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Title	A NEW SCALE－INSECT, XYLOCOCCUS ALNI, ON ALDER, WITH SPECIAL REFERENCE TO ITS METAMORPHOSIS AND ANATOMY
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Citation	北海道帝國大學農科大學紀要, 8(3), 77-109
Issue Date	1919-03-30
Doc URL	https://hdl.handle.net/2115/12546
Type	departmental bulletin paper
File Information	8(3)_p77-109.pdf

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A NEW SCALE-INSECT, *XYLOCOCCUS ALNI*, ON ALDER, WITH SPECIAL REFERENCE TO ITS METAMORPHOSIS AND ANATOMY

BY

Kan Oguma

(With Plates II-IV and 1 Textfigure)

At the beginning of May, 1913, Profs. Y. NIISHIMA and K. MIYABE of the Agricultural College, Sapporo, kindly handed over to the author some branches of the alder, *Alnus japonica*, which were infested by multitude of the interesting scale-insect now described here. The individuals of the insect in question are almost completely hidden from our sight, owing to their being imbedded in the tissues of the branches, but betray themselves by the presence of a long, white and thread-like tube projecting from the vent of each animal, presenting an extraordinary appearance (see Textfigure). The spherical body at the extremity of the tube owes its origin to the honey excreted by the insect.

The species of plants which become prey of the scales under consideration is, so far as is known, restricted to *Alnus japonica*, which is abundantly found in swampy places along the streams in Sapporo. The aged trees which have been repeatedly attacked by these insects get very serious damages, and their branches often die away.

A close examination revealed the fact that the infested parts of branches are always older than three years of age, the young shoots, as well as those grown during the previous year, being entirely free from the attack. The question, therefore, arises as to whether the insect in question prefers the older branches to the younger. With a view to unraveling this question and also to investigate other interesting features in connexion with the morpholo-

[Jour. of the College of Agr., Hokkaido Imp. Univ., Sapporo, Vol. VIII, Pt. 3, February, 1919]

gy of the insect, the present investigation has been carried out during the past four years.

Unfortunately, at the close of the summer of 1913, the adult insects emerged out during my absence, and on my return, only dead females were found in the cases in which they had grown. In the spring of the following year, 1914, new eggs hatched out, and so that I was able to study the larval life from its very beginning. The larvae led their infant life during the whole of that year, and finally hibernated *in situ*. They did not become converted into adults even in the succeeding year, and again passed the winter still in the larval state. In the spring of the succeeding year, 1916, they attained nearly the same size as those examined three years ago, in 1913, so that it was expected that they will emerge out into adults by the end of the summer. It came up to the expectations, and as a result adults as well as pupae were collected in a considerable quantity.

So far as I am aware, only one pedigree of the insect in question exists in Sapporo, in other words, all the specimens, which have been examined, show the same stage in their development, and no single case has been found, in which specimens of different ages occur in one and the same year. The facts above mentioned clearly vindicate that at the time of the discovery, there were found no branches younger than two years old infested by this insect. The branches growing during the past two years were entirely free from infestation, because the attack of the larvae took place three years back.

As a result of a close investigation of the structures and metamorphosis, the coccid has proved to be an underscribed species of the genus *Xylococcus*, for which I now propose the name *X. alni*.[1]

To Profs. S. HATTA and S. MATSUMURA the author is under the greatest obligation for their kind advices during the progress of the present investigation, and to Mr. I. KUWANA he is also greatly indebted for determining the name of the coccid.

1) This name has already been published based upon my information in the 'O-yô-Konchiugaku Vol. I. p. 294 (1917), edited by Prof. S. MATSUMURA in Japanese.

I. External characters of the adult coccid.

Male (figs. 21, 22, 23). Body is cylindrical with the abdomen slightly depressed, and not markedly tapered towards the both extremities. Head is broad, but strongly narrowed at the posterior end; it is covered in the greater part by soft integument of orange-red colour, hardened portions on the ventral side as well as occiput are dark brown in colour; posterior margin of occiput and the median line of vertex blackish. Antenna is remarkably long, composed of ten segments, of which the proximal two are short and stout, of the same colour as that of the head and are provided rather short hairs, while the remaining eight segments are long and slender, dark brownish in colour and covered by long hairs, the terminal one without digitules. Projected laterally on either side of head are large, globular compound eyes which are composed of a great many ommatidia with black pigments.

Thorax is large, orange-red with dark brownish sclerites; prothorax is in the greater part soft, sclerites being not developed, but the anterior margin has a hardened brownish ridge; mesothorax with well developed tegrum, pleura and sternum, scutum is large, pentagonal and the small scutellum is distinguished from the former by a darker line, pleuron roundish and sternum somewhat pentagonal; metathorax also with these sclerites but far poorly developed, especially the sternum being only represented by a small triangular plate.

Wings are large and broad, somewhat smoky in colour with the dark brownish costa; in addition to the costal vein two more incomplete veins are found near the apex and base. Balancers (figs. 24, 25) rather broad, brownish in colour, usually curved upwards at their extremities on which four curved hooklets are present. Legs (fig. 27) are long, dark brown in colour, covered with comparatively long hairs, those on the distal part of the tibia are especially long but digitules are entirely absent.

Abdomen is scarcely longer than the thorax, composed of eight segments, very thinly haired, orange-red in colour but sometimes crimson, tegra and sterna are represented by narrow sclerites of dark brown in colour; behind the tegrum in the segment 7 and similarly in 8 is found a specially defined

part in which from thirty to thirty five tubular protuberances are settled. These protuberances (fig. 28) are longitudinally striated and long waxy filaments are produced from their distal openings. The waxy filaments are variable in length, the longest ones exceeding the whole length of body. Tegra in the segment 7 and 8 are usually divided at the middle point into two separate plates. From the last segment is projected a long triangular sheath of penis. Penis (fig. 26) is markedly long, in full length it is nearly as long as the entire length of body, and its surface is covered by short, closely arranged bristles.

Length of the body measures 3 mm., expanse of wings 7 mm.

Female (figs. 29, 30). In short, the adult female is merely a grub as in the usual cases of coccids. Body depressed, variable in shape, but usually somewhat ovoid (fig. 30), at the thoracical part broadest, tapering towards the posterior extremity. Occasionally body is long elliptical, only narrowing towards the posterior end (fig. 29). The body is thickest along the median longitudinal line and the marginal parts are thinner. Colour is clear orange-red or crimson. At the head are present a pair of short antennae, and imperfect eyes. Antennae (fig. 31) consists of only a single segment with a round tip, on which about seven hairs are usually found. A muscular bundle is attached to the antenna, and by its contraction the latter is forced to sink down to some extent from the level of the body surface. Eye is seen like a black spot under the low power of microscope, while under the high power lense it can easily be found that the eye is made up of a thick corneal lens and a number of retinular cells in which black pigments are developed. Mouth organs are entirely absent, only a shallow longitudinal depression indicates the opening of the mouth (fig. 29).

The thoracical part has no traces of appendages; two pairs of small spiracles lie on the ventral surface.

Abdominal segments are not well defined, and five or six irregular transverse foldings can be counted with some difficulty. Anal plate also not well developed, merely a slight thickening of chitinous integument is to be found

at the very extremity, where the rudimental anus opens, arround which a number of short bristles are present. Genital opening lies at the centre of the ventral surface of the terminal segment. It is cross-shaped and can be closed by many foldings arranged transversely against the cross split.

All over the surface of the body and beneath the integument are scattered wax-secreting glands, through which they can easily be observable. They are more numerous on the segments near the distal end, and the greatest number are found near the genital opening. The secreting pores are always round, and through which, the insect, when alive, secretes a small amount of wax. As an exceptional case, when the female is reared under confinement and prevented copulation for a long time she secretes a pair of long white tufts from either side of the anus, as is seen commonly in her immature stage *(vide infra)*.

Length of the body measures 4–6 mm., breadth at the broadest portion 2–4 mm.

II. Metamorphosis.

1. The first year (1914).

Larvae of the first stage. At the beginning of the first year, the eggs change their colour from yellow into crimson owing to the development of larval body under the chorion. It was May 26, 1914, some newly hatched larvae (fig. 2) were first found on branches. As soon as the larvae have hatched out, they crawl out of the cases in which they have been enclosed, and begin to wander about on the surface of bark. They are 0.7 mm. in length and 0.51 mm. in breadth, elliptical, flattend but thicker along the mid-dorsal line. The ground colour of the body is orange-red, but the terminal five segments of the abdomen are dark brown due to the chitin thickening, and this brown colour becomes gradually paler towards the remaining anterior segments. There is a conspicuous deep red streak on the mid-dorsal line of the body, and three broken streaks of the same colour are found on each side of it.

