Some Notes on the Oyster Shell Scale

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During the past two years a number of observations have been made at Vernon in the Okanagan Valley on the life history and control of the oyster shell scale.

The following article deals mainly with the formation of the scale with which the insect protects itself during its development and its life as an adult.

Different Stages of the Insect

The eggs when laid are slightly larger than when measured in the early spring being .33 mm. and .28 mm. in length respectively. They are a pearly white and about half as wide as they are long and are covered with a very fine waxy powder. These lie dormant from September until May. The parent scale is so tightly packed that the eggs are pressed very much out of shape. Among them are found occasionally shrivelled specimens showing a discolouration. After the mild winter of 1920-21, Mr. Venables examined 83 scales in March, out of which only four eggs exhibited this discolouration. and he quotes J. D. Tothill in Vol. IX, Bulletin of Ent. Research as saying: "As a rule one rarely finds more than 2% or 3% of such eggs."

Subsequent observations in Vernon during the last two years lead to the same conclusions and as one finds this small percentage of dessicated eggs in the autumn they would appear to be merely accidents. In the spring of 1929 and 1930 following severe winters there were, however, a number of eggs which while retaining more or less their normal shape were brown in colour. The average number for all our counts was only 8%, but in some localities especially on trees in the town of Salmon Arm, the percentage of these damaged eggs was in some cases 90%.

Webster has shown that the eggs will withstand a temperature of -31 degrees F., but will succumb to -32 degrees F. Unfortunately he does not describe the appearance of the eggs when killed by frost.

The minimum temperature for the last two winters in Vernon has been around -24 degrees F. although it is possible that lower readings might have been made from such localities where the severest injury to the eggs was found.

No cause other than cold weather can be assigned for the discolouration of these eggs but the more important point is that these eggs are killed and interfere with the hatching of the sound eggs.

Incubation of the Egg

The eggs appear to require a period of rest. Samples brought into the laboratory in October show no sign in December of any change. The eggs have been described as pearly white and are just as opaque as a pearl. By examining them in cedar oil and slightly pressing them under the weight of a thin cover glass they are sufficiently transparent to observe from day to day the changes taking place prior to hatching.

The embryo is more or less enveloped in the embryological folds, but on May 4th distinct signs of the chitinous mouth parts could be detected appearing as a faint V. On the 12th the pharyngeal pump could be seen as a small dot at the angle of the V. On the 15th the stylets became visible as an extension of the sides of the V but curving in their course so as to represent two coils on either side of the head. The chitinous ring around the base of the labium was also in evidence.

On the 16th antennae and legs were plainly to be seen and hatching commenced on the same day. Eggs from trees sprayed with oil and lime-sulphur at winter strengths showed a similar development. These dates do not determine the actual time required for this development of the embryo. The method employed required the observation of a number of eggs and are not to be construed as precise data of the changing phases within a single egg. It is, however, possible to predict when emergence is likely to take place and it may be possible to judge the duration of the hatching period by such means.

Hatching and Emergence

While the development of the embryo has been proceeding, the eggs which are packed so tightly within the scale as to be much flattened, have been gradually resuming their normal spherical shape in which they were first laid. Covered as they are with a powdery wax they are able to accommodate themselves to an expansion of the egg mass which by the swelling of the eggs must inevitably take place. This expansion appears to lift the posterior end of the scale which is the only part not attached to the bark by a ventral skin and thus an exit is provided for the hatched nymphs.

This period appears to be the most critical in the life of the oyster shell scale. A percentage of dessicated, winter killed, or otherwise injured eggs which cannot regain their normal shape must collapse under pressure and thus prevent the expansion necessary to lift the scale and provide freedom of exit to the enclosed nymphs. If, on the other hand, there are no injured eggs, but their waxy covering is destroyed so that the eggs adhere to each other, the mass will nevertheless expand but the pressure will be unevenly distributed and many eggs may collapse. Moreover, a compact mass of eggs would make it very difficult for the young nymphs to get out of the egg.

Nature, in the case of the oyster shell scale, seems to have contrived such a well-adjusted piece of mechanism that a very slight interference may put the delicate machinery out of gear.

