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A STUDY OF COPULATION AND THE FORMATION OF SPERMATOPHORES IN MELANOPLUS DIFFERENTIALIS

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Grasshoppers are one of the most common and most harmful insects known to people in agricultural districts. Because of this they have been carefully studied, and much is known about their habits and devastating ways. However, very little is known regarding the mating habits of these insects. This study of the copulatory habits of Melanoplus differentialis has been made to obtain more accurate information regarding mating in this species.

It was found that the time at which grasshoppers mate seems to be largely controlled by various weather factors such as heat, light and humidity. Under natural conditions very few grasshoppers were found to copulate during the early morning hours or on cold rainy days. It was also noticed that under these conditions grasshoppers show very little activity. As the air becomes warmer and less humid the activity of the grasshoppers increases, as the activity increases the matings correspondingly increase.

Graph I has been computed on 109 matings over a period of approximately two weeks to point out what time of day most grasshoppers start to mate. As clearly shown, most of the grasshoppers started copulation in the afternoon from 2 to 3:30 o'clock.

The study of the length of time taken for a single mating has brought up new and interesting problems. No definite statement can be made as to the exact minimum time needed for successful transfer of sperm. However, sperm were often found in the spermatheca of the female after two hours of copulation. In spite of this all the grasshoppers which had spermatophores formed stayed in copulation at least four hours and sometimes as high as forty-eight hours, unless the mating grasshoppers were disturbed.

Graph II, page 4, has been computed on 206 matings over a period of two months (August and September, 1937). As seen on the graph the vast majority of the copulations lasted from 18 to 24 hours. Only a few broke before 12 hours and only a very few remained together longer than 30 hours.

There seems to be a definite courtship between the male and fe-

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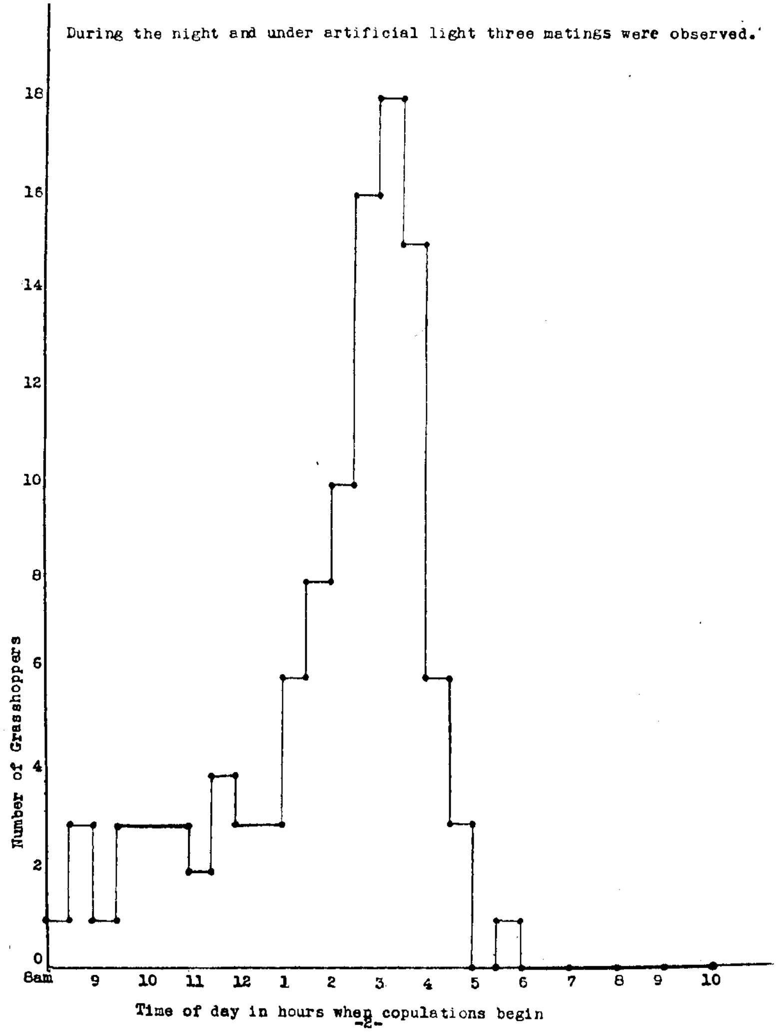

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male grasshopper before mating. From observations made on various matings the female seems to attract the male. It is very probable that the male is attracted to the female by a scent produced by a secretion of the oviducal vesicles (figs. 6 and 8, sc) which are small glands opening below the ventral valves of the ovipositor (Slifer and King, 1936).