Antenna (fig. 3) is rather short, composed of six segments, pale red in

colour; terminal segment is provided with more than seven long hairs, one of which is especially long; the remaining segments are furnished with less and shorter hairs. Eyes are small, blackish in colour with a corneal lens highly developed. The mouth is represented by a small pit without rostrum, and the every mouth organ made of a brown chitinous substance is clearly observed through the integument, the long buccal setae of dark brownish colour is looped in the labial cavity as delineated in fig. 8. Legs are pale brownish in colour, thinly haired, with two digitules at the base of the claw (fig. 4). It is worth while to note that the trochanters are comparatively long, and the proximal halves are strongly narrowed. It is at these weak portions that the distal segments of leg are become broken off later.

Abdomen is eight segmented, a spiracle is found at the either side of each segment. Between every two spiracles are two marginal spines, of which one lies slightly on the dorsal side, and the other on the ventral to the spiracular line (figs. 5, 6). At the end of abdomen the anus opens by a short projecting tube. This anal tube is inserted for a considerable length into the body, as is easily observed through the integument, and by the secretion from the adhered glands a long, tubular, waxy filament is produced later on. Surround the anal tube is a set of short spines arranged in a circle, and two long caudal spines are present outside. Wax-secreting pores are arranged as is shown in the figures (figs. 5, 6). There are three pores of enormous size arranged longitudinally along the mid-ventral line near the anus (fig. 5). Unfortunately it has been unable to ascertain what a function they have, except that they are at least not wax-secreting pores, for I have never found any trace of wax around pores in question.

The larvae are quite active, crawling about on the bark to find any minute fissures or crevices suitable to get in. About twenty hours after hatching, all the larvae were found imprisoned in the fissures, some being entirely hidden from our sight but the majority remaining with their posterior parts of body still exposed. The larvae now begin to stretch the buccal setae through the mouth and pierce probably into the soft cambium of the branch. From this

time on they are nourished by the juice sucked from the tree. Then the secretion of wax takes place from whole surface of the body. The wax thus secreted takes different forms according as the different parts of the body. The most conspicuous kind of the secretion is that which grows out of the anal tube; it is a hollow, almost straight tube, but becomes gradually curved in the course of growth, and when fully grown it measures 2 mm. (fig. 7) in length. The wax secreted from the pores on the lateral sides of body forms fine filaments, entangling each other, as cotton wool. The secretion of the least degree is that from the smallest pores which are scattered about whole surface of the body; it looks like white powder.

No remarkable growth of body is noticed until the end of June. A specimen collected on June 20th is shown in fig. 7, it is nearly the same in size and form as the larva immediately after hatching from egg. Soon afterwards, however, the legs fall off from the basal parts of trochanters which are very weakly constructed as described above. Unlike the legs, the antennae and the eyes remain without undergoing slightest changes.

During July and August, the larvae grow markedly in their size. At the beginning of September nearly all of them were found already attains 1 mm. in length and 0.65 mm. in breadth (figs. 8, 9). Inspite of such immense growth in size, no ecdysis has been taken place. All the structures found in the newly hatched ones may still be obserbable in these larger forms. Scars of the fallen legs are clearly seen on either side of the body, and three peculiar pores on the mid-ventral line near the anus are also observed without slightest difficulty. One of the characteristics in these larvae is the expansion of skin due to the increase of mass of the body; the foldings of the abdominal skin, which were found in the younger ones and appeared subsequently as transverse lines, have entirely disappeared. The colour of the body now becomes pale crimson, except at the terminal part which is brownish. The caudal filamentous tube grows about 5 mm. by this time, and excretes a drop of honey of strong concentration.

Larvae of the second stage. The first ecdysis takes place in autumn. A-

mong the specimens collected on November 12th I found some individuals larger than those just described. They measure 1.5 to 2 mm. in length and 0.9 mm. in breadth (fig. 10). Not only in size but also in the structure of the body they markedly differ from the larvae above described, and should be distinguished as belonging to the second stage. The first ecdysis seems to take place in a comparatively long duration of time, as because the larvae of the second stage are always found mingled with the younger larvae during early to late autumn.

The older larvae are more yellowish than the younger ones, but the part near the anus which corresponds to the anal plate in the other coccids becomes still more darker. The antennae are greatly reduced into small protuberances, but the terminal hairs are still to be found (fig. 14). They are five in number, and two of them being markedly longer than the remaining. The buccal setae are not yet streched into full length but partly looped in the labial cavity. Eyes are still seen as black spots but legs are entirely absent. A pair of caudal spines as well as the peculiar pores along the mid-ventral line are lost with the exuvia cast off. But closely around the anal tube are found short spines, which may be designated as perianal spines. On either side of the anal tube a pair of small tubercles make their appearance, to which the last spiracles come to direct contact. The wax-secreting pores are arranged rather irregularily as compared with those in the former stage, though they still abound on the anal area.

The larvae hibernate in this stage, the smaller and the younger larvae seem also to reach this stage before the winter sets in.

2. The second year (1915).

As soon as the trees awake from the winter sleep in May of the second year the coccids too begin to exhibit their activity; they commence to produce the waxy caudal filaments which once fallen off during the last winter. On every infested branch, long, white, and sometimes more or less curled filaments are seen, whose terminal opening is crowned with a drop of honey.

The larvae now grow larger, and at the beginning of June they measure 1.8 mm. in length, but ecdysis does not seem to take place as yet.

The larvae of the second stage live without any further metamorphosis through the summer of the second year, but continue growing larger, though not so much markedly as in the last year. Corresponding to the growth of the insect the branch increases its diameter by new formation of tissues. As the bodies of the insect are quite unable to move back, on account of the buccal setae being deeply inserted into the tissues, they consequently become immersed into the newly formed tissues. In other words, increment of tissues takes place, except at the spot, where a coccid has pierced its buccal setae, and as a result, the insect becomes left behind, so to speak, and burried passively deeper and deeper into the tissues only exposing the terminal portion of the hardened anal area covered by secreted wax.

Thus they will again pass the comming winter *in situ*.

3. The third year (1916).

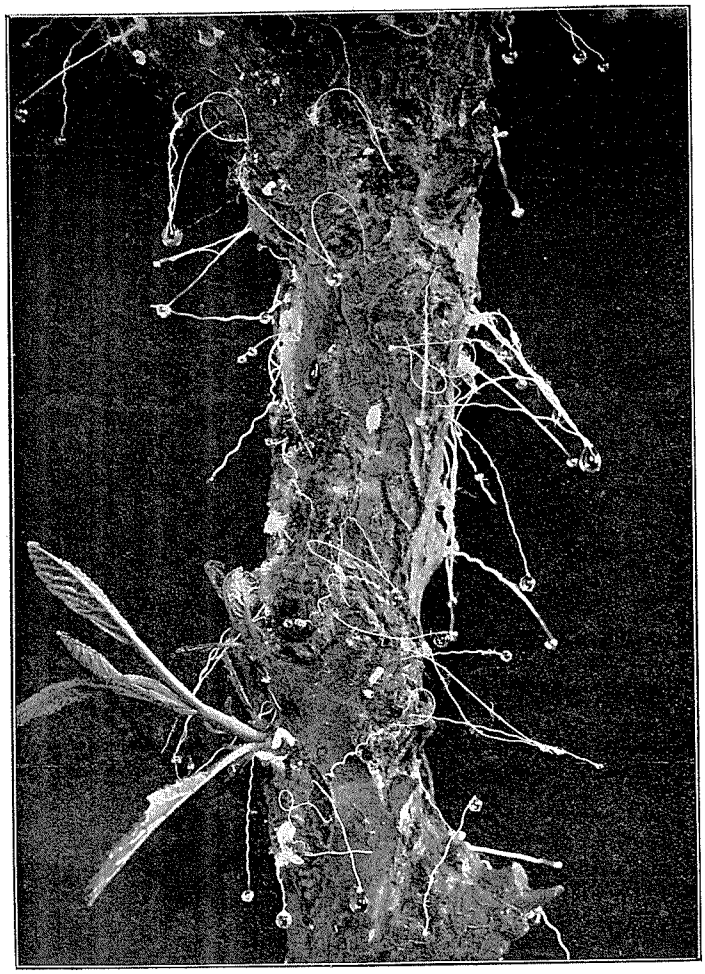
This year is of great importance in connexion with the metamorphosis of the insect. At the end of April or the beginning of May, the second ecdysis takes place, and the larvae of the third stage are produced.