Providing all goes well during the hatch, the egg at the extreme caudal end, which were laid a month earlier than those of the anterior end, will be the first to hatch. As these first nymphs leave the parent scale space is provided for eggs to separate from the mass and so on until all the nymphs have had room to struggle out of their envelope and pass through the exit in orderly succession. It is quite another matter if cold or wet weather intervenes which may disincline the first hatched nymphs to venture forth. These may in this case die or linger at the exit or completely block the doorway by settling down and starting their preliminary scales, but whatever they may happen to do under varying circumstances, their presence within the scale is apt to cause a congestion that is of fatal consequence to the rest of the family.

Much of the above can be confirmed observationally. That the caudal end of the scale is firmly attached to the bark until the spring is verified by the fact that in so many cases in the autumn one finds that the mite **Hemisarcoptes coccisugus** has to force an entry through the thin exuviae or cast skins at the anterior end of the scale.

That pressure is exerted by the expanding egg mass in the spring is demonstrated by the manner in which the eggs scatter when the scale is detached from the bark, which does not happen in the autumn.

The large number of dead nymphs and partially hatched eggs that are found beneath the scales when the weather has been unfavourable at the time of emergence makes the description given of what takes place under certain conditions more than a matter of mere conjecture.

However careless Nature may appear to have been in providing for every contingency a further scrutiny of the insect during the making of the scale will at least show how painstakingly Nature endeavors dur- during the insect's life to provide against the weather, especially wet weather.

The First Instar

The nymphs extricate themselves from their surrounding envelope in much the same way as during a moult. The anterior end of the egg breaks, setting free the head and the thin membrane gradually splits until the legs are freed and the insect is able to quickly disengage itself from its covering.

The newly emerged nymphs are creamy white in colour. They are smaller but similar in appearance to the tiny lenticels on the smooth young bark which to the unaided eye may easily be mistaken for settled nymphs. There are two small lemon coloured areas, one being at the caudal end and the other at the anterior. In the neighbourhood of these yellow areas are scale producing organs.

The antennae protrude slightly ventrad being composed of six segments, the distal segment is as long as the first five and is armed with six stout spines. The length of the antennae is not more than equal to the breadth of the head.

The legs are stout, the tarsus ending in a single claw around which are four projecting capitate hairs (digitules).

The simple eyes have only one lens behind which is a bright red pigment. It is only during the short active period before settling that the legs, antennae and simple eyes are of any service, these all being cast away in the first moult.

The labium appears as a small chitinous ring when viewed from above. Laterally this is seen to be a small half sphere like a pimple projecting the length of its width and down the centre of this is a vice-like process whereby the stylets are gripped.

The long stylets, mandibular and maxillary, which were coiled in the head of the embryo immediately before the hatching of the egg have coalesced and moved down and when viewed in the nymph they extend from the mouth to the pygidium where they curve back to the centre of the body. Here they form a small loop and then double back to the pygidium and return to the mouth, terminating in the short labium. The length of the stylets is considerably greater than the length of the insect and the uses of this excessive length will be more evident at a later stage.

The pygidium at this stage is segmented to become hereafter fused in the adult. The median lobes are very wide apart between which protrude a pair of very long setae, more than half the length of the body. These trail behind the nymph as it moves and probably assist the creature in adhering to the smooth bark. Incidentally the predaceous mite **Hemisarcoptes coccisugus** Lignieres is also equipped with similar appendages. Laterad to the median lobes are a paid of rudimentary secondary lobes and between the lobes and projecting from the margin of the lower abdomen are 8 to 10 blunt gland spines resembling nipples rather than setae. These are the spinnerets, which with two large wax pores of the head in the centre of the lemon coloured areas at the anterior end, manufacture the preliminary waxy covering.

The Active Stage After Emergence

On leaving the parent scale the activity of the crawling nymphs appears to be largely dependent on temperature.

Experiments with a twig of heavily infested dogwood have shown that at 64 degrees F. in the laboratory the emerged nymphs were reduced to a comatose condition. Taken into the sunshine at a temperature of 85 degrees F. the same twig became a seething mass of movement. Repeated trials proved beyond doubt the effect of light and temperature.

Quayle has shown that the distance travelled by **Lepidosaphes beckii** Newn. at a temperature of 89 degrees F. was three times the distance attained at a temperature of 68 degrees F. He has further demonstrated that the insects are attracted towards the light. The question of how long and how far the insects crawl before settling must therefore vary according to light and temperature.

Grace Griswold in three experiments with the lilac form showed that it only required an hour or so for this form to settle and that the scales are completed within from thirty to forty-eight hours.

