Copulation and spermatophores of *Gryllomorpha dalmatina* (Ocsk.)

(Orth. Gryllidae)

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My observations on copulation of *Gryllomorpha dalmatina* (Ocsk.) were made in the period 7-19 VIII, 1926, on the south coast of Crimea, about 5 km. east of Yalta. *Gryllomorpha* was very common there and as soon as the dusk becomes darker these crickets appeared on the walls in houses, and in still larger numbers on the outer walls of buildings made of somewhat loose stones; I used to find them also under stones on the ground. Mostly adult and sexually mature individuals were observed, while larvae (10-14 mm. in length) were rare. In the Eastern part of the Crimean coast *Gryllomorpha* seems to be generally less common; at any rate during two seasons which I spent in Karadagh (July to September, 1925 and 1926) I never met with it, and only a single female (adult) has been taken by V. V. Karpov under a stone in an oak forest near the Kisiltash monastery.

A. Shugurov (1911) records *G. dalmatina* from the following localities in Crimea: Ayan, Simferopol district; Laspi and Karabach, on the South coast.

When cathing *Gryllomorpha* a pocket electric flash-lamp proved to be very useful, the insects being quickly, but cautiously covered with a glass, or with a small wire-net cage. The light does not frighten the crickets at first and they remain for some time on the same spot, but the slightest touch, or even movement of air (from breathing), results in strong leaps, and the insect disappears immediately into some crack between stones.

In the cages, made of wire-netting, I used to keep females separated from the males, bringing them together (2-5 couples at a time)

only during the observations on copulation (between 9 in the evening and 2 in the morning). For food the crickets received white bread, killed insects and water. During the day the crickets were sitting quietly, in a group or singly, in the least lighted corners of the cage, becoming active only at the dusk.

Observations on the mating habits must be made by the light of short flashes of electric lamp, because the crickets are very shy at that time and the pairs separate easily. When, however, the copulation actually begins and the spermatophore is already made, all observations may be continued by the light of a candle.

After the males are let into the cage with females, the copulation begins within 1-1 $^1/_2$ hours, but sometimes almost immediately; in one case the crickets copulated during the excursion.

The spermatophore of a male ready to copulation lies in the, so called, «spermatophore pouch» (Cholodkovsky, 1910), being already completely formed, and it can be taken out, by gently pressing the end of the abdomen by a forceps, or by fingers.

All details of courting, which lasts often not longer than 1-2 minutes, cannot be observed, but on the whole there is not much difference from what happens in other Gryllids. In the darkness I often heard faint drumming noise produced by the body (abdomen ?) against the walls of cage, which suggests that the males of *Gryllomorpha*, like those of *Arachnocephalus* (Boldyrev, 1915), and of *Meconema* (Gerhardt, 1914), use this curious method of attracting females.

Approaching the female closely, the male turns the end of his abdomen towards her and makes some jerking movements. When the pair is, at last, *in copula* their respective postures are as in other Gryllids.

The female stands under the male and heads of the copulating insects are looking in the same direction; end of the male abdomen is somewhat raised and closely approached to the base of the ovipositor of female; cerci of the male are directed upwards crossing (like an X) the cerci of the female; posterior femora of both insects are broadly spread from the body. The whole process of copulation takes 5-10 or 12 minutes.

Immediately after the close coupling of the pair by means of the

male genital appendages [1], between the lateral lobes of its subgenital plate there appears a rounded semi-hyalinous slimy ball, out of which after 1-1 1/2 minutes emerges an oval flask-like body with the white seminal cavity visible through its semi-hyalinous walls; from these two connected bodies (fig. 3) the filiform neck of the flask is seen entering under the slightly raised subgenital plate of the female. The process of appearance of the just described parts of spermatophore occupies about three minutes, and during the remaining time of the copulation the insects do not move and the spermatophore lies, without undergoing any changes, between the subgenital plate of the male and the base of ovipositor of the female; at last the latter jerks its body forward, the end of its abdomen is separated, with some difficulty, from that of the male, and the pair separates; sometimes the female before the separation begins moving its antennae, palpi and legs.