Larvae of the third stage. In general appearance the larvae of this stage are indistinguishable at a glance from those of the previous stage, except the size of the body (figs. 11, 12). The body is pear-shaped, varying orange-red to crimson in colour, and measures 2 to 2.3 mm. in length. The rudimental antennae and eyes are still present as in the former stage. The chief points by which the larvae of the present stage can be sharply distinguished from those of the former are (1) the anal area being more thickened with net-like sculpture, (2) appearance of the genital opening on the ventral surface between the anterior margin of the anal thickened area and the anal opening,[1]

1) PERGANDE states, in his paper on *X. betulae*, that in the fourth stage of the female there appears, placed medioventrally at the region between the fourth and the fifth pairs of stigmata, a brownish organ, probably the *anus*. This newly appeared opening obviously corresponds to the genital aperture in my case, not the anus, which is represented always by the terminal opening of the abdomen from which a waxy hollow thread with a drop of honey is produced.

and (3) the disappearance of the small tubercles at the last spiracular openings in abdomen.

The waxy filamentous tube produced from the anal opening becomes strikingly long and stout, usually measuring 1–2 cm. in length (Textfigure). In nature, the filamentous tube is frequently broken off by wind or rain, as the spring is the windy season in Sapporo. But if the branch be brought under a calm condition, the tube very often acquires a remarkable length; in the indoor culture one of tubes was found measuring 3.2 cm. on May 17th.



Textfigure. A photograph from life (enlarged).

As a rule it is nearly straight or more or less curved, but not unfrequently strongly or almost spirally curled ones were observed. It is a hollow tube as already stated, but the wall is made up not of homogeneous mass of wax but consists of very fine waxy threads, some of which often separate from the wall and curl back towards the anus. The excretion of honey is also in full activity during this month, the largest drop measured being about 2 mm. in diameter.

The secretion of wax from the pores scattered all over the body is also active in this season, especially at the both sides of the anus the wax forms a pair of large tufts as shown in fig. 13.

The larvae reach their full grown stage in August. When I collected at the middle of August, I found two kinds of individuals with regards to their size, one being 3–3.2 mm. in length and 1.5 mm. in breadth, and the other 2.3 mm. in length and 1.2 mm. in breadth. The former represents, as readily supposed, female-producing larva while the latter male-producing (figs. 11, 12).

The larvae now become embedded still deeper in the wood by the formation of a new year ring. The cavities in which the larvae are enclosed are lined with a rather hard, blackish callus-like tissue. The space between the walls of the cavity and the surface of the insect-body is filled with a thick layer of wax secreted by the insect.

At the end of August metamorphosis of the both kinds of the larvae takes place. The female-producing larvae transform themselves into adults, without pupation as the usual case of the Coccidae, directly from the preceding full grown larval stage. The last ecdysis occurs at the beginning of September. The metamorphosis of the male-producing larvae is, on the other hand, quite different from what happens in the case of the female-producing larvae, as detailled below.

Male-producing larvae of the fourth stage. Near the end of August the male-producing larvae cast off their third larval skin. The newly emerged insects are of a very different shape from those of the former stage (figs. 15, 16). They have a much elongated body, slightly tapered towards the hind extremity and deep red in colour. The head bears a pair of well developed

antennae, comparatively long and distinctly nine segmented (fig. 17). The basal two segments of the antenna are considerably broad as compared with the remaining seven and furnished with short hairs, while the distal segments are provided with long ones. Of these segments the most distal four are sharply marked off by their brownish colour, and the terminal segment bears several very long hairs on the tip but without digitules. Eyes are also present slightly behind the antennae as in the former stage, but the corneal lenses are thicker. As the most characteristic feature of the present larvae three pairs of legs are well developed on thorax; they are rather long with a claw in each, thinly haired for the most part, although we find a tuft of digitules on the terminal part of tibia (fig. 18). Abdomen is long, nearly the same breadth throughout except the terminal three segments. Eight segments are clearly marked by the transverse foldings. There are found, all over the surface of body, an immeasurable number of wax-secreting pores scattered rather irregularly, but most abundant in the last few abdominal segments where long hairs are present. Length of body measures 6 mm.

The larvae crawl out of the cases in which they have lived and walk about on the bark to find places where they pupate. For the place of pupation they usually prefer fissures in the bark, though not unfrequently they choose plane surface. After two or three days the cocoons are produced in which they convert into pupae.

Cocoons. The cocoons are found often at a considerable distance from where they were bred, and in most cases on the under surface of horizontally stretched branches. They resemble very much those of the ichneumon-flies in their general appearance; it measures 6 mm. in length, and is pure white in colour (fig. 32). The cocoon is of course the product of wax glands inspite of silky appearance, so that after the emergence of adult it becomes gradually decayed and destroyed by rain or wind.

Male pupae. The pupa (fig. 19) is very similar in shape to that of the allied genera, but deep red in colour. All the imaginal structures, such as ten segmented antennae, globular compound eyes, are completely prepared

in this stage. The head, however, is not narrowed at the posterior end and with the whole breadth it connects with thorax. Wings are narrow, bluntly pointed, and extended scarcely to the posterior margin of the third abdominal segment. Balancers are represented by a pin-head like swelling of the thoracic wall underneath the wings. Legs are tolerablly long and smooth, imaginal parts being clearly visible through integument (fig. 20). Length of body measures 2.5 to 3 mm.

Emergence of adults and copulation. Duration of the pupal stage seems to be about one week. The male adults emerge out of cocoons in a very slack manner. It takes at least half a day before they completely get out of cocoons. But as soon as they get free, they commence to search their mates very actively. It is a very conspicuous fact that they, during this time, errect their caudal hairs vertically upward from the dorsal surface of abdomen.

During this time, the females also reach their mature condition, but they are unable to walk out freely and left in the cavity, in consequence of their being devoid of legs as already described. The females, however, come out along the walls of the cases with their posterior ends forward, by contraction and stretching of the abdominal muscles, in the like manner with the grubs, and at last they succeed to project out of the cases three or four terminal segments of abdomen, or sometimes more than half the whole length of body.

When the male finds a mate in such a condition, he soon inserts his long penis into the vagina of the female. The copulation takes place only in the morning, and lasts a few minutes. After a copulation the males walk away to discover another female to mate again. The female, on the contrary, draws back her body entirely into the case immediately after the copulation, but she again tries to expose her posterior parts of body on the following morning to receive a new visit of males.

A single male seems to live only one day, so the repeated copulation of a single female is done by other males which would hatch out during a few successive days. Then the female begins to lay her eggs within the case, and at the end of September, she is found as a thin dead body covering eggs under her ventral surface.

Eggs. The newly laid eggs are pale yellow in colour. Length varies from 0.51 to 0.55 mm. and breadth 0.33 to 0.36 mm. Eggs laid by a single female exceed one hundred in number. They remain *in situ* until the next spring.

III. Anatomy of the internal structures.

The works upon the anatomy of the Coccidae hitherto undertaken are those by LUBBOCK (1858), TOZZETTI (1868), MARK (1877), PUTNAM (1880), WITRACZIL (1886), LIST (1887), KUWANA (1907), MOULTON (1907) and FULLAWAY (1910). The material used by these workers, however, differs a great deal from the present new coccid and consequently represents much different results comparing with mine.

For the research on the minute internal structures I selected chiefly the larvae of the third stage in metamorphosis, because in this stage they are not only in the largest size but also all the inner organs, except sexual glands, are represented in the highest grade of development, as their function is most active throughout the whole life cycle. To get a clear idea of the gradual changes of certain organs I studied the younger larvae as well as the pupae and imagines. The material was fixed in Carnoy's mixture, imbedded in parafin as usual, and a large number of serial sections were cut. Dissections by means of fine needles were only applied when necessary.

1. Body cavities.

The body cavity enclosed by the hypodermal epithelium is generally filled up, in all the coccid larvae hitherto investigated, with the mesenchymatous supporting tissue. In the present species, however, there are two distinct body cavities into which the supporting tissue cells utterly fail to enter. One of them may be called the central body cavity and the other dorsal sinus. The former is a long cylindrical cavity with both the anterior and posterior extremities tapered, especially so at the hind end, and occupies the central axial part of the body, while the latter is flattened and lies immediately beneath the dorsal hypodermis. In the central cavity are contained the central

nervous system, the alimentary canal with the appended glands and the sexual organs as well (fig. 49). Although there cannot be found any kind of peritoneal membrane lining this cavity, the cells of the surrounding massive part arrange themselves, at the margin of this cavity, closely side by side like an epithelial structure, so the cavity becomes sharply defined from the surroundings. In the spaces between the viscera contained, a number of large oenocytes are always found, though I have no knowledge as to their function and fate during metamorphosis.

