilin terms ' pièce en brosse ' (*loc. cit.*, Plate VIII, fig. 37, *f*, and *f* in other figures) which may be homologous, but as we have been unable to study these forms we cannot give a definite opinion as to their homologies.

Again there are the paired structures to which we have given the term ' membranous lobes.' These are very indefinite structures. They appear in the case of *Hypoderma bovis* (fig. 3, *mb*) to correspond in position with the parastomal sclerites described by Lowne (1890) in the third stage larva of *Calliphora erythrocephala,* whilst in *Dermatobia hominis* they appear to be in a more anterior position, lying well in front of the bases of the mouth hooks.

It is interesting to note that in these three closely allied forms, all adapted to the same mode of life, quite different dispositions of the mouth parts exist. Thus the larva of *Dermatobia* penetrates the unbroken skin of man and animals, that of *Cordylobia* the skin of rats and sometimes man, and that of *Hypoderma* the tough hide of cattle. Of the three, *Dermatobia* perhaps approximates most closely to the condition shown by *Calliphora,* differing from it markedly by the absence of the median tooth, and by the strong development of the stomal plates; *Hypoderma* agrees with *Calliphora* in the possession of lateral hooks and median tooth, but differs in the disposition of these organs, the lateral hooks being directed outwards instead of downwards. *Cordylobia* is the most aberrant of the three, the mouth hooks being modified in a most extraordinary way, and directed dorsally instead of ventrally; the latter character is no doubt correlated with the mode of penetration of the larva in a horizonal direction under the skin, as has been well described by Blacklock (*loc. cit.*).

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EXPLANATION OF PLATE IV.

Dermatobia hominis.

FIG. 1. Adult mosquito (*Psorophora posticata*) carrying a batch of eggs of *Dermatobia hominis* on the ventral surface of the abdomen. Note that in one instance the embryo larva is shown partly protruding from the egg. × 10.

FIG. 2. Larva, First Instar. Lateral view. From a specimen macerated in caustic potash. Showing the arrangement of the dermal spines and the main sub-lying tracheal tubes. × 140.

FIG. 3A. Dermal spines from the cephalic segment.

FIG. 3B. Dermal spines from a thoracic segment.

FIG. 3C. Dermal spines from a thoracic segment.

FIG. 3D. Dermal spines from the penultimate abdominal segment.

FIG. 3E. Dermal spines from the terminal abdominal segment.

Figs. 3A-3E (inclusive) × 500.

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EXPLANATION OF PLATE V.

Mouth Parts of First Instar Larva of Dermatobia hominis.

FIG. 1A. Profile.

FIG. 1B. Ventral.

FIG. 1C. Dorsal.

FIG. 1D. Mouth hook.

FIG. 1E. Two views of the proximal portions of the stomal plates, detached from the cone-shaped process.

Mouth Parts of First Instar Larva of Cordylobia anthropophaga.

FIG. 2A. Ventral.

FIG. 2B. Dorsal.

FIG. 2C. Profile.

FIG. 2D. Terminal portion of mouth hooks, ventral view, showing the arrangement of the teeth × 1000.

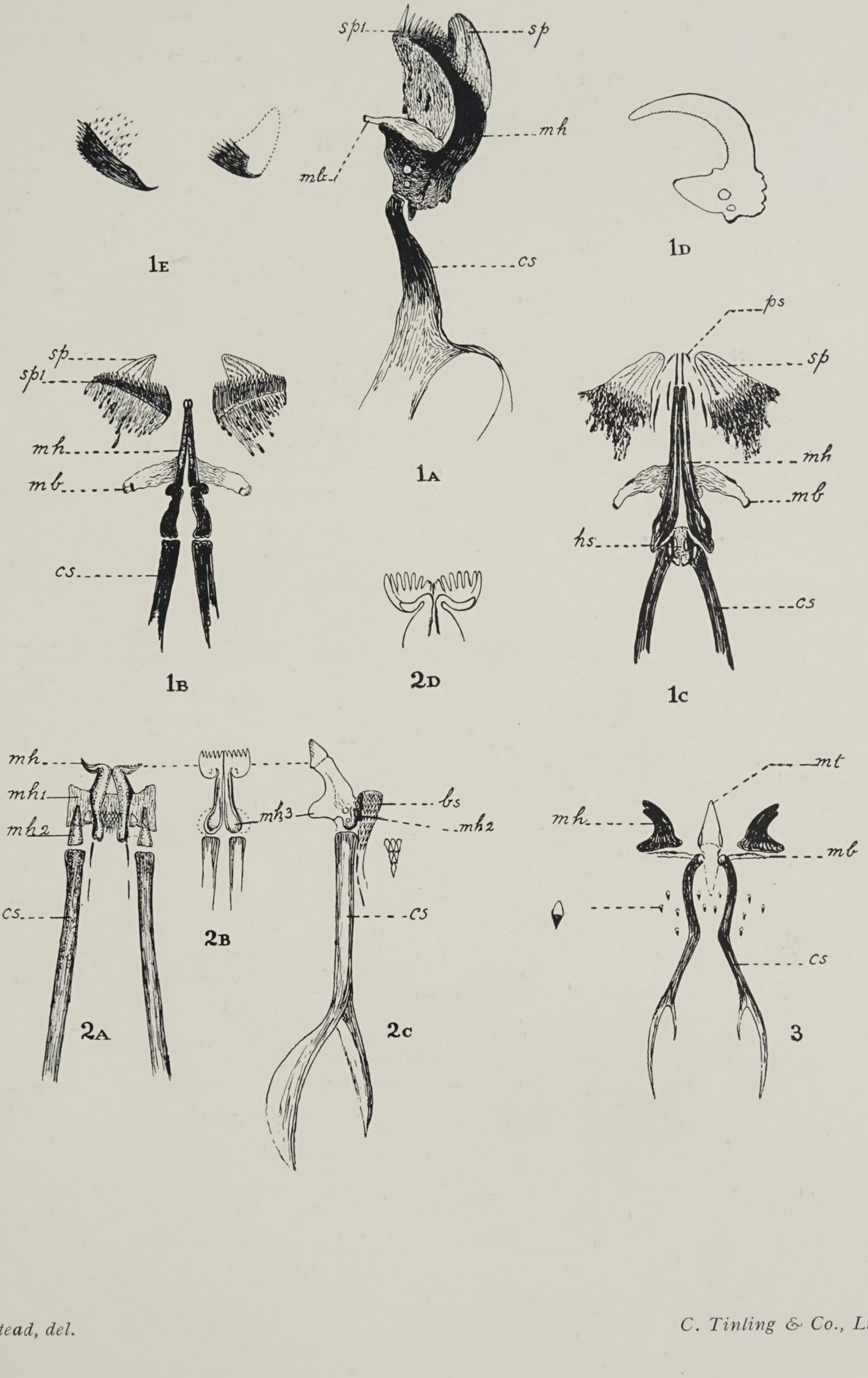
Mouth Parts of Third Instar of Hypoderma bovis.

FIG. 3. Dorsal.

All the figures with the exception of Fig. 2D. × 500.

EXPLANATION OF LETTERING.

cs = cephalo-pharyngeal sclerites.
bs = buccal spines.
hs = rudimentary hypo-pharyngeal sclerite.
mb = paired membranous bands.
mh = mouth hooks.
mh1 = lateral proximal extension of the mouth hooks.
mh2 = ventral proximal flange of the mouth hooks.
mh3 = dorsal proximal process of the mouth hooks.
mt = median tooth.
ps = prestomal sclerites.
sp = stomal plates.
spl = proximal pieces of stomal plates.



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