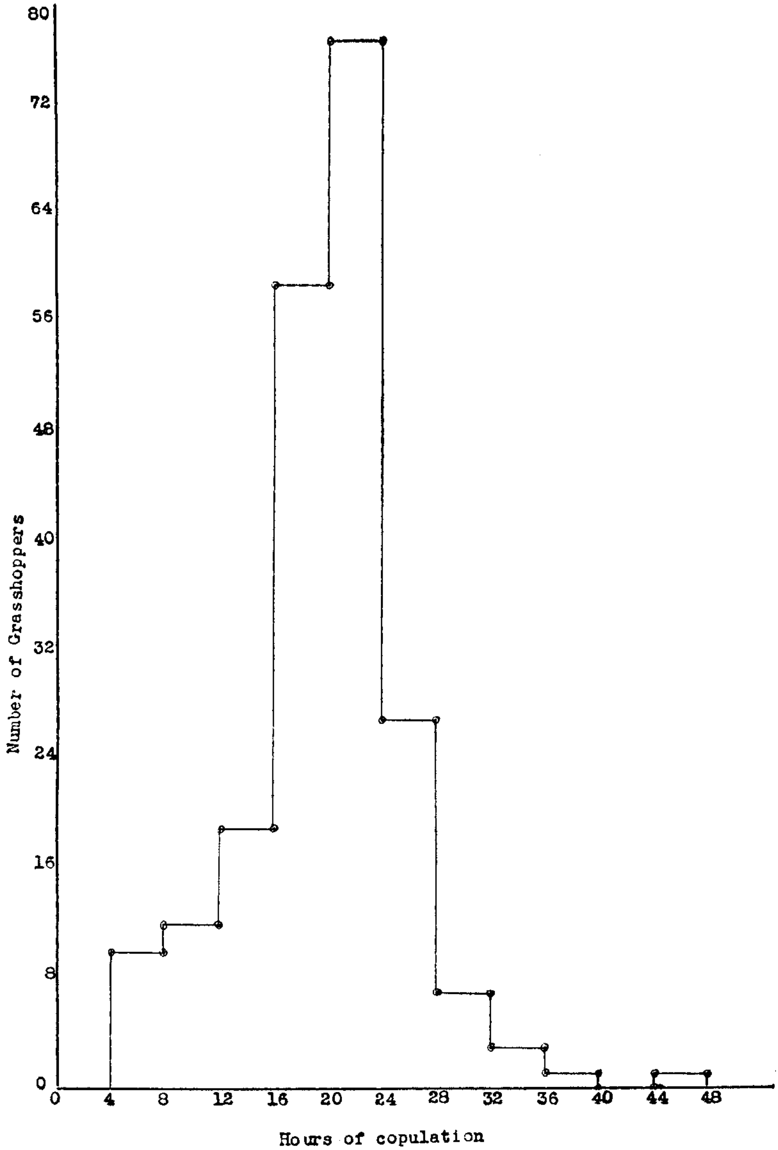
As soon as the male finds the female he approaches her, cautiously at first, and rubs her antennae with his. Frequently the female merely turns away, but the male is usually persistent. He follows her and jumps upon her back, grasps her pronotum with his fore legs, clasps her with his second pair or legs immediately back of the thorax, just dorsal to where her hind legs are fastened to her body. His long hind legs are left free. The male is not always successful in the first attempt to place himself upon the female. Frequently he is kicked off by the female, who usually kicks violently with her hind legs.

As soon as the male is firmly settled he stretches his abdomen out as far as he can along the side of the female. There seems to be some controversy as to which side the male lowers his abdomen. The observations made for this paper showed that both sides were used with nearly the same frequency. The pallium (figs. 2, 3 and 4, p.) folds back opening up the genital chamber of the male (fig. 4, g) thus exposing the aedeagus (fig. 4, da). In this position the abdomen moves about until it finds the ovipositor of the female (fig. 1, d, m, and v). The cerci (fig. 2, c) grasp the abdomen of the female just above the eighth sternite (fig. 1, 8) forcing the egg guide (figs. 1 and 8, eg) down and slightly opening the genital chamber of the female (fig. 6, g). Frequently the cerci clasp some other segment, in which case the male releases his grip and tries again.