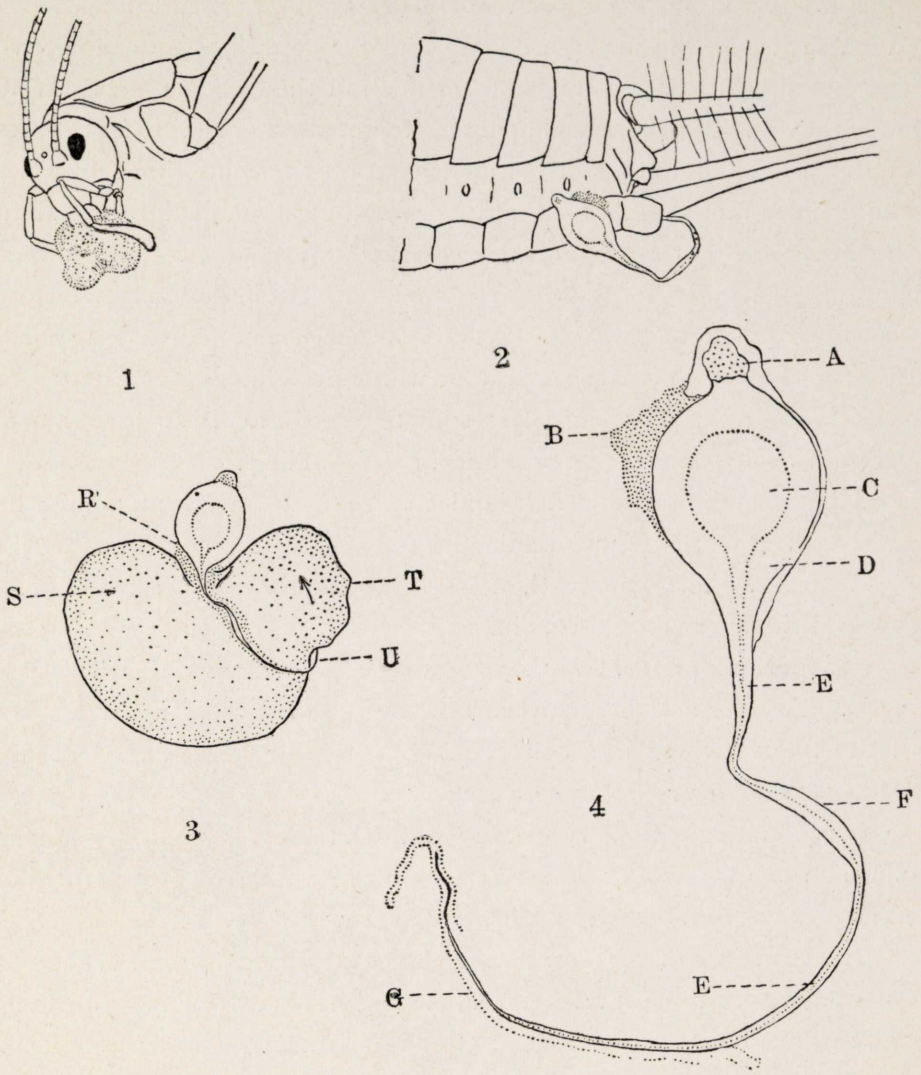
The female does not remain quiet more than one minute; under its ovipositor is visible now something like a pearl, of about half the size of the head. The female then curves its body, bending her head towards the spermatophore, sinks its mandibles into the mucous section of spermatophore, tears that section off and then straightens itself again. A large mucous ball can now be seen between the mandibles of the female which immediately begins to chew it (fig. 1). At the base of the ovipositor remains now the flask on its long curved neck; on one of its side walls is visible a dull-whitish sticky pad, by means of which the whole apparatus is fastened (perhaps not always) to the last sternites from below, or somewhat sideways (fig. 2).

The tendency of the female to remove spermatophore after the copulation is so strong, that neither the bright light, nor my blowing, could prevent her from doing so: a female disturbed by blowing, when beginning to bend, straightens herself only for a moment, but then bends again and tears off the mucous portion of spermatophore by its mandibles.

Subsequently, the female for about two hours (in one case under observation, 1 hour 55 minutes) is ruminating the sticky mucous mass, while the flask containing sperm remains where it was, but loses gra-

[1] Male copulatory apparatus of *G. dalmatina* was described recently by Chopard (1920). In this coupling of the pair the most important rôle is played by the, so called, titillator (pseudépiphalle of Chopard).

dually its contents which flows into the receptaculum seminis. As a result of the latter process, the white cavity of the flask becomes



Figs. 1-2: Female, devouring the protective portion of spermatophore, or the spermatophylax (fig. 1), while the basal portion of spermatophore, with sperm, is attached at the base of ovipositor (fig. 2).—Fig. 3: Spermatophore, fully developed, taken out of a male. *S*, spermatophylax; *T*, its, outer membrane; *R*, mucous band connecting flask with spermatophylax; *U*, neck of the flask where it bends over on to the opposite side of spermatophylax (its end there indicated by an arrow).—Fig. 4: Basal portion of spermatophore (flask and its neck) after being separated from spermatophylax. *A*, tubercle; *B*, mucous pad, from which begins the connection of flask with spermatophylax; *C*, cavity of flask (with sperm); *D*, inner and outer layers of walls of the flask; *E-E*, neck of flask (its filiform portion with a canal for sperm in it); *F*, rudimentary «lamellate appendix» of the neck; *G*, mucous envelope at the end of the spermatophore, forming a long band (a stopper ?).

empty and transparent already after an hour, while the outer walls of the flask remain only semitransparent.