The dorsal sinus (*ds*) is broad but much flattened cavity, and bounded, by the similar way to the central cavity, by the cells of connective tissue at the ventral margin while the dorsal margin is in direct contact with the dorsal hypodermis. This sinus is seen, in preparations, usually filled with chylus residue in which some of blood cells (*bl*) are floating.

There is no other organ comparable to the dorsal vessel in other insects, the circulation of blood is probably carried out by the contraction of this sinus by aid of dorso-ventral muscles.

The dorsal vessel has been described in coccids only by List (1887). In *Orthezia cataphracta* he finds a very narrow tube applied closely to the dorsal part of a Malpighian tubule. This tube is consisted of a very thin membrane in which a great many fibrilles are found and has a supply of nerves in its abdominal portion. Judging from these descriptions this fine tube in question evidently corresponds to the dorsal vessel, as he supposes. But there remain yet rooms for doubt whether such a completely built organ of circulation is practically present in coccids in general. Still more he could find it only in dissection of intestine and Malpighian tubules and not in sections. In my present study no trace of such an organ could be made clear, not only in dissection but also in sections cut in all directions.

2. Nervous system.

The present coccid shows no marked difference as regards the nervous system from that of the recorded species.

Ganglia. The coccid has only two large ganglia, of which one is the

supraoesophagial ganglion or brain lying just in front of mouth, and the other is thoracic ganglion situated at the ventral side of thorax. Both are completely imbedded in the central body cavity beneath the other viscera (fig. 58). The brain (*br*) is a bilobed body with a pointed end in each half, and from the hind margin a pair of thick paraoesophagial commissures are despatched, which embrace the oesophagus and connect with the thoracic ganglion. The thoracic ganglion (*tg*) is of a considerable size, flattened, broad lanceolate in form, possively consisted at least of five ganglia—infraoesophagial, three thoracic and one abdominal, which completely fused together into a large mass.

Nerves. In larva I found only a pair of large optic nerves attached to the anterior pointed ends of cerebral lobes. But in the male imago another pair are found in addition to these at the sides of the optics, they are antennaries. On the periphery of the large thoracic ganglion, in the larva, only a single abdominal nerve, attached to the posterior pointed extremity of it, can be discovered, while in the male adult, however, more five pairs, for legs, wings and balancers, are to be found on the sides of it.

3. Respiratory system.

The respiratory system is highly developed in this species as compared with that of all the described coccids. It is consisted of two pairs of wide tracheal trunks with their branches and ten pairs of spiracles, of which two are in thorax and eight in abdomen. The thoracic spiracles open on the ventral surface while abdominal ones on the sides of the body.

Tracheal trunks. Of two pairs of the tracheal trunks one pair are in a little dorsal and the other slightly ventral to the central body cavity, all being embedded in the mesenchymatous connective tissues. The former shall be called the dorsal trunks and the latter the ventral trunks (figs. 33, 36). A dorsal trunk (*dt*) terminates anteriorly in the first thoracic spiracle, while posteriorly it connects, before the anal opening, with the corresponding trunk on the other side by a bar-like commissure. To make a connexion with the first thoracic spiracle, it must curve down in its anterior part, for the spiracle

lies on the ventral surface of body, instead of the dorsal position of the dorsal trunk. At the point of this curving arises a large branch which runs forwards and soon splits into many narrow branches supplying air to the head part.

The ventral trunk (*vt*) ends anteriorly at the second thoracic spiracle in similar way to the preceding, but in the posterior extremity there is no direct connexion with the mate on the other side of body. At a short distance from the second thoracic spiracle is found a branch of trachea in connexion vertically with the dorsal trunk. It would be noteworthy to find a tracheal chiasma or crossing on the ventral side of thorax; two anterior arms of the cross are a little narrower than the posterior two (figs. 34, 35). In the newly hatched larva, moreover, there is found at the crossing point a small spherical swelling (fig. 35) which somewhat resembles in appearance the PALMEN's organ found in the May-flies. But through the succeeding ecdysis this peculiar swelling gradually vanishes, as we see no like structure in the full grown larva (fig. 34). The anterior narrower arms join to the descended parts of the dorsal trunks at a short distance before the first spiracles, the posterior thicker arms to the ventral trunks far behind than where the dorso-ventral commissures are attached.

The transverse tracheal commissures between the thoracic spiracles on both sides have been already described in many of coccids, by WITRACZIL (1886), LIST (1887), KUWANA (1907), MOULTON (1907) and FULLAWAY (1910) &c., but I am not aware of such a crossed commissure in this group of insects.

Contrary to all the coccids hitherto investigated the present species, as already mentioned, has eight pairs of spiracles on the sides of abdomen. To each one attaches a trachea which afterwards splits dorso-ventrally into two branches. The ventral arm of this Y-shaped bifurcation is connected to the ventral trunk while the dorsal arm to the dorsal trunk. These bifurcated arms are considerably long and looped in the youngest larva (fig. 36), though not so in the full grown form (fig. 33).

Spiracles. Spiracles on the thorax are of the simplest structure (fig. 37). The opening is very minute and round, guarded by a chitinous ring slightly

elevated from the level of body surface. The opening dilates, however, within the body into a long tubular chamber of some width. There is a filter at the bottom of this chamber, with which the trachea comes in direct connexion.

The abdominal spiracle, on the contrary, is more complicated (fig. 38). The opening is larger in diameter than the preceding, and the chamber behind it is considerablly longer and wider. In the newly hatched larva the spiracular chamber seems to be nearly straight, but in the full grown larva it always curved strogly as is shown in the fingure. At the bottom the walls of this chamber reflects obliquely to constitute a funnel-like filter with fine radial striation. At short distance before the filter the tubular chamber makes a constriction, and the inner surface of the constricted part is provided with a number of circular sculptures. Surrounded this part and where the filter lies the hypodermis grows thicker in somewhat glandular appearance.

In *Xylococcus betulae*, PERGANDE (1898) describes the tracheal system at some length. The structure of the abdominal spiracle and the mode of ramification of trachea connected with it seems to come fair coincidence with my case. But it remains still obscure as regard to the remaining structure of this system.

Among coccids previously studied by other authors, *Orthezia cataphracta* seems to be a unique form in which the tracheal system is so well developed as comparable to the present species. In *Orthezia* LIST (1887) finds nine pairs of spiracles, one pair less than in my case, of which seven are belonged to the abdomen. But in mode of tracheation *Orthezia* may be said too simple compared with my species. Namely, *Orthezia* has none of trunks common to all the branchlets connected with spiracles. The tracheae belonging to the abdominal spiracles stand not only nearly independently with each other but also with no relation to those attached to the thoracic spiracles. It is evident, therefore, the present species is far highly organized so far as the tracheal system is concerned.

4. Digestive system.

Alimentary canal. The mouth opens, in the larva of the first stage, be-

tween the second pair of legs, but this position seems to become more posterior after the first ecdysis has taken place. The pharynx is represented by a wide but flattened room, of which on the both sides the ducts of salivary glands open. It narrows abruptly at the dorsal part into the oesophagus which runs perpendicularly upwards through the space left by the paraoesophagial commissures and then again widens into ventriculus.

The ventriculus (fig. 48, *v*) is a very long canal and loops twice in a different way from ordinary coccids. The ventricular canal varies in diameter in different portions. It is widest at the proximal portion included cardia and then gradually tapers towards the distal end or pylorus. The widest portion runs nearly straightly along the right side of the central body cavity in which it is enclosed. Then it runs to the left and thereafter ascends along the left side of the body cavity up to the anterior limit of the latter. When it arrives there bends again gradually to the right, and descends along the right periphery of the body cavity until the level of cardia. At this level it reflects abruptly to make a narrow loop and passes into the ileum.

At the cardia there are found several slender cells by which a valve is formed (fig. 41). In the main part, however, the mucous epithelium of ventriculus is composed of considerably large cells with a conical projection in which rich amount of dark brown pigment granules are developed (fig. 42). The cells are covered by a thick transparent intima, and a large nucleus is always found at the base of cone, where the pigment being absent, in each cells.

There is no marked constriction at pyloric portion, the ventricular tissue passes gradually into that of ileum.

The ileum (fig. 48, *i*) commences at the level of the mouth, at first it lies transversely against body axis but soon bends backwards along the right side of the left ascending limb of ventriculus. At a short distance before the turning point of the ventriculus the ileum moves to the right side of the proximal descending part of ventriculus, then taking the reverse course to the latter it ascends up to the level of oesophagus, where it again turns to the left and is communicated at last with the rectum which occupies the axial part of the

central body cavity. In the whole length it is nearly the same in its diameter except in the last short part which is much narrower and flattend to some extent.