Simultaneously as the cerci clasp the subgenital plate of the female, the pallium folds over the ventral valves (fig. 1, v) of the ovipositor, thus keeping the genital chamber of the male open and at the same time holding the abdomen of the male rigid. As this is taking place the subgenital plate (fig. 1, 8) of the female is forced down over the pseudo-sternite (fig. 9 and fig. 5b, ps) by the cerci. The outer two lobes of the subgenital plate fit snugly behind the posterior transverse processes (fig. 9, pt) as in figure 5, where this is clearly shown.

Just what takes place from here is not clear; however, it seems logical that either of the following two descriptions are possible.

It seems that as the cerci clasp harder on the subgenital plate


80
72
64
56
48
40
32
24
16
8
0
Number of Grasshoppers
0
4
8
12
16
20
24
28
32
36
40
44
48
Hours of copulation

-4-

of the female it opens wider. As it opens it may force down the pseudo-sternite with it. This would release a set of muscles leading from the pseudo-sternite to the anterior part of the endophallic bulb (fig. 4, b), and a pair inserted on the small sclerites at the side of the pseudo-sternite which normally hold the genital organs in place. The release of these muscles and the downward force of pseudo-sternite on the aedeagal apodeme force the entire bulb up and push the aedeagus forward into the female genital chamber (fig. 5b).

It may also be that the cerci in clasping the subgenital plate lower the plate just enough to fit behind the posterior transverse processes of the pseudo-sternite. The large muscles which lead from the pseudo-sternite to the anterior part of the endophallic bulb then contract and pull down the pseudo-sternite and the genital plate of the female. The downward force of the pseudo-sternite on the aedeagal apodeme caused by this contraction of the large muscle, along with the contraction of large side muscles then force the aedeagus up into the copulating position. In either case the pseudo-sternite in pushing on the aedeagal apodeme seems to be directly responsible for the pushing of the aedeagus up and out of the male genital chamber into that of the female.

The entire aedeagus of the male is found in the genital chamber of the female. The dorsal lobe which is divided into two halves by the phallotreme cleft has only one of its halves inserted into the copulatory pouch of the female (fig. 5b, cp). Either half may be inserted into the pouch, but never are both halves found in the pouch at the same time. It seems that the factor which decides which side of the dorsal aedeagal lobe is to be inserted is the side upon which the male lowers its abdomen.

Sperm are transferred in grasshoppers through tubular sacs, called spermatophores which are found during copulation. In Melanoplus differentialis these tubes are about 5 to 8 mm in length. Figure 10 shows a spermatophore under high power. The tubular structure stands out very plainly. Figures 11, 12, and 13 are typical spermatophores enlarged about ten times.

The spermatophores are secreted by the accessory glands (figs. 4 and 5b, ac) as a jelly-like substance. This substance passes through the ejaculatory ducts (figs. 4 and 5b, ej) to the ejaculatory sac (figs. 4 and 5b, es). From here it passes through the gonopore (fig. 5b, go) into the spermatophore sac (fig. 5b, ss) where it fills the entire slit-like sac. Up to this time the spermatophore has no definite form, but as it leaves the spermatophore sac

PLATE I

EXPLANATION OF FIGURES

1 Side view of the tip of a female grasshopper's abdomen. X 5.
- d dorsal valve of the ovipositor
- m median valve of the ovipositor
- v ventral valve of the ovipositor
- eg egg guide
- c cercus
- 8 eighth sternite (subgenital plate)

2 Side view of the tips of abdomens of copulating grasshoppers. X 5.
- c cerci of both male and female
- d dorsal valve of the ovipositor
- p pallium of the male
- dl distal lobe of 9th sternum of the male
- pp proximal sternal plate of the male

3 Side view of the tip of a male grasshopper's abdomen. X 5.
- c cercus
- p pallium
- dl distal lobe of 9th sternum
- pp proximal sternal plate of the male