The rate of chewing up of the mucous portion of spermatophore by female is not the same throughout. At first, the mandibles work uninterruptedly, and so do both pairs of the palpi, the labial palpi adhering closely to the mucous mass from behind, while the maxillary palpi touch its surface from the sides and only from time to time. The outer membrane of the mucous ball is thin, but rather firm and semihyalinous, covering the perfectly transparent, ductile, sticky mass (fig. 3, T and S). The mandibles of the female immerged into the mass naturally get hold of it first of all, while the outer membrane is being devoured less quickly and mainly towards the end of the whole process. This unequal temp of chewing up the two portions of the mucous ball results in the appearance of small wrinkles on its surface.

Approximately after an hour from the beginning the mucous ball loses its original shape (it being at first kidney-shaped, slightly subdivided into two somewhat asymmetrical portions) and becomes nearly half the former size. At the beginning of the second hour in the mucous mass appear some bubbles of air which got there during the chewing. After 1 $^1/_2$ hours the female begins to tire and makes interruptions of $^1/_4$ - $^1/_2$ - 1 minute, which are gradually becoming more and more frequent and the chewing less energetic. Towards the end of the second hour only a small semi-transparent ball is visible between the mouth-parts, but it also soon disappears. Until that moment, the female occupied by mastication, sat motionless, but now she makes 2-3 paces, stops for about a minute, then curves her body and, bending her head downwards, reaches by its mandibles the flask and extracts it from her genital opening. The flask, oval, semitransparent, with its long (up to 5 mm.) hair-like neck, may be seen for about three minutes between the mouth-parts of the female, which rapidly devours its firm walls, biting irregular pieces of them, and finally even the neck disappears in her mouth. All is ended and the insect, extending her maxillary palpi in front of her and waving her antennae starts crawling round the cage.

What interpretation could be given to all occurring during the spermatophore fertilization in *Gryllomorpha dalmatina* ♀. Here are entirely applicable the explanations which I offered (1912, 1913) for fertilization in *Tettigoniidae* by means of so called «compound» spermato-

phores, but this time I found the same phenomena in *Gryllidae* (so far only in *Gryllomorpha*), in which the mating habits and the structure of spermatophores are usually different from those in most of *Tettigoniidae*.

The spermatophore of *Gryllomorpha* must be undoubtedly classified into the category of «compound flask-shaped spermatophores» [1], which consist of the following parts: *a*) basal portion—a hollow flask containing sperm, and *b*) protecting portion (spermatophylax), in which there is no sperm, preventing the female to tear off the portion with sperm before the spermatozoids from it went over into the receptaculum seminis. This sticky mucous portion occupies the female for about two hours during which time the sperm flows into the receptaculum; the flask itself is then devoured within three minutes, but it is already empty. It is very interesting that the basal portion of the spermatophore in *Gryllomorpha*, though there is a spermatophylax, preserved the general flask-like shape as in other *Gryllidae*, but I will return to this later on.

Protection of sperm in all *Gryllidae* studied so far [2], in which there is no protective spermatophylax, is organised in various ways (a summary see in my paper of 1915; also Gerhardt, 1921), but protection by spermatophylax has been never found in the group. In the American literature, however, we find a description of copulation in *Gryllotalpa borealis* Burm. given by Baumgartner (1905; 1910), who says, as follows (quoting from Gerhardt, 1913):

«As the vesicle was being transferred, or just after it had been put in place, there was an outflow of some transparent fluid on either side of the vesicle. This soon hardened. It is this part of the apparatus that the ♀ was chewing. The spermatophore was found to consist of an oval ampulla which contained the sperm in the cavity at the center. At one end of the ampulla there is a projection by which the apparatus is held in the vagina, and through which the sperma are carried into the spermatotheca. On either side of this projection is an irregularly shaped mass formed by the above mentioned outflowing fluid

[1] This term is being introduced here for the first time, as I used to differentiate formerly only «compound» (with a spermatophylax) and «simple» (without it) spermatophores.

