PSYCHE.

OBSERVATIONS ON THE BREEDING HABITS OF THREE CHRYSOMELID BEETLES, *CALLIGRAPHA BIGSBYANA*, *C. MULTIPUNCTATA* AND *C. LUNATA*.

BY ROBERT W. HEGNER, MADISON, WISCONSIN.

DURING the summers of 1905–07 I was engaged in the hybridization of a number of chrysomelid beetles, chiefly three species of the genus Calligrapha, namely *C. multipunctata*, *C. bigsbyana* and *C. lunata*. My experiments are not yet completed but some points of interest have developed in regard to the breeding habits of these species while kept in the laboratory under artificial conditions.

The geographical distribution of the Calligraphas cannot be given accurately because of the fragmentary condition of the data concerning their occurrence. They have been reported from eighteen states situated in boreal America and no doubt may be found in favorable localities anywhere in this region.

The willow is the principal food plant of *C. bigsbyana* and *C. multipunctata*; all authors who have made observations on the subject include this plant, and all specimens that have been collected for me or by me were found on its leaves. The beetles prefer the long-leafed species, *Salix longifolia*, and, as far as I know, do not occur in nature on any other form. They will live however on other willows if forced to do so as adults and larvae will eat *Salix amygdaloides* in the laboratory. Hamilton ('95) gives Alnus and Acer as the food plant of *C. bigsbyana* in southwestern Pennsylvania as does Smith ('99) also for New Jersey.

C. lunata has been found only on the wild rose, Beutenmuller ('90), Lugger ('99) and others having reported its capture on this plant.

There are four methods that may be mentioned of keeping these beetles in the laboratory — all of which have been used. First, the glass tank made in such a way as to allow the experimenter to subject the insects to various degrees of moisture, temperature, etc; second, the plaster of paris cage used by Janet ('93) for breeding ants and later by Dimmock and Knab ('04) for raising carabid beetles; third, the ordinary wire cage; and fourth, glass covered slender dishes. The last named was found to be the easiest to manage. The dishes should be about 10 cm. in diameter, if larger the food tends to become dry.

One or more pairs of beetles may be kept in a single dish. A few fresh leaves of willow or rose were placed in each dish every morning and the partly eaten leaves of the previous day removed.

Eggs were collected at various times, usually in the morning unless the exact time of laying was desired when the dishes were examined every hour throughout the day. They are laid in batches on the side of the leaf which is beneath. The part of the leaf to which the eggs were attached was cut out and placed in a watch glass. A water soaked piece of filter paper was included to prevent desiccation. If kept too moist a fungus, one of the mucors, attacks the eggs. The eggs remained in the watch glass until they hatched.

The larvae were placed in small dishes and fresh food was given them every day as in the case of the adults. When the larvae were nearly ready for pupation they were transferred to dishes containing an inch of sandy loam. They burrowed into this and formed a spherical chamber in which they lay on their backs while their last larval skin was shed and during the pupal period. The imagos escaped to the surface immediately after being freed from their pupal covering and before their color pattern had made its appearance.

Egg-laying in *C. multipunctata* will answer for that of the three species under consideration as there was no appreciable variation in time, number, or method. A number of beetles were examined while laying, the process being as follows. The beetle selects a leaf and clings to its under surface. The tip of the abdomen moves rhythmically up and down about fifteen times at intervals of a little less than one second. This results in the exudation of a drop of viscid colorless fluid about one third the transverse diameter of the egg. The egg is forced out a moment later and carries with it this drop of fluid by means of which it is fastened to the leaf. When the egg reaches the leaf it is pushed back away from the beetle which then moves to one side and begins the rhythmical movements which precede the laying of another egg. In this way eggs are laid in a double row as shown in the accompanying figure, but frequently three or more may be laid in one row. The intervals between the layings of the individual eggs average one minute and twenty seconds.

