# HISTORY OF THE GERM CELLS AND EARLY EMBRYOLOGY OF CERTAIN APHIDS, A DISSERTATION, PP. 610 - 642

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649168644

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Edited by Trieste Publishing Pty Ltd.
Cover @ 2017



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Trieste

The University of Chicago
FOUNDED BY JOHN D. ROCKEFELLER



# HISTORY OF THE GERM CELLS AND EARLY EMBRYOLOGY OF CERTAIN APHIDS

A DISSERTATION

SUBMITTED TO THE FACULTY OF THE OGDEN GRADUATE SCHOOL OF SCIENCE IN CANDIDACY FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

(DEPARTMENT OF ZOÖLOGY)

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BY

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CHICAGO
1908

# History of the Germ Cells and early Embryology of certain Aphids.

By

**Geo. W. Tannreuther.**

With plates 49—53.

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## Introduction.

The investigations in the following paper were undertaken for the purpose of studying the development of certain aphids. The significance attached to the development of aphids from different kinds of ova, — sexual and parthenogenetic, — which have the same origin, appearance and fate, the one requiring fertilization and the other not, can not be overestimated. The behavior of these eggs during maturation and the relation of the sexual to the parthenogenetic individuals, afford invaluable material in attempting the determination of sex.

With the importance of these facts in view, I propose to give the history of the aphids upon which the results of this paper are based, paying special attention to the phenomenon of spermatogenesis, ovogenesis and early development.

The work of most previous investigators concerned mostly the habits and life history of the aphids, only incidentally touching the problems of morphology and cytology of the germ cells.

STSCHELKANOVZEW, J. P., 1904, was among the first of the investigators to take up the cytological problem of the aphids. He studied the maturation of the parthenogenetic eggs in *Aphis rosae* and found fourteen chromosomes of various sizes in the prophase of the maturation spindle. After the formation of the polar body, the nucleus contained eight single and three double chromosomes. STEVENS, N. M., 1905, studied the germ cells of *Aphis rosae* and *Aphis oenotherae*. In the maturation of the parthenogenetic eggs of *Aphis rosae*, ten chromosomes of five different sizes were found. This being the somatic number no reduction took place in the formation of the single polar body. In the maturation of the sexual egg, five chromosomes, the reduced number, occurred and both maturation divisions were longitudinal.

## Natural history.

The life history of the aphids was studied not only for the purpose of getting a clearer idea of the relation of the parthenogenetic and sexual generations as they occur in nature, but from an experimental standpoint. Individuals from each succeeding parthenogenetic generation were sectioned and studied in order to determine if any morphological or cytological differences occured,

especially in the structure and organization of the germ cells. A careful study proves as far as we are able to determine microscopically that the sex cells or ova of each succeeding parthenogenetic generation are uniform and that no structural differences occur. The somatic number of chromosomes, four large and two small in *Melanoxanthus salicis* and *M. salicicola*, is constant in the ova throughout the entire parthenogenetic generations and in the formation of the single polar body the six chromosomes divide equally.

In order to verify these results a number of different species were studied in the sub-families Aphidina and Pemphigina for the purpose of comparison.

The complete life history of only two species *Melanoxanthus salicis* and *M. salicicola* will be given in detail. The habits of both species throughout their entire cycle are very similar, both being found simultaneously on the same host. *M. salicis* is often found on the cottonwood and willow at the same season of the year, but *M. salicicola* is found only on the willow throughout its entire period of existence.