The composing cells in the main part of ileum are similar in shape to those of ventriculus but entirely free from pigment granules (fig. 43). The peculiar fact in the structure of ileum is seen in the posterior ascending limb at the right side of the body; for some length the cells are converted into very flat ones, and this part shows a tendency to envelope, in more or less degree, the cardiac part of ventriculus, so that if one look at the section made through this part (fig. 47) he would find a semilunar lumen of ileum by which the ventriculus is closely, though partly, covered. Behind this part, however, the cells again recover their size in certain degree at the narrowest extremity where the ileum attaches to the rectum (fig. 46).

The rectum (fig. 48, *r*) forms the widest part in the whole length of alimentary canal and occupies, as already stated, the axial part of the central body cavity. It is somewhat clavate in shape, strongly tapering towards the anus while bluntly pointed at the anterior, part making a blind sac. The ileum is connected to the rectum at a long distance from this blind end. This blind sac, therefore, may be called as coecum. It is, however, impossible to discriminate, from the histological point of view, between the coecal part and the rectum proper; it is thin walled throughout the both parts, the epithelial cells with transparent intima are very flattened, though the parts where the nuclei lie being projected into the rectal cavity (fig. 45).

The mode of communication between the ileum and the rectum is not uninteresting; the ileum, as is well shown in figure 45, is inserted vertically to the rectum and some cells of the former constitute, as a whole, a valve guarding the entrance.

A similar structure as regard the coecal blind sac and the mode of connexion of the ileum and the rectum has been recorded only in *Orthezia* by List (1887) so far as coccids are concerned. The coecal diverticula recorded as occurring in *Lecanium* by Leydig (1854), Lubbock (1858) and Tozzetti

(1867) was assertained by MARK (1877) as a blind end of the 'Chylusmagen', consequently it has no relation to the present case in which the coecum belongs without slightest doubt to the rectum. The coecum in the present case seems to serve as a reservoir of liquid excrement or honey.

The rectum grows narrower towards the hind extremity. The anus opens at the bottom of the chitinous anal tube (fig. 52) which is long inserted into body tissue and guarded by a short funnel-shaped tubule.

In conclusion to the description of the alimentary canal I wish to call here the reader's attention to the fact that the rectum has been known in majority of coccids to envelope the ventriculus with convolution. The interesting character was first made clear by TOZZETTI (1867) and also by MARK (1877) in anatomy of *Lecanium*. Afterwards WITRACZIL (1886) verified the same structure in the same coccid, and KUWANA (1907) described it in *Gossyparia*. The similar structure has also been recorded by the former author (1885) as being present in some of Psyllidae. From these facts it may rightly be concluded that the ventriculus is, in majority of coccids, covered by or invested into the rectal wall.

In a striking contrast to the repeatedly described facts I have here another case recorded by LIST (1887) for *Orthezia* in which he found no convoluted condition of ventriculus and no dilated portion of rectum enveloping the former. It is clear that the present case is in complete accordance with his results. Moreover, it is of special value to know that the hind part of ileum, instead of rectum, shows a tendency to envelope the anterior part of ventriculus. My results have been obtained not only from a dissection by means of needles but also from a careful reconstruction of serial sections, thus leaving no room for doubt. It is very certain that the dilated and enveloping portion is, in the present coccid at least, the posterior part of ileum, but not reutum. If there exists, therefore, a homology between the present and previously studied cases, the so-called dilated rectal part might be in reality the hindmost part of ileum.

In the adults the essential structure of the alimentary canal still remains

with little changes, except the mouth organ and the anal tube both constituted of chitinous substances. These organs available for the larval life are entirely lost in adults, but all parts in digestive canal, from pharynx to reutum, remain almost unaltered, only the composing cells being on the way of degeneration.

Salivary glands. The present species has a pair of well developed salivary glands enclosed also in the central body cavity. Each single gland is bilobed into equal parts (fig. 39), and one of the halves is composed of about fifteen glandular cells with considerably large nuclei. In the section of the gland it can easily be observable that the secrete is semitransparent in the stained preparations and sharply distinguished from the granular protoplasmic portion (fig. 40). As the glands lie at the very front of the mouth the ducts, by which the secrete is to be conveyed to the pharynx, are necessarily long. They are very narrow tubes arising from the junctions of two lobes in each gland, and running straightly, without coming into a direct communication between themselves to make a common duct, open at last separately in each side of pharynx. In this point the new species differs from all the species of coccids hitherto studied, in which the pair of ducts are united into a common canal and open into pharynx as a single pore.

5. Malpighian tubules.

In our new species the Malpighian tubules show a very peculiar structure. There are four of them, each being communicated individually with the ileum in four different positions (figs. 47, 48). The four tubules are nearly equal in length, and are as wide as the median part of ventriculus. They are, in living insects, dark reddish brown in colour, representing a conspicuous feature among viscera.

A single tubule is made up of two rows of cells (figs. 54, 55, 56) and the one is displaced half the length of the cell, so that the entire tubule shows a slightly zig-zag appearance. Each composing cell has a thick intima, and contains two large nuclei triangular in shape in the longitudinal section of

the tubule. The nucleus has often short projections towards the centre of the cell. The axial lumen embraced by the two rows of cells is very narrow in general, but at the middle part of a cell it is dilated between two nuclei into a conical chamber, when seen in a longitudinal section.

Two kinds of cells may be distinguished in the tubule according to their histological nature; one is found in the proximal small part of tubule, and the other in the remaining main portion. The cells of the former kind have granular contents taking up haematoxylin very intensively, while those of the latter kind have contents less granular and less deeply stained (figs. 55, 56). In both kinds, however, the parts near central lumen are more transparent than the remaining parts probably due to accumulation of excrete.

So far as I am aware, the Malpighian tubules in coccids are found sometimes two and sometimes four in number. In the former case two of them are united into a short common duct communicating to the alimentary canal, while in the latter case every two of four join and give rise to two common ducts which again fuse together and finally form a single duct. The present species, therefore, differs greatly from all other coccids that have been studied for the mode of communication of tubules to ileum. Special interest attaches to the structure of this organ found in our new species, because it resembles that of Psyllidae, instead of the coccids hitherto studied (c. f. WITRACZIL, 1885).

6. Reproductive system.

The reproductive organs were examined first in the full grown larvae of the third stage. The larvae of this stage are, as stated above, quite similar in shape in both sexes except the size, so it is almost unable to determine the sex conclusively unless the sexual organs are examined in sections.

Female organs. Ovaries are found in this stage on both sides in the central body cavity, lying rather dorsal to the remaining viscera as shown in fig. 47. An ovary (fig. 67, *ov*) is consisted of thirty to fifty round follicles arround the central fine oviduct (*od.*). All the germ cells found in this stage

are in their maturation process. At the posterior part of the body cavity, where the Malpighian tubules scarcely reach, two oviducts in both sides become united giving rise to a single long vagina which passes obliquely through the massive supporting tissue until it arrives at the ventral surface of the anal hardened area. The vagina (*vg*) becomes gradually thicker towards its extremity, and the opening is distinctly assigned by a small pit.

In the adult female these structures do not differ essentially from the larva, except a considerable growth and elongation of follicles and complete formation of vaginal opening. Ova are arranged in a single series as usual, each making a connexion with the terminal nurse cells by means of a long protoplasmic thread.

Male organs. The male organs are very different according to the age of the insect. In the larval stage the organs are still simple; a pair of large testes occupy the dorso-lateral space of the central body cavity, and each consists merely of a large follicle in which innumerable cysts, containing several germ cells in each, are found (figs. 61, 62). A remarkably short vas deferens arises from the posterior extremity of each testis and soon opens into the ejaculatory duct of thick walls. In a similar way to the vagina in female the ejaculatory duct opens on the ventral surface of the anal hardened area as a small pit, but the position is always more posterior than the vaginal opening.

The adult organs, however, are very different and much complicated. Instead of paired testicular bodies there is found a cylindrical body of yellowish colour lying in the central body cavity. When examined this body in sections the pair of testes can at once be found completely enclosed within a thick covering (figs. 63, 64, *M*) which may be called a scrotal sac and is composed of muscle fibers arranged in a circle. Within the muscular covering two testes come to close contact with each other, especially so at the anterior portion. At the posterior portion, nevertheless, both of testes separate apart for some distance in order to make a room for a large seminal vesicle (*sv*).