Fifty-four pairs of beetles were examined daily during the laying period and a record made of the number of eggs laid. One pair produced fourteen eggs on June fifteenth and a batch was laid every day with the exception of several longer intervals until August twenty-seventh. Two to nineteen were laid at one time, the largest number for any one day being twenty-nine and the average number per batch, eight. The total number laid by this pair was three hundred and seventy-six in seventy-four days. Other pairs produced eggs as follows: 281 between June 22 and Aug. 3, 38

days; 287 between June 22 and Aug. 1, 41 days; 352 between June 11 and Aug. 31, 82 days; 234 between June 25 and Aug. 3, 40 days. This is sufficient to show the quantity of eggs laid by a single female during its life, the average of 54 records being 315.

There is no definite number of hours constituting the hatching period as the time varies from 4 to 7 days according to conditions of temperature and moisture. The average for many batches was 5⅔ days. All the eggs of one batch are in approximately the same stage of development and the larvae grow up together,— all pupating at about the same time. Larval life ranges from 17 to 24 days, 20 days being the average. Food conditions are no doubt responsible for the rapid growth of some larvae and the slow growth of others. The pupal period is usually 12 days although many emerge in 11 days and a few linger on to 13 or 14 days. The entire period then from the laying of the egg to the emergence of the imago is 38 days although a few covered this period in 35 days and others occupied 40 days.

The sexes of the imago are distinguishable because of the larger size of the female. A number of beetles were allowed to select their own mates; others were artificially paired. Copulation occurred from 6 to 10 days after emergence and the first eggs were laid 10 to 16 days later making the entire cycle a period of 64 days.

The eggs are differently colored and of different sizes in the three species studied. Those of *C. bigsbyana* are the smallest and are straw colored; those of *C. multipunctata* are slightly larger and are light orange in color; while the eggs of *C. lunata* are white and are larger than either of the other two. The figure gives a good idea of the comparative sizes. As may be expected, the newly hatched larvae have a ground color similar to the color of the egg being straw colored, light orange, and white according to the species.

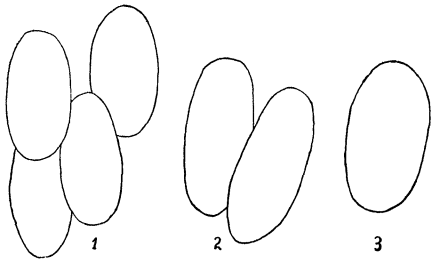

Fig. 1. Eggs of *C. bigsbyana*. Fig. 2. Eggs of *C. multipunctata*. Fig. 3. Egg of *C. lunata*.

Pedigreed material raised in the laboratory was experimented with in an effort to learn the results of hybridizing different species. Pure specimens of *C. bigsbyana* and *C. multipunctata* crossed freely, their eggs being always fertile. The eggs and larvae produced by these crosses were of course in size and color like those of the female parent. No differences were noted in the size or coloration of the hybrids until emergence when the resultant beetles were always intermediate between the two

parents. Specimens similar to these intermediate forms are frequently found in nature, a fact that points towards a widespread crossing of these beetles, the food plant, breeding range, and period of growth being identical for the two species. The ontogeny of the color pattern is similar to that recorded by Miss McCracken ('06) for *Lina lipponica*, i. e., it is the same for both species up to a certain point where the color of *C. multipunctata* ceases and retains a rufous tint, while that of *C. bigsbyana* proceeds until the rufous is covered by a layer of darker green pigment.

C. lunata is more difficult to cross with the other two species and only one such case was brought about. A female *C. lunata* was crossed with a male *C. multipunctata*. Both beetles were raised in the laboratory and had not been contaminated before they were put together. They were often found in copulation and two batches of eggs were laid. The first batch did not hatch although the full grown embryos could easily be seen through the chorion. The eggs of the second batch were preserved at the age of five days for microscopical examination.

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PROFESSOR V. L. KELLOGG, of Stanford University, will be in Europe from April to December of this year. His address is, care French, Lemon & Co., Florence, Italy.