

PSYCHE.

ON THE MATING INSTINCT IN MOTHS.

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[Annual address of the retiring president of the Cambridge Entomological Club, January 12, 1900.]

During the past summer the author carried out a series of experiments to determine the nature of the mating instinct of *Callosamia promethea*.

A large number of the cocoons of this moth were kindly collected for the author by W. L. Tower, Esq., in the neighborhood of Cambridge, Mass.; and others were found by the writer at Maplewood, N. J. Altogether 449 cocoons were obtained during the winter of 1898-99. These were allowed to remain out of doors in Cambridge where they were exposed to the winter's cold, and then on May 5th they were taken to Loggerhead Key, one of the Dry Tortugas Islands, Fla.

This situation was most favorable for the prosecution of the experiments, for the insect does not extend south of the Carolinas, and thus the moths were separated many hundreds of miles from others of their species. Moreover Loggerhead Key is a small sandy island, surrounded by many miles of ocean, and thus no interference with the experiments could come from the outside.

The cocoons were hung under the

shade of some trees, where they were protected from the direct rays of the sun. It was remarkable that all but five of the moths (3 ♀ and 2 ♂) issued from the cocoons during the early morning hours between sunrise and eleven o'clock.

The following table will show the rate at which the moths issued from the cocoons:

Date.	No. of ♂♂	No. of ♀♀	Total.	Date.	No. of ♂♂	No. of ♀♀	Total.
May 18	1	2	3	June 8	1	1	2
19	1	2	3	9	6	1	7
20	1	2	3	10	13	3	16
21	1	0	1	11	10	1	11
22	1	0	1	12	7	3	10
23	0	0	0	13	5	3	8
24	1	0	1	14	10	2	12
25	1	1	2	15	8	5	13
26	0	0	0	16	2	9	11
27	1	1	2	17	3	3	6
28	0	0	0	18	4	1	5
29	2	1	3	19	2	1	3
30	0	1	1	20	2	1	3
31	0	0	0	21	1	1	2
June 1	5	2	7	22	1	2	3
2	6	2	8	23	0	0	0
3	3	3	6	24	0	1	1
4	2	3	5	25	0	0	0
5	4	1	5	26	0	0	0
6	3	2	5	27	0	1	1
7	3	3	6				
				Total	111	65	176

It will be seen that 63% of the moths were males, and 37% were females.

As is well known, in this moth the wings of the female are reddish-brown in color, while in the male the wings are black; also the antennae of the male are large and bushy, while in the female they are small and slender. The male possesses the ability to seek out the female even though she be at a considerable distance. The males usually fly toward the females in the afternoon hours between two o'clock and sunset, and it is a common thing to observe several dozen males fluttering about the place where a female is resting. In seeking the female the male flies up against the wind until he comes into her near presence, and then he often flutters to and fro in a bungling manner that for want of better words we may designate as "stupid" and "aimless." Often he may fly into the immediate neighborhood of the female, and even then he will often flutter away without having made any attempt to mate with her. At other times, however, a male will fly at once to the female, and mate with her immediately.

After issuing from the cocoon the female commonly remains quiescent for some hours until she is fertilized, after which she flies actively about, and deposits her eggs. During her period of rest the female remains with her wings closed over her back, but when a male moth, or indeed any large object, comes near her within range of her vision she slowly and majestically opens and closes her wings several times. The males,

when resting, react in a similar manner, but they are by no means so sensitive as the females. In captivity the moth lived from three to five days.

OBSERVATIONS AND EXPERIMENTS.

The first experiments were directed to determine whether the male was attracted by the sight of the female, or whether he merely perceived some odor which might emanate from her.

Five females were placed in a large clear glass battery jar, having a wide open mouth. The mouth was covered with coarse-meshed mosquito netting, thus allowing a free circulation of air between the interior of the jar and the outside. Five males were liberated about one hundred feet away from the jar, and immediately flew to it, and fluttered about the open mouth. The jar was then inverted (placed mouth downward) and sand was packed around the open end, so as to prevent any escape of air from the interior of the jar. The females thus remained visible through the clear glass sides of the jar, but no scent could come from them. Under these circumstances all of the males at once flew away, and soon disappeared from sight. When the jar was turned open end up again, however, all of the males reappeared, and flew excitedly around the mouth. This experiment was often repeated, and always with the same result. The males never pay the least attention to females which are enclosed in a hermetically sealed preserving jar of

clear glass. Assuming that the males are able to see through glass which appears transparent to us, we may conclude that sight alone is not sufficient to attract the male toward the female, or even so retain him in her presence when he is within a few inches of her.

