likely to do more harm than the more or less ineffective artificial protection of a few industries would do good. It is to be hoped, therefore, that institutions in which such scientific research is carried on will be placed beyond the effect of the new restrictions on import.—*Nature.*

SPECIAL ARTICLES

THE PRACTICAL SIGNIFICANCE OF THE REVOLUTION OF THE EMBRYO IN APHID EGGS

IN 1916 W. F. Turner[1] and the writer published a paper on the green apple aphis, in which certain studies on the embryology of the species were reported. Studies on other species have since been completed and it seems now worth while to point out the important bearing that certain phases of the embryonic development have on the hatching of the egg under varying conditions. This seems especially urgent from the viewpoint of control in the egg stage.

As pointed out by Baker and Turner, the egg envelopes in the three common apple species, *pomi, malifoliæ* and *prunifoliæ* (*avenæ* of American authors) are two in number, the chorion which is thick and glossy black in color and the vitelline membrane which is delicate and transparent. At the time of deposition the egg is embedded by the female in a viscid material which serves to hold it in place on the twigs. This soon hardens and firmly fastens the egg in its location. This material covers irregularly all eggs and serves not only to cement them to the twigs but also as a protection for the chorion during the winter. It no doubt corresponds, in the Aphiinæ to the waxen coating with which the females of the Eriosomatinæ cover their eggs. A somewhat comparable condition is met with in other insects in which a glutinous cap covers the micropyle-area and may extend as an envelope over the greater part or even the entire egg.

The eggs of all three species when laid are of a somewhat greenish color and this changes ultimately to the glossy black of the winter-ing egg. This change in color coincides with preliminary embryonic development. This usually occupies about five day's time. Eggs which are infertile or in other ways abnormal do not change color in the usual way. In fact most infertile eggs are not of the normal green color when laid but have an orange or brownish tinge which may darken with age.

One of the most interesting phases in the development of these aphids is the resting stage of the embryo. All eggs, no matter whether laid early or late, reach this same stage for wintering. This is the normal dormant condition. The embryo lies in the center of the egg with its cephalic portion toward the posterior pole. The caudal half of the abdomen is reflexed dorsad in such a manner as to include the ovarian yolk. Segmentation is well marked and the formation of the appendages has begun. The stomatodeum and proctodeum are present while the formation of the mesenteron has begun. The genital rudiments are separated into two groups but the ovarian yolk is not yet divided and at the posterior pole lies the polar organ.

In this condition the embryo, especially of *pomi* and *malifoliæ,* remains until early spring and it must remain in this condition throughout the winter until normal growth is resumed. Attempts to force the eggs to their spring development are without success.

In the early spring development is resumed. This takes place in the vicinity of Washington, about the middle of March with *pomi* and *malifoliæ.* This development is accompanied by a movement of the embryo through the yolk toward the posterior pole until that portion of the amnion which lies above the head comes in contact with the serosa at its junction with the polar organ. The two envelopes then rupture here and the embryo revolves. This is a most important period in the development of the species and the time of this revolution is of great significance in understanding certain results which have been obtained by different workers.

It has been shown by Baker and Turner that an elevation of temperature before revolution is fatal to the embryo. It is also im-

[1] *Journal of Agricultural Research,* Vol. V., No. 21.

portant to remember that after the revolution of the embryo the eggs are much more susceptible to contact and similar injury. Recently Peterson[2] has published an important paper on the hatching of the eggs of these species, but he has apparently failed to note the fact that the time of revolution is extremely important in interpreting the results of experiments. It is very probable that the revolution of the embryo in New Brunswick takes place considerably later than in Washington. Judging from the conditions this would in all probability begin during the first week in April. It is evident then that in eggs taken during most of March and possibly some of those taken early in April the embryos would still be in the resting stage. Under such conditions eggs placed under a high temperature for hatching purposes would fail to hatch as all the embryos would be killed. In examining Peterson's Table I., p. 16, it will be seen that out of 4,400 eggs of *pomi* taken on March 14, not an egg hatched at 80° F., whether in dry air or in different percentages of saturation. Other eggs taken on April 6, gave a variable percentage of hatch. In dry air (expt. 105) some hatching occurred and also in 63 per cent. and 100 per cent. of moisture, but in 22 per cent. moisture (expt. 106) no hatching occurred. It seems probable that many of the embryos in the eggs used had not revolved and that more such eggs were present in experiment 106 than in experiments 105, 107 and 108. In fact these results seem to contradict Peterson's conclusion for more hatched in dry air than in 22 per cent. moisture in which there was no hatch whatever. Certainly since more hatched in dry air than in 22 per cent. moisture one can not claim that it was lack of moisture which prevented the hatch. Some other factor must have been at work and this factor was evidently the condition of the embryo.

The writer does not intend to convey the impression that moisture has no influence on the hatching of these eggs for, as Peterson indicates, it undoubtedly has but he wishes to point out the fact that in experiments of this kind the stage of embryonic development must be considered if accurate conclusions are to be drawn.