Similar experiments in Vernon were inconclusive owing to weather conditions but were sufficient to indicate that the crawling period of the apple form is at any rate of brief duration. From the control point of view this stage would seldom if ever permit of 100% control. Under optimum conditions hatching and emergence must be a matter of days and under unfavourable conditions may be extended for five weeks. In 1930 the eggs started to hatch May 16th, and an examination on June 23rd revealed the presence of newly emerged nymphs and a few unhatched sound eggs.

The distance that the nymphs crawl does not have to be very great to be harmful in the case of the apple with its short fruit spurs, and it is possible that the effect of a dormant spray may be such as to drive the nymphs on to the unsprayed new growth.

Formation of the First Preliminary Scale

Shortly after settling a number of fine filaments of a bluish white colour are seen to emanate from the spinnerets or gland spines around the margin of the lower abdomen. At the same time two coarser strands of a metallic lustre proceed from the two large wax pores of the head. These coarse strands directed backwards from the head coil on the body much like the spring of a watch and in doing so catch the finer strands of the pygidial gland spines. This warp and woof gradually produce a clumsy coat which hides all but a small portion of the head.

Under this preliminary and elastic covering the insect is able to develop and grow, but this coat is soon lost and does not form any part of the completed scale.

The First Moult

At the first moult the insect remains in situ and does not cast its skin away, but makes use of it as a protective casing. The dorsal skin has gradually hardened and thickened into a shell and at the moult loosens and becomes free. The ventral skin has meanwhile remained thin and flexible and breaks at a point just caudad of the antennae. This thin venter is pushed down enabling the second instar to come in contact with the bark while closely confined beneath the hard dorsal skin (the exuvia). In this moult the antennae, the legs, the eyes and the long setal trailers are dispensed with. The redundant antennae adhere to the anterior end of the exuvia and the discarded legs are visible in the crumpled ventral skin at the posterior end.

A set of stylets have been formed and are coiled within the head previous to the moult in the same position as they appeared in the head of the embryo within the egg previous to hatching. The old stylets are not withdrawn but remain embedded in the tissue of the bark.

The Second Instar

The second instar ensconced beneath the first exuvia is minus antennae and legs and without organs of sight. It is pear-shaped the posterior end being somewhat broader than the anterior. The colour is creamy white as in the first instar but there is only one lemon coloured area and this is at the caudal end. Now that protection is afforded by the first exuvia the anterior wax pores have served their purpose and cease to exist. Instead of advancing from a simple larva to a more organized form of existence, the scale at first sight seems to have a retrograde metamorphosis from a nymph with the sense organs and appendages of an adult insect to a distinctly larval type of form. A closer acquaintance with the second instar will enable one to appreciate the fact that a very great advance is really in progress, namely, an advance from an unspecialized nymph to a highly specialized adult, in which the centre of interest lies in the pygidium.

This has undergone considerable change. The large median lobes are much closer together and the secondary lobes more distinct. The stubby spinnerets have become more spine-like. Four large piston-shaped glands are developed on either margin of the pygidium and two others appear in a rudimentary condition. None of these appear to have any role in the formation of the second temporary scale which again emanates from the gland spines.

This time the first exuvia and its clumsy covering form a matrix for the succeeding coat. Instead of the waxy filaments extending into space and being haphazardly caught by the coarse strands from the head they strike the low ceiling of the first exuvia and a sweeping movement to and fro of the insect's lower body weaves these threads compactly. This movement of the insect makes its second coat, which by the way is very much better than its first attempt—considerably wider than the insect beneath and it is only during the second stage that the appellation oyster shell scale is really suitable.

Two or three weeks elapse before the second moult which is a repetition of what took place in the first. The dorsal skin hardens and becomes free while the ventral skin breaks at the anterior end and is pushed down to allow the adult to have free access to the bark.

The Third Instar or Adult

The adult is very similar in appearance to the second instar. The new stylets are considerably longer and for a short time after moulting are extended in several graceful loops within the body.

The drawings by Grace Griswold of the lilac form give a different contour of these loops to what is observed in Vernon on the apple form. A very eccentric arrangement of the stylets has been observed in the two specimens of **Aspidiotus pinifoliae** which were caught at this particular stage. It would appear that a particular pattern of these loops is constant to the different species and probably to variations of the same species.

The pygidium shows several alterations. The median lobes are very close together and are notched on their margins. The second lobes are cleft to form two distinct lobes but the purpose of these lobes is obscure.