4 Cross section of a male grasshopper's abdomen showing genital organs. X 5.
- g genital chamber
- p pallium
- dl distal lobe of 9th sternum
- ps pseudo-sternite
- es ejacultory sac
- b muscle covered endophallus
- ej ejaculatory duct
- ac accessory glands
- bf basal fold
- ph phallotreme
- ad dorsal lobe of aedeagus
- a apical process

5a Sagittal section of copulating grasshoppers. X 5.
- f female
- m male
- eg egg guide
- v ventral valve of the ovipositor
- d dorsal valve of the ovipositor
- p pallium

5b Same as 5a with internal organs all in place. X 5.
- da dorsal lobe of aedeagus of male
- x dorsal sclerite
- w dorsal wall of meatus
- y ventral sclerite
- es ejaculatory sac
- va ventral lobe of aedeagus
- ap transverse arm of apodeme
- ph phallotreme cleft
- ss spermatophore sac
- ps pseudo-sternite
- en endophallic plate
- ej ejaculatory duct
- ac accessory glands
- go gonopore of male
- od median oviduct
- sd spermathecal duct
- sp spermatheca
- cp copulatory pouch

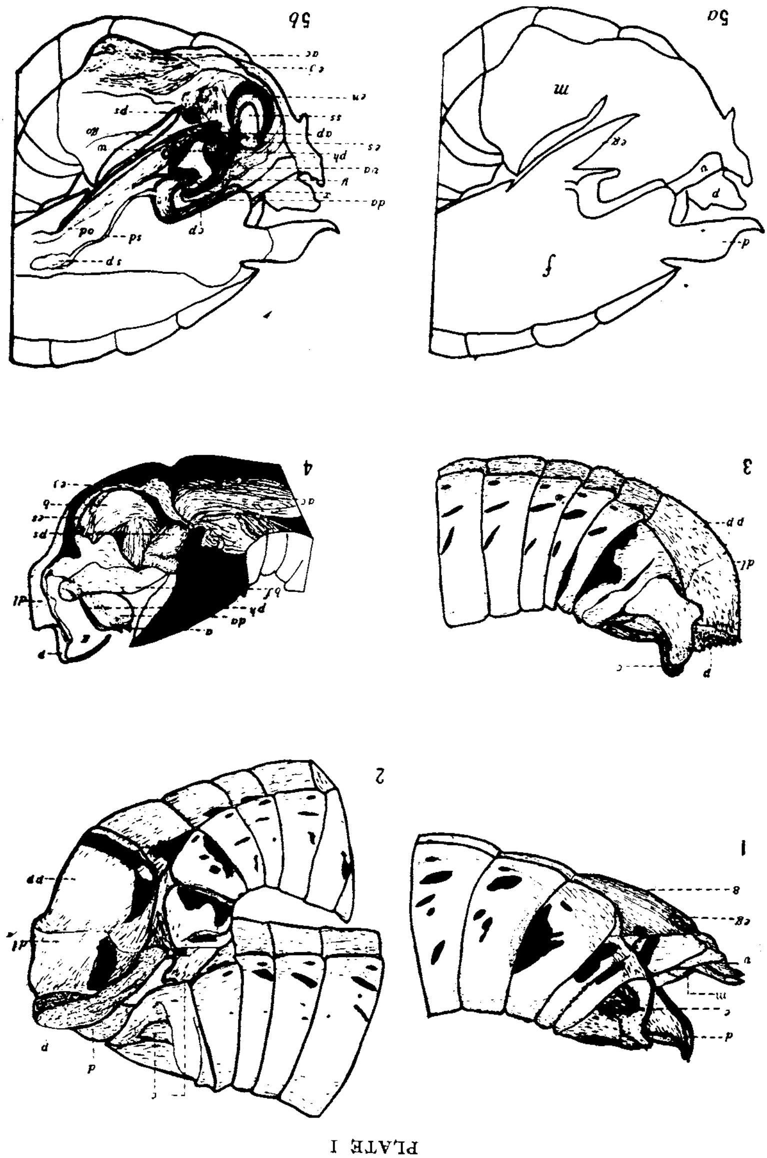


PLATE I

PLATE II

EXPLANATION OF FIGURES

6 Internal genitalia of a mature female grasshopper. X 5.
- ac accessory glands
- o ovary
- od oviduct
- sd spermatophore duct
- go gonopore
- eg egg guide
- g genital chamber
- oc opening to copulatory pouch
- v ventral valve of ovipositor
- cp copulatory pouch
- sp spermatheca
- e mature follicle (egg)
- sc opening to scent glands