To avoid confusion I have drawn the whole organ disclosed the scrotal sac in fig. 65. As is seen in this figure each testis (*T*) is represented by a

wide and elongated follicle, though much shortened as compared with that found in the larva, and the testicular lumen is homogeneously filled up with a swarm of spermatozoa. Vas deferens (*vd*) is a extremely short canal through which the testis communicates with a broad ejaculatory duct (*ed*). A large seminal vesicle (*sv*) is attached to the proximal end of ejaculatory duct and much elongated between the testes. When the insect is at rest we see within the seminal vesicle a considerably long penis (*p*) convoluted many times. The penis is an interesting organ from the histological point of view. In such an enclosed condition it appears as a beautiful rosette in a transverse section (fig. 66). It is made up of two distinct layers of cells; the inner one is an epithelium with a hair-like projection in each of composing cells, and the outer is a muscular layer, of which composing fibers are arranged in about thirty strings running longitudinally along the entire length of penis. The former tissue is continued with hypodermal epithelium at the posterior extremity of the ejaculatory duct underneath the chitinous integument, while the latter tissue is contiguous with the wall of the ejaculatory duct. When in activity for copulation the penis constructed in this manner prolapses or protrudes inside out, subsequently the inner epithelium with hair-like processes becomes to form the external layer of penis.

From the histological structure described above it may be supposed that the protrusion of penis and the ejaculation of sperm are due to the contraction of the muscle fibers composing the scrotal sac, and the drawing in of the penis is chiefly done by the contraction of the muscle layer composing the wall of the penis.

The genital openings are, in both sexes, slightly ventral to the anal openings. This fact surely confirms the finding of WITRACZIL (1886), in contrast to the earlier knowledge based on the results obtained by SCHMIDT or T-TOZZETTI, according to whom the genital ducts are said to open into the rectum instead of direct communication with the ventral surface of body.

7. Wax glands.

Conspicuous secretion of white waxy substance, which becomes filament-

ous, wooly or sometimes powdery, is of course the products of wax glands scattered nearly all over the body. Four kinds of glands can be distinguished, but there is none of unicellular glands present, such as found in *Orthezia* by LIST (1887) and in *Physokermes* by MOULTON (1907).

(1) The smallest glands are those most widely distributed, not only nearly everywhere underneath the chitinous integument of the larvae but also in adults. This kind of gland (fig. 51) is composed of several glandular cells aggregated into a globe and has a secreting pore of simple canal. The secreted matter from this gland is of powdery appearance when in small amount, but when accumulated in a large quantity it gives rise to a thick cluster, covering the whole surface of the body, as we see in larvae. The wax glands drawn by SASAKI (1905) in *Ericers pe-la* and by KUWANA (1907) in *Gossyparia* seems to belong to this category.

(2) The glands of the second kind are those found in the perianal region of larvae as well as the female adults (figs. 50, 52). They are much larger than those of the first group and are composed of taller cells which are, as a whole, clavate in form. The secreting pore has a sieve-like filter near the bottom. The secretion is of wooly appearance. The tuft-like secretion, very frequently found in the full grown larvae (fig. 13) or rarely in the female adults (*vide* p. 81), is the products of the glands of this kind.

(3) Those of the third kind are represented by those found at the bottom of the anal tube (fig. 52). They are of similar appearance to the preceding but considerablly larger, and are characterized by being so intimately aggregated that one can scarcely distinguish each single one. These componud glands are arranged in two different groups, of which one at the level of the end of the rectum and the other at a short distance from the former. The secreting pore is polygonal, and the secretion from each pore is filamentous. But all the filaments secreted become assosiated and finally form a long hollow tube growing out of the anal tube, the most peculiar product of this insect.

(4) The glands of the fourth and last kind are found only in the male

adults. We have already learned that on the tegra of 7th and 8th abdominal segments in the male are projected a number of tubercles from which long white filaments are secreted. These filaments are the products of these glands. The glands (fig. 53) are characterized by the glandular cells of much larger and less in number than in any of those above described, and by having a large lumen. The secreting pore possesses a projected tube as already mentioned.

IV. Systematic consideration.

Since the discovery of *Xylococcus filifer*, parasitic on Tilia in Austria, and the establishment of the new genus *Xylococcus* (1882), three more species[1] have been recorded by different authors from different parts of the world as belonging to this remarkable genus, as tabulated below. The second species is *X. betutae* reported by HUBBARD aud PERGANDE (1898) from birch trees grown in North America. The third was found by Ehrhorn (1900) in California and named *X. quercus*, on account of its attacking an oak, and the fourth has been known also as a pest of an oak, *Quercus serrata*, found in Tokyo, and first described by KUWANA (1914). It is therefore the fifth example that I have described in the foregoing pages.

Name	Food plants	Localities	Authors
X. filifer	*Tilia grandifolia*	Baden, Austria	LOEW 1882
X. betulae	*Birch, Aspen*	Lake Superior U. S. A.	HUBBARD & PERGANDE 1898
X. quercus	*Quercus chrysolepis*	California, U. S. A.	EHRHORN 1900
X. napiformis	*Quercus serrata*	Tokyo, Japan	KUWANA 1914
X. alni	*Alnus japonica*	Sapporo, Japan	OGUMA 1918

At the time when the species *X. filifer* was first found, Loew was unable to follow its life cycle in completeness, and some misunderstandings were resulted. According to his descriptions the adult female of *X. filifer* is an

1) KUWANA (1907) has described one more species, *X. matsumurae*, from a pine in Japan, but this species has since been considered as to be placed in another genus, *Matsucoccus*.

oval or pear-shaped animal without antennae and legs, and the anal segment is provided with a short conical tube from which proceeds a long hollow thread made of the secreted wax-like matter. SIGNORET (1882) has suggested already that the supposed adult female of this species would be of still larval condition. A complete life-cycle of this genus was first made clear through investigations upon *X. betulae* collaborated by HUBBARD and PERGANDE (1898). HUBBARD has come to the conclusion, in comparison of his species with Loew's, that the coccid considered by the latter author as adult form is evidently one of the legless intermediate larval forms.

On the other hand in *X. quercus* the adult female has been reported as being a very active insect provided with well developed antennae and legs. KUWANA (1914) describes the adult female of *X. napiformis* as being so much helpless and without any appendages, but provided with an anal waxy filamentous tube, and the body burried under the bark. Such condition just coincides with some larval stages of *X. betulae* and of *X. alni*. The insect considered as an adult female by KUWANA seems at least to represent an immature stage of female-producing larva.

Taking the view above expounded in mind we can find a fair coincidence between the five species of *Xylococcus* so far as the chief points of their body structures and of metamorphoses are concerned. Accordingly, the common characters of the genus *Xylococcus* may be summarized as follows, amplifying and amending at the same time the generic characters originally defined by Loew.

"The newly hatched larvae active with 6-jointed[1] antennae and well developed legs; in the larvae of the second and third stage both antennae and legs entirely reduced or lost. During these stages the larvae introduce themselves under the bark which they infest, and produce from the anus a long waxy hollow thread from which drops of honey are excreted. At the fourth stage the male-producing larva regains legs and antennae of 9-joints, while the female-producing one still retains the former inactive state and her shape

1) *X. napiformis* is only exception, the antennae 3-jointed.

unaltered. The adult male is provided with long caudal tufts composed of white waxy substance ; antennae 10-jointed, halter with four hooklets.[1] The adult female active in *X. betulae* and *X. quercus* as being provided with legs and 9-jointed antennae, but in *X. alni* she is legless and antennae very rudimentary."

As there are somuch coincidence, in the morphology and the life histories, between the species of the genus *Xylococcus*, we can expect also such identity or the closest resemblance at least, in the internal anatomies of their bodies. Unfortunately, however, I am ignorant of any worker having attempted the anatomy in great detail. Provided that the chief points described in the anatomical parts of the present paper similarly occur in the remaining species of the genus, the genus *Xylococcus* differs markedly from all other groups of the Coccidae, and eventually must be placed far from the latter. Because we do not find such peculiar structures of the Malpighian tubules, the salivary glands, the alimentary canal and the tracheal system &c. in any other subfamilies.

Comparing *X. alni* with the species hitherto studied by other authors the present species is no doubt closely related to *X. betulae*. The food plants of these two kinds of coccids are of the same family, Betulaceae, although *X. betulae* are not found on adler and *X. alni* not on birch. The importan points with which these two species are to be distinguished are as follows.

1. The newly hatched larvae of *X. alni* have three median abdominal pores, of which the function is as yet uncertain, while in *X. betulae* there are five.

2. The larvae of the second and the third stage of *X. alni* have rudimental antennae, while in *X. betulae* they are completely lost.

3. The adult female of *X. alni* is legless, quite unable to escape out of the case in which she has grown, and with a pair of protuberances representing the antennae, while in *X. betulae* she is more highly organized with nine jointed antennae and well developed legs.