The gland spines are now in pairs instead of single, one pair projecting between the median lobes and four pairs projecting on either side from the margin of the pygidium making nine pairs in all. Above the pygidium several gland spines are prominent on the sides of the abdominal segments and a number of stubby spinnerets similar to those of the first instar are scattered over the ventral surface of the sides of these segments. The large piston-shaped glands which were evident but were not at work in the formation of the second covering are now twelve in number and in good working order.

All these scale producing organs are thus situated more or less on the outer margin of the body.

The anus is situated on the dorsal surface some distance from the extreme posterior end and it appears that the waste matter from the body is incorporated in the final scale.

In addition a number of small pores are scattered on the dorsal surface of the pygidium which do not seem to produce scale material but may excrete a substance that gives the scale its inner polished surface.

On the ventral surface there are five groups of circumgenital pores. There being two posterior and two anterior lateral groups and one median group arranged in the shape of a horse shoe around the vulva. Each group consists of about 12—15 pores and each pore has a central flower like structure consisting of 5 and sometimes 6 roundish cells surrounding a central cell. This cell arrangement is exactly similar to the head wax pores of the woolly aphis **Eriosoma lanigera** Haus. From the circumgenital pores is derived the waxy powder with which the eggs are covered. Similar pores are found around the two pairs of spiracles where this waxy secretion is also encountered.

Formation of the Scale

The thick dorsal scale is made up of thread like filaments emanating from the gland spines as on previous occasions, but in addition a thick ribbon-like material is exuded from the large piston shaped pores. The waste matter from the anus provides further material and the small dorsal pores may emit a substance which counteracts the adhesiveness of this mixture. The movement of the insect's body from side to side so enlarges the scale that it allows for the growth of the insect and also enables it to move down the lengthening scale. Simultaneously the spinnerets on the ventral margin of the abdomen are engaged in producing the fine material of which the thin ventral scale is composed, but these spinnerets being situated towards the middle of the body, the ventral scale does not extend to the full length of the dorsal scale thus when the scale is raised an opening is provided for the hatching nymphs to crawl through.

The formation of the scale can only be deduced by observing insects denuded of their covering. Most of these die very soon but some will continue to produce scale material for several hours. Under these very adverse circumstances the rate at which these threads are produced is about 1 mm. in 10 hours. Allowing 30 days for the completion of the scale and the number of organs employed there must be considerably over 30 yards of this material in the completed scale under normal conditions if production is constantly maintained.

The completed scale measures from 3—4 mm. in length being over 4 times the length of the insect beneath. It is during the construction of the scale that the uses of the extraordinary length of the stylets becomes apparent. These have been seen to be lying in several graceful loops within the body immediately after the last moult. Only a part of this great length is inserted into the bark for in order to reach the cambium it is only requisite that one-third of the length of the stylets should be thus employed. But the insect must move down the lengthening scale and as this takes place the reserve length within the body is utilized. This is pulled out of the body so that on completion of the scale the insect is at the posterior end with its stylets stretching tautly to the tiny orifice in the venter where they were originally inserted. If during the construction of the scale the insect is detached by a sharp razor blade which serves the stylets, a considerable length of styles will be seen to be conserved within the body.

Filling the Scale

On completing the scale the insect has become cylindrical in shape and its body is replete with eggs in all stages of development. It proceeds to deposit these as they mature and as it does so works its way back to the anterior end. This takes a matter of a month or so, the body contracting as the eggs are disposed of and the life history comes to an end in September when the scale is so packed with eggs that there is no room for any more and the shrunken adult is squeezed into the extreme anterior end where it first moulted. The number of eggs show a range from 21—77.

Grace Griswold's counts range from 20—108 for Ithaca, New York. The number of eggs varies with the size of the scale and in some years the scales are larger on the average than in other years. Large scales with few eggs are not met with and the insect appears always to have the ability to pack to the utmost the scale which it provides.

Both the apple and lilac forms of **Lepidosaphes ulmi** appear to be completely parthenogenetic on their common host plants. Grace Griswold says "During the past two years I have examined thousands of scales from many host plants but have never seen a male." Imms (1925) says "In **Lepidosaphes ulmi** (L.) males are unknown on its commonest host plant (apple) and have only been observed on one or two less frequently infested plants."

There is no record of a male being observed in B. C.