In the spring the stem mother or the first parthenogenetic generation hatches from the winter eggs, which are deposited in the fall. The time for the appearance of the stem mother varies greatly with the condition of the spring season, and the stage of development the embryo reaches in the fall after the eggs are deposited and before cold weather begins. Immediately after hatching the young aphids begin to feed by thrusting their beaks through the bark of the willow twigs and sucking out the sap. They grow very rapidly and moult twice during the first week of their existence. A third moult occurs about the eleventh or twelfth day. At the end of the second week the stem mother begins to reproduce, parthenogenetically. Some individuals observed did not begin reproduction until the twentieth or twenty-fifth day. It requires from five to eight days for the deposition of the forty to seventy-five young aphids by the stem mother. In some instances as in *Pemphigus populi-transversus* a single stem mother may give birth to two-hundred young aphids. The young aphids of the second parthenogenetic generation at the time of birth are completely formed and do not differ in structure and size from the first generation at the time of hatching from the winter eggs. No winged forms are produced in the first generation, but in the second and succeeding

generations a few winged forms appear. There is, however, considerable variation in the number of winged forms in the second generation of *M. salicicola* from a given stem mother; as observed in many instances, ninety-five per cent. of the offspring may become winged. These winged individuals go from the original host to another of the same species and start a new colony. In this way the aphids become more or less evenly distributed in a particular locality. The succeeding parthenogenetic generations agree with the first and second in their habits and structure.

The conditions of food and temperature are a very important feature in aphid development, though they influence only in an indirect way the appearance of the sexual forms. Starting with a given stem mother, favorable conditions promote rapid growth and hasten the reproduction of the succeeding parthenogenetic generations, while unfavorable conditions retard growth and lengthen the time for any given generation.

From a series of observations made in the field and experiments in the green-house, in order to determine the time period for each succeeding generation and the number of parthenogenetic generations that intervened before the appearance of the sexual forms, it was found that external conditions, whether severe or normal, would not bring about the production of the sexual generation before a definite number of parthenogenetic generations intervened. Abundance or scarcity of food is not a factor in determining the sex in case of the aphids. This is shown beyond doubt in the presexual or last parthenogenetic generation where different individuals produce either all males or sexual females irrespective of external conditions.

The minimum period of existence for any given generation in favorable conditions is fifteen days. In unfavorable conditions the maximum period is thirty-five days. If conditions are normal throughout the summer season the average time required for the completion of each parthenogenetic generation is about twenty to twenty-five days. This irregularity for the appearance of succeeding generations is due to food and temperature.

In a number of instances where the host was in an abnormal condition, the required number of parthenogenetic generations (necessary before the appearance of the sexual female) was not produced until the middle of November and very few winter eggs were deposited. In more severe conditions no sexual females were produced at all. Normally, the sexual females appear about the middle of

September after the production of six parthenogenetic generations. These six generations include the stem mother and the presexual generation.

The question naturally arose, — could not the production of the sexual females be brought about earlier in the season with the intervention of fewer parthenogenetic generations? It was found by experimentation that if a stem mother and offspring were kept in favorable conditions in the green-house on the same species of host as out of doors, the time and length of period for each succeeding generation was approximately the same as out of doors and that in both instances the sexual females and males appeared after six parthenogenetic generations intervened. On the other hand, if kept in unfavorable conditions the normal number of parthenogenetic generations intervened before the appearance of the sexual females and males as above. The only differences resulting from the varying of external conditions, are the great irregularities in the appearance of the successive parthenogenetic generations from different stem mothers.

Whether the intervention of six parthenogenetic generations before the appearance of the sexual forms would remain constant or not through a long series of experiments I am unable to say, as the experiments were carried on during two seasons only.

The parthenogenetic and sexual females and males are found coexisting outside from the middle of September until the last of November. If scarcity of food influences the appearance of sexual forms, we would not expect to find some aphids reproducing parthenogenetically so late in the season when the food supply is quite low.

The number of winter eggs that hatch out in the spring is about two per cent. of those that are deposited in the fall, and not more than twenty-five per cent. of those that hatch out reach the adult stage in development. There are no appreciable differences in the appearance or structure of the six parthenogenetic generations.

The presexual generation produces from fifteen to twenty eggs which are like those of the preceding generations. There are no differences in appearance or structure of the ova that produce the parthenogenetic generations and those of the presexual generation that produce the sexual females and males. The behavior of these eggs during maturation and early development is the same in both instances, one polar body being formed without a reduction division.

A very interesting phenomenon occurs in the fifth partheno-