Another experiment which seems to show that the male depends solely upon scent and not at all upon sight in seeking out the female, may be performed as follows: A female is wrapped in loose raw cotton so as to be invisible, and yet allow some scent to emanate from her. The males then fly to the cotton and crawl over it, fluttering their wings excitedly, and grasping the cotton repeatedly with their abdominal claspers.

In another series of experiments the females were inclosed within a wooden box having a paper chimney arising from one end, and the other end being open and covered with mosquito netting. This box was so arranged that a current of air blew in through the open end, and out of the paper chimney. The females within were invisible from the outside, and yet any scent arising from them would be carried up through the chimney into the outer air. When the males were liberated they flew to the mouth of the chimney and fluttered about in its neighborhood. None came to the large open end of the box into which the air was blowing. I then poured some CS_2 in a large flat evaporating dish and placed it near the open end of the box in such a

manner that the fumes passed up the chimney and mingled with the scent from the female moths. The males, however, paid no attention to the new odor and still remained fluttering around the chimney; nor did they seem to be distracted by the fumes of ethyl mercaptan which possesses a most nauseating and putrid odor. Evidently the scent which arises from the female is sufficient to overcome the fumes of CS_2 or ethyl mercaptan, if indeed the males have any perception of the latter odors.

The entire abdomens of five females were cut off and placed upon a table, while the males were placed within a large mosquito-net cage about five feet away. Two males were liberated within five minutes of the time when the abdomens were cut off. They both flew to the recently severed abdomens and paid no attention to the abdomen-less females in the cage. I repeated this experiment many times but in all subsequent trials the males paid no attention either to the severed abdomens or to the mutilated females. As far as positive results go, however, it appears that the scent which attracts the male emanates from the abdomen of the female.

When the eggs are cut out from the female she no longer attracts males, nor do the males pay any attention to the detached eggs. Dead or dying females never attract males, nor do they come to the empty cocoon from which a female has issued.

When a female has remained for

some time in any place she seems to impart an odor to the locality, for males will continue to come to it for at least two hours after she has left.

It is interesting to notice that the females increase in attractiveness as they become older. This was repeatedly demonstrated as follows. Several females all of which were about six hours old were confined in a large cage made of mosquito netting, and which allowed a very free circulation of air through it. The same number of females about thirty hours old were placed in another similar cage about six feet away from the cage containing the younger females. Out of thirty-seven males, thirty-five came exclusively to the cage containing the older females. Of the other two males, one came to the cage holding the younger females and one divided his attention between both cages. When the females are reversed from one cage to the other the males still go to the cage containing the older females. Upon testing females thirty hours old against females fifty-five hours old, it appears that they are about equally attractive. Thus of seven males, three came to the cage holding the thirty hour old females, one divided his attention between both cages, and three came to the fifty-five hour females. It thus appears that females about six hours old are not so attractive as are females one or two days old.

Virgin females are more attractive than are fertilized females of the same age. When the virgins are confined in

one cage and an equal number of fertilized females are placed in another cage about five feet away from the former, the majority of the males come to the cage holding the virgin females. Thus out of eleven males eight came to the virgin females, two to the fertilized females, and one to both cages. Fertilized females are still quite attractive to males, however, and the males will readily mate with them. This was first observed by Miss Caroline G. Soule, in 1894, who had two female promethea moths, each one of which was mated with four males and still they remained attractive to other males. In fact as long as she remains alive and in health the female attracts males to her.

One of my males mated four times with three females, and three others mated three times each. The males will make frantic efforts to mate with a female which is at the time coupling with another male.