Thus the small percentage of hatch secured by Gillette in Colorado is explained by Peterson entirely on moisture conditions and yet the writer has just shown that the failure to hatch in some of Peterson's own experiments with *pomi* is due to an entirely different factor.

The hatching of the different species takes place in very much the same way although *prunifoliæ* is much earlier than *pomi* and *malifoliæ* which two hatch at approximately the same date.

After revolution of the embryo hatching can be advanced or retarded greatly by weather conditions. An elevated temperature which before this time is fatal serves afterwards to hasten hatching unless the atmosphere is extremely dry. The gelatinous matrix in which the egg is embedded has by this time become more or less brittle and splits irregularly, usually in a longitudinal direction. This is soon followed by a rupture in the shell made by the egg burster. The young nymph continues to push its way outward until it stands in an erect position just above the slit in the shell. At this time the membrane has not ruptured and the aphid sometimes dies without freeing itself. Normally, however, the membrane ruptures to the right of the egg burster and gradually works downward carrying this structure with it. The young insect then leaves the egg and this thin pellicle is left as a shrivelled structure partly protruding from the slit in the shell. In speaking of the fate of the egg burster Peterson (*l. c.*, p. 14) says: "During emergence this ridge disappears and only a faint line remains along the meson." As far as our observations go, however, the egg burster retains its identity as part of the membrane in much the same way as that of *Corydalus cornutus*, described by Riley. In some cases the writer has observed young of viviparous aphids to free themselves while on the leaf. Packard[3]

[2] New Jersey Agr. Exp. Sta. Bull. No. 332, 1919.

[3] "Text Book of Entomology," 1909, The Macmillan Co., p. 583.

has reported the casting of the amnion of *Melanopus spretus* while the nymph is free from the egg and mentions observing this condition in the hatching of several other insects. In fact, it has been observed that very many insects, including the seventeen year cicada, are entirely enclosed in this membrane after hatching.

In the aphids as the embryo revolves the serosa contracts and draws with it the cells of the polar organ and the serosa and polar organ from the dorsal plate. This then invaginates, forming the dorsal body which separates itself from the amnion completely and is ultimately absorbed. Thus only the serosa and polar organ disappear while the amnion closes the gap and remains as a distinct membrane over the embryo. This membrane separates, remains distinct, and, as previously indicated, is left behind as a thin, transparent membrane by the hatching nymph.

Headlee[4] has stated that "A third layer may be seen as the nymph hatches, but this is probably the first-cast skin of the nymph," and this view seems to be held also by Peterson (*l. c.*, p. 10) who says, "This layer is shed by the nymph as it emerges, consequently it must be an exuvium." The writer is unable to agree with this view for the exuvia cast by the nymph during its growth are quite different from this embryonic membrane which it leaves behind when hatching.

After the embryo has revolved and is proceeding toward hatching the egg is in much more critical condition than during the dormant period. It is less protected by reason of the fracture of the gelatinous matrix enclosing it and the embryo which is actively growing is more susceptible to the effect of spray solutions. This undoubtedly explains the varying results obtained by different workers in spraying experiments on aphid eggs. In many lots wherein the embryo had revolved good results were obtained, whereas in other lots where no revolution had taken place, hatching was about normal. In this connection it is important to bear in mind that *pomi* and *malifoliæ* revolve at about the same period, the middle of March in Washington, and that early in April these eggs are very susceptible to treatment with such sprays as lime sulphur. At the time these eggs are in this critical period of embryonic development those of *prunifoliæ* have hatched and the young are in the first or rarely the second instar. These young nymphs are not affected greatly by lime sulphur but are easily killed by nicotine sprays.

It seems clear therefore, than in interpreting hatching records of aphid eggs in the course of spraying or other experiments, account must be taken of the condition of the embryo in regard to revolution. Knowledge of this fact is also essential in practical control work. Thus in the case of the three apple aphids here considered, the recommendations for use of the combined lime-sulphur-nicotine spray as a "delayed dormant" treatment, is seen to be based on scientific reasons —the lime sulphur to destroy the later hatching eggs, principally *pomi* and *malifoliæ*, and the nicotine for the already hatched aphids.

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[4] New Jersey Agr. Exp. Sta. Bull. No. 328, 1918.

THE AMERICAN CHEMICAL SOCIETY

(*Continued*)

SECTION OF CELLULOSE CHEMISTRY

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Effect of adding various chemicals to wood previous to distillation: L. F. HAWLEY. Several different chemicals have been mixed with wood and the mixture distilled for the determination of the effect of the chemical on the yield of valuable products. The chemical was mixed with the sawdust by sprinkling in case it was water soluble or by mixing the solid in case it was insoluble. The mixture was then briquetted and the briquets distilled in a special retort in which mechanical pressure could be applied to the briquets during distillation. The only chemical tried which had a beneficial effect when used in reasonable quantities was sodium carbonate. When about one per cent. of sodium carbonate is mixed with wood previous to distillation the yield of methyl alcohol