1) In *X. quercus* the number of hooklets of the halter unknown.

I am not aware how long *X. betulae* spends its larval life burried in the tissues of the wood; this point is not clear to me in the other species of the genus. My new species is marvelous in this respect; it requires, surely, two years and a half. Therefore at the beginning of autumn of the third year from the spring when the first larvae hatched out, we can find first the adult insects as already described. And I do not know also that there are any other species of the coccids that passes so long a time for its growth and maturation.

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Explanation of Figures.

Abbreviations.

a, anus; *as*, abdominal spiracle; *bc*, body cavity; *bl*, blood cell; *br*, brain; *c*, cuticle; *ds*, dorsal sinus; *dt*, dosal trunk of trachea; *ed*, ejaculatory duct; *hd*, hypodermis; *i*, ileum; *M*, muscle; *m*, Malpighian tubule; *os*, oesophagus; *ov*, ovary; *od*, oviduct; *p*, penis; *r*, rectum; *sg*, salivary gland; *sv*, seminal vesicle; *T*, testis; *t*, trachea; *ts*, thoracic spiracle; *tg*, thoracic ganglion; *v*, ventriculus; *vd*, vas deferens; *vg*, vagina; *vt*, ventral trunk of trachea.

Fig. 1. Egg.

Fig. 2. Newly hatched larva. × 51.

Fig. 3. Antenna of the same. × 460.

Fig. 4. Hind leg of the same, proximal part of femur omitted. × 460.

Fig. 5. Larva (newly hatched) of the first stage, showing the arrangement of wax-secreting pores, ventral view.

Fig. 6. The same, dorsal view.

Fig. 7. The earliest stage of the second larva. × 51.

Fig. 8. Advanced stage of the same, ventral view. × 51.

Fig. 9. The same. × 16.

Fig. 10. The most advanced stage of the same, ventral view. × 16.

Fig. 11. Male larva of the third stage, dorsal view. × 16.

Fig. 12. Female larva of the third stage; note the new appearance of genital opening on ventral side. × 16.

Fig. 13. Caudal secretion of wax of the same. × 16.

Fig. 14. Antenna of the same. × 230.

Fig. 15. Male larva of the fourth stage, dorsal view. × 16.

Fig. 16. The same, ventral view. × 16.

Fig. 17. Antenna of the same. × 51.

Fig. 18. Tibia with tarsus of the same. × 103.

Fig. 19. Pupa of male. × 16.

Fig. 20. Tibia with tarsus of the same. × 103.

Fig. 21. Male imago. × 16.
Fig. 22. The same, ventral view. × 16.
Fig. 23. The same, lateral view. × 16.
Fig. 24. Balancer, curved × 103.
Fig. 25. Balancer, stretched. × 103.
Fig. 26. Penis. × 51.
Fig. 27. Tibia with tarsus of male imago. × 103.
Fig. 28. Wax-secreting pores on abdominal tegrum of the same. × 230.
Fig. 29. Female imago, ventral view. × 16.
Fig. 30. The same (largest form), dorsal view. × 16.
Fig. 31. Antenna of the same. × 230.
Fig. 32. Cocoons of male larvae. × 16.
Fig. 33. Tracheal system of the third larval stage.
Fig. 34. Tracheal chiasma of the same. × 230.
Fig. 35. Tracheal chiasma in the first stage of larva. × 691.
Fig. 36. Tracheal system of the same stage. × 103.
Fig. 37. Longitudinal section of trachea through thracic spiracle. × 230.
Fig. 38. Longitudinal section of trachea through abdominal spiracle. × 230.
Fig. 39. Salivary gland. × 230.
Fig. 40. Cross section of the same. × 230.
Fig. 41. Longitudinal section of ventriculus with a part of oesophagus. × 460.
Fig. 42. Ventriculus, cross section. × 460.
Fig. 43. Ileum, cross section. × 460.
Fig. 44. Hindmost part of ileum. × 460.
Fig. 45. Cross section of rectum with a part of ileum. × 460.
Fig. 46. Transverse section of female larva at the level where the ileum is passing into rectum.
Fig. 47. The same but slightly posterior to the preceding.
Fig. 48. Alimentary canal with four Malpighian tubules of which three partly drawn (reconstructed from sections).

Fig. 49. Transverse section of male larva of the third stage. × 51. Note the anlarge of legs (*l*) which develope merely in the male larva of the fourth stage.

Fig. 50. Wax gland in peripheral region. × 460.

Fig. 51. Wax gland in anterior part of body. × 460.

Fig. 52. Longitudinal section through anal tube with wax glands attached. × 103.

Fig. 53. Wax gland under abdominal tegrum of male imago. × 460.

Fig. 54. A part of Malpighian tubule, longitudinal section. × 220.

Fig. 55. Transverse section of proximal part of Malpighian tubule. × 220.

Fig. 56. Transverse section of distal part of Malpighian tubule × 220.

Fig. 57. A part of ileum showing arrangement of four Malpighian tubules attached.

Fig. 58. Nervous system, dorsal view. × 103.

Fig. 59. Longitudinal section of the same, × 103.

Fig. 60. Peripheral part of thoracic ganglion. × 103.

Fig. 61. Sexual organ of male larva in the third stage (reconstructed from sections). × 103.

Fig. 62. Transverse section of testis of the same, showing cysts in which germ cells of various stages in development are contained. × 460.

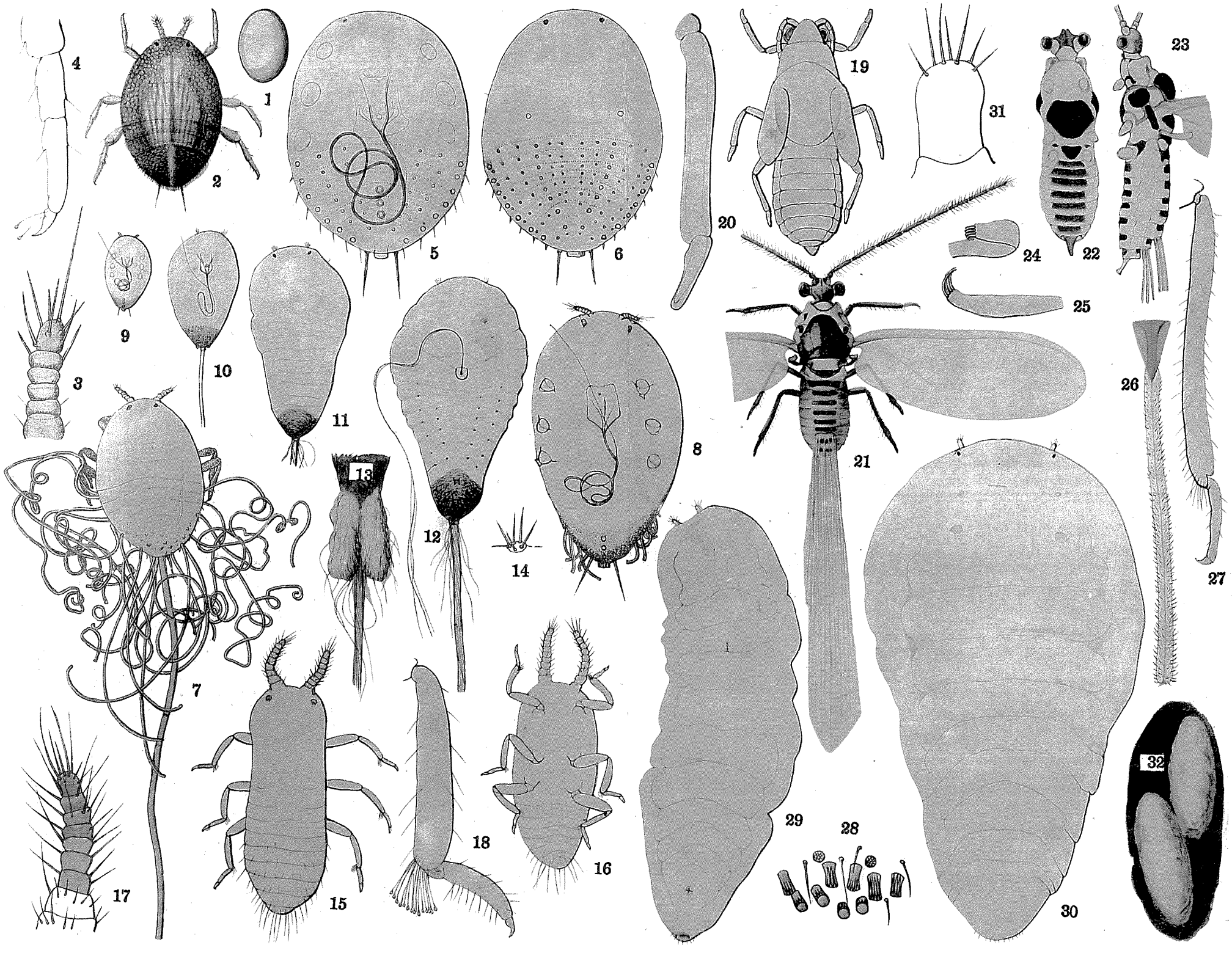
Fig. 63. Male sexual organ of imago, a part of testis and muscle covering are cut off. × 103.