The male will fly toward the female with normal eagerness even though his entire abdomen be cut off, and he will still seek the female when his abdomen is cut off, and the sides of his thorax are covered with impervious glue. It is therefore evident that the spiracles are not the seat of the organs by which the male perceives the female scent. If, however, the antennae of the male be covered with shellac, glue, paraffin, Canada balsam, celloidin, or photographic paste*, he no longer seeks the

* The photographic paste used in these experiments is sold in the market under the name of Stoffer's white paste. Probably any impervious paste would serve as well.

female, and will display no excitement even though he be placed within an inch of her. In five instances I dissolved the photographic paste off in water, and in four of these cases the males readily mated with the females. Upon re-covering the antennae with the paste, however, the males again failed to display the least excitement when placed near the females.

There can be but little doubt that the organs by which the male perceives the female are situated in the antennae. Indeed, it has long been recognized that the olfactory organs of insects are found chiefly upon the antennae. Hauser, 1880, and Kraepelin, 1883, have given excellent descriptions of the minute anatomy of these organs, and Hauser has carried out an elaborate series of the physiological experiments to determine their function. He cut off the antennae of a number of species of insects, and found that their sense of smell was then either greatly impaired or totally lost. Covering the antennae with melted paraffin gave the same results. Hauser also found that when the antennae of the male *Saturnia pavonia* were removed the moth never makes any attempt to mate.

Packard, 1898, gives an excellent review of all researches relating to the anatomy and physiology of the olfactory organs in insects.

If the eyes of a male *Callosamia promethea* be covered thickly with pitch or Brunswick black* so as to preclude

the possibility of sight remaining, the male will still mate in a normal manner if he be placed near the females.

It will be remembered that in this moth the male is black in color, while the female is reddish brown, and in accordance with the well known theory of Darwin the peculiar coloration of the male might be due to sexual selection on the part of the female. We might suppose, indeed, that the females preferred dark colored males, and thus under the influence of sexual selection the males became darker and darker until the present melanic coloration had been attained. In 1897 the author showed that the melanic coloration of the male of this moth is phylogenetically newer than the color pattern of the female, and this fact, as far as it goes, lends support to this theory of Darwin's. In order to test this hypothesis I cut off the wings of a number of females leaving only short stumps from which all the scales were carefully brushed. Male wings were then carefully glued to the stumps, and thus the female presented the appearance of a male. Under these circumstances the males mated with the females quite as readily as they would have done under normal conditions. I then tried the converse experiment, and glued female wings upon the males. Here again, however, the mating seemed to occur with normal frequency, and I was unable to detect that the females displayed any unusual aversion toward their effeminate looking consorts. It is also interesting to observe that normal males pay no attention to

* This substance is commonly used as a microscopic cement, and is of a pitchy consistency and a dense brown-black color.

the other males who display female wings. In another series of experiments the wings were cut entirely off of both males and females, and also all of the scales were brushed off their bodies; and yet these shabby looking males were readily accepted by normal females, nor could I see that normal males displayed any aversion to mating with the wingless females. We are, therefore, forced to conclude that the melanic coloration of the male has not been brought about through the agency of sexual selection on the part of the female. In this connection it is interesting to notice that Plateau, 1897, concludes that insects are attracted only by the odor of flowers and not at all by their color.

In conclusion it gives me great pleasure to express my gratitude to Miss Caroline G. Soule for advice and aid; to W. L. Tower Esq. for his kindness in collecting many cocoons of the moth; and to Dr. Robert W. Fuller who provided me with reagents used in the manufacture of ethyl mercaptan.

Summary of Conclusions.—The male is positively chemotactic toward some substance which emanates from the abdomen of the female, and which he perceives through olfactory organs situated upon his antennae.

ENTOMOLOGY FOR THE YOUNG.—Ginn and Co. of Boston have just issued a second series of Stories of Insect Life, by Mary E. Murtfeldt and Clarence Moores Weed, intended for children. It is a little reading book of 72 pages, well illustrated, and in its few chapters ranges a wide field.

Females 30–60 hours old are much more attractive to males than are young females 5–10 hours old. Virgin females are somewhat more attractive than are fertilized ones of the same age.

The male will mate at least four times either with the same or with different females.

Neither males nor females pay any attention to the appearance of their partners. The melanic colors of the male have not been brought about through sexual selection on the part of the female.

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A considerable portion of Blatchley's *Gleanings from Nature* (The Nature Publishing Co., Indianapolis), intended to awaken an interest in nature in the youth of Indiana particularly, is devoted to insects and especially to Orthoptera. A good many interesting facts may be found in it.



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