7 Aedeagus and endophallus with muscles removed. X 5.
- a apical process
- bf basal fold
- da dorsal lobe of aedeagus
- va ventral lobe aedeagus
- en endophallic plate
- ap apodeme of endophallus
- ps pseudo-sternite
- ss spermatophore sac
- ph phallotreme cleft

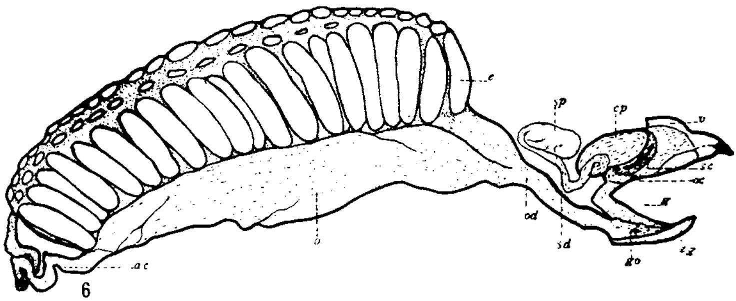
8 Ventral view of the tip of a female grasshopper's abdomen with the 7th and 8th sternite folded back to show the external genitalia. X 5.
- eg egg guide
- go gonopore
- od oviduct
- d dorsal valve of aedeagus
- v ventral valve of aedeagus
- oc opening to copulatory pouch
- sc opening to scent glands

9 Pseudo-sternite. X 12.
- pt posterior transverse process

10 Spermatophore under high power. X approx. 100.

11, 12, 13 Views of typical spermatophores. X approx. 10.

PLATE II



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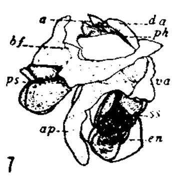

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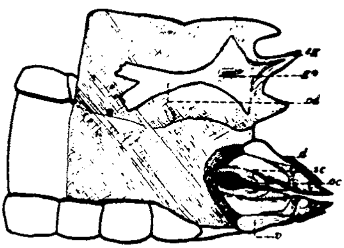

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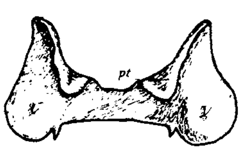

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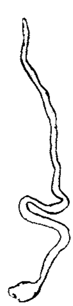
10

11



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13

through the phallotreme cleft (fig. 5b, ph) it takes the form of a slender tube. From here it is guided through the aedeagus by the dorsal and ventral sclerotic processes (fig. 5b, x and y) which run laterally down the aedeagus from the distal portion. These processes hold the spermatophore between them as it is forced through the phallotreme cleft and guides them into the copulatory pouch of the female from where it slips into the spermathecal duct (fig. 5b, sd).

Only one spermatophore is needed for the successful transfer of sperm. It is believed that when more than one are formed they are just continuations of the original spermatophore that have been broken off due to the shifting of the copulating insects, or by the growing of the spermatophore out of the lobe of the aedeagus leading into the female genital chamber. Never was more than one spermatophore found in the spermathecal duct at one time. However, as high as twenty-one spermatophores or parts of them were found between the valves of the ovipositor after copulation.

After separation of the mating grasshoppers the spermatophores are ejected from the female along with a milky albuminous fluid which bind them into one mass. They are lodged between the valves of the ovipositor, here they soon dry and become brittle. After an hour or so they drop off leaving no evidence of the mating.

SUMMARY

The time copulations begin and the length of time copulations last are influenced by warmth, moisture and light. Copulations occur most frequently on bright, sunny days. Copulations last longer on dark, cool and more humid days.

The pseudo-sternite plays a definite role in the mechanics of copulation. It holds the genital chamber of the female open and helps force the aedeagus into the copulatory pouch.

Sperm are transferred through tube like structures called spermatophores. Under the most favorable conditions they form in about an hour. In Melanoplus differentialis they are about 5 to 8 mm. long.

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