Fig. 64. The same, transverse section. × 103.

Fig. 65. The same, the whole covering taken off. × 103.

Fig. 66. Transverse section of penis in the state concealed in seminal vesicle. × 460.

Fig. 67. Female sexual organ in the third stage of larva, right ovary cut off (reconstructed from sections). × 103.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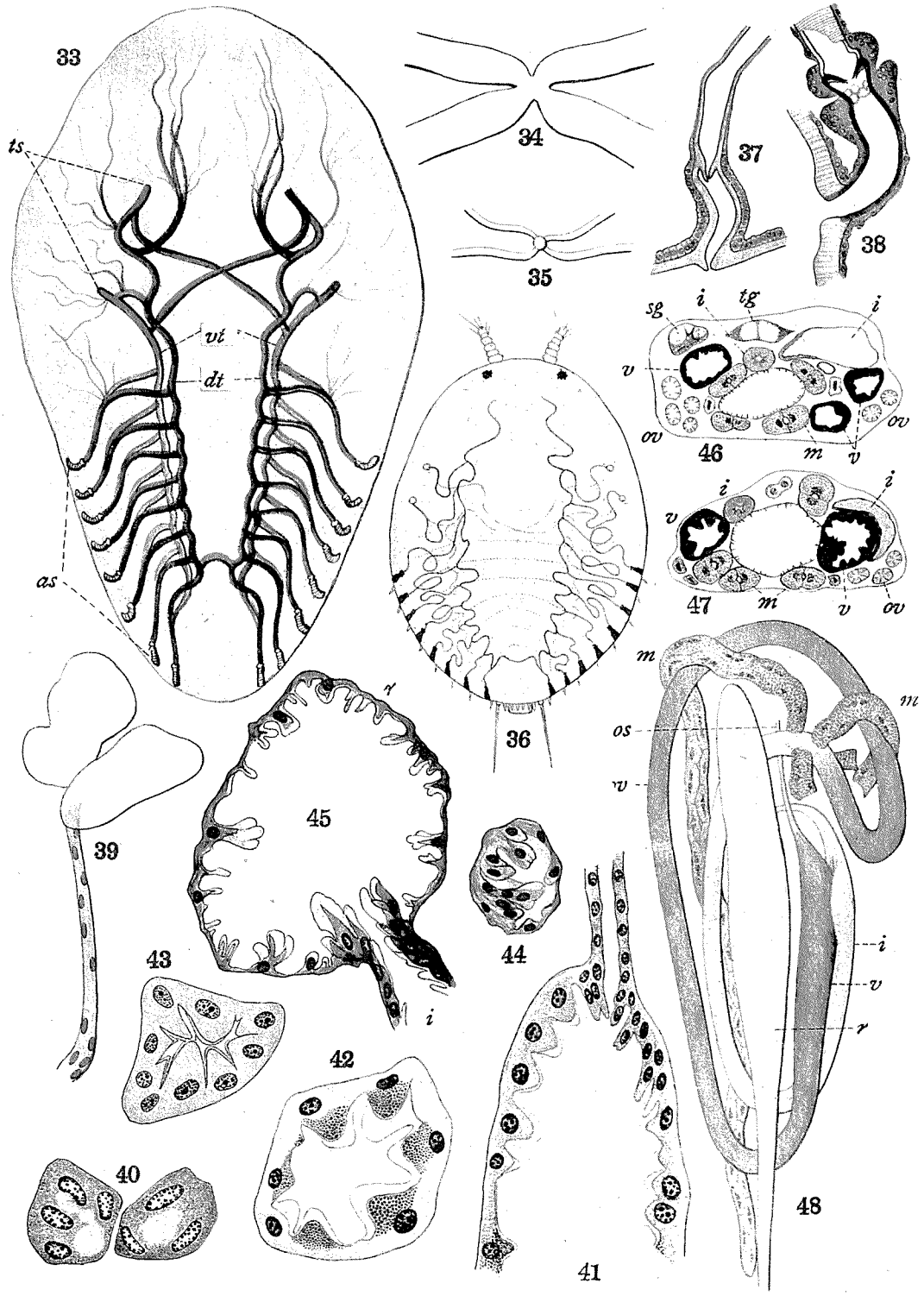
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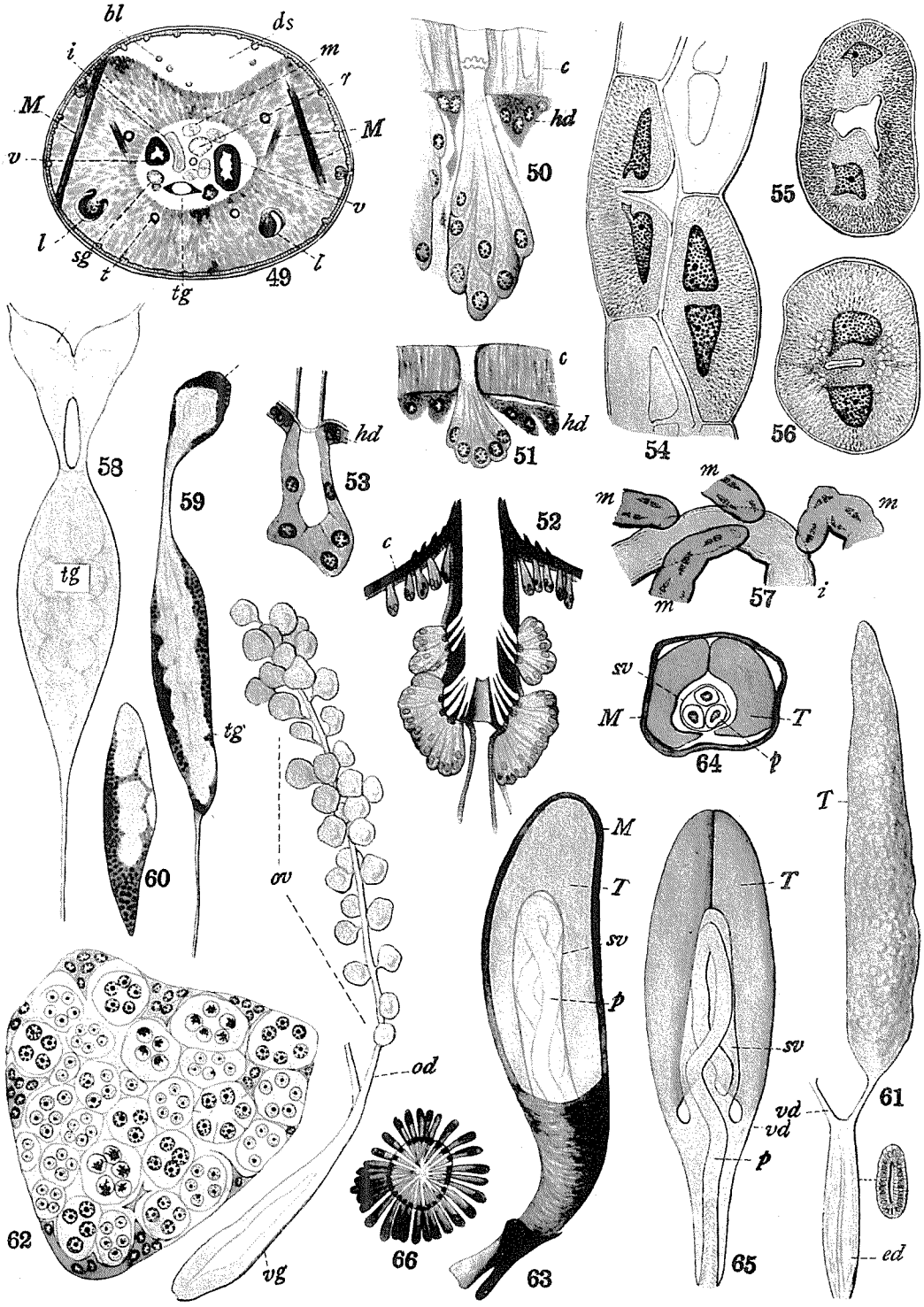
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