[2] I have studied the genera *Arachnocephalus, Oecanthus, Gryllus, Gryllodes, Nemobius, Gryllotalpa.*

during the transfer. The two sides are unlike, as part of one side was pulled and eaten away by the ♀, and the other side was pressed out of shape by some falling sand before it had time to harden.» After separating of male and female the latter carries spermatophore for about half an hour, without devouring it, then she loses it. It still seems to me that Baumgartner had before him not a spermatophylax-like structure, but a spermatophore with special mucous substance which, when hardened, served to fix the spermatophore in its place. In the European *Gryllotalpa gryllotalpa* L. the spermatophore has no spermatophylax (Boldyrev, 1913) and this makes one to be very careful in interpretation of what may be observed in its American congener, *G. borealis*, which should be more fully studied before a definite conclusion may be reached.

It would be extremely interesting to study the structure of spermatophore in *Discoptila fragosoi* Bol., another member of the group *Gryllomorphini* occuring in Crimea [1].

In any case there remain unstudied quite a series of groups of *Gryllidae* (*Tridactylinae*, *Trigonidiinae*, *Eneopterinae* a. o.) which may offer fresh surprises in the structure of spermatophores and in their mating habits, while all we know so far is very fragmentary and relates only to few European and North-American forms.

I will now give a detailed description of the spermatophore of *Gryllomorpha dalmatina*. Material was obtained either from males, or from just fertilized females, and studied both fresh and fixed in 90° alcohol, subsequently clarified in the clove-oil.

The basal portion containing sperm consist of an oval, thick-walled flask, gradually narrowed at one end into a long (5 mm.) neck, curved like a scythe; this portion is feebly connected with the protective apparatus—spermatophylax (fig. 3). Spermatophylax is represented by a somewhat asymmetrically kidney-shaped mass, 4-4 1/2 mm. broad, 3-3 1/3 mm. high and 3 mm. thick. Externally spermatophylax is covered by a thin, not very firm semi-transparent membrane (fig. 3, *T*), which is only slightly sticky; the whole mass of spermatophylax under

[1] Recorded by Shugurov (1911) and, before that, by Retowsky. In 1926 I have seen a male of this species taken by Prof. A. N. Kazansky near Simferopol (Salgirka), and a female in the collection of Mr. S. M. Fedorov from the South coast of Crimea.

the membrane is like a strongly ductile, sticky, transparent mucus (fig. 3, *S*). The flask with its neck adjoins the spermatophylax asymmetrically, its oval portion being placed into an emargination of spermatophylax, while the neck crosses one of its halves obliquely and then bends over on to the opposite side (an arrow on the fig. 3 indicates the position of the end of neck on the opposite side of spermatophylax). A distinct emargination is visible where the neck bends over the side of spermatophylax. Flask and its neck are adhering to the spermatophylax by means of semi-transparent mucous bands; near the base of the neck these bands (fig. 3, *R*) connect the flask with the sticky pad (fig. 4, *B*) which remains on the flask after the spermatophylax is torn off. The narrow neck of the flask is also enveloped into a layer of mucus which fastens it to the spermatophylax; it is possible that only the apical third of the neck remains free, because during the copulation it enters the genital duct of the female. After the spermatophylax is separated from the basal portion, on the latter, at the point *R* (fig. 3) of one side, there remains always a piece of mucous band, while on the surface of spermatophylax, along the line where the neck was lying, a transparent, fairly broad band may be seen.

Basal portion with sperm preserves the general type of simple flask-like spermatophore of *Gryllidae* (fig. 4). It consists of an oval thick-walled flask, 2 mm. long and 1 $^1/_4$ mm. in diameter, with an apical tubercle (*A*) which has no communication with the sperm cavity (*C*). The tubercle has thick, yellowish-hyaline walls, which on one side touch the beginning of the mucous pad (*B*), and on the other sides they gradually spread over the sides of the flask forming a thin, not firmly adhering, outer membrane. Cavity of the tubercle is filled with a mass less transparent than its walls.

On one side of the flask there is a firmly fixed dirty-white, sticky, slimy pad (*B*), which connects flask with the spermatophylax and, after the latter is torn off, fixes the flask on to the last abdomina sternites.

Oval cavity of the flask (*C*), which is gradually narrowed towards the neck and continues as an outlet for sperm, contains sperm and other subsidiary elements (so called «Druck-Körper» and «Zwischensubstanz» of Regen, 1924); these details are omitted in my figure. The neck of the flask (*E-E*) is a direct continuation of its gradually

narrowed basal portion, and its general shape is that of a scythe with a handle; throughout it goes a narrow channel for outlet of sperm; the channel has its own walls coloured darker than the surrounding hyalinous substance of the neck (this detail is omitted in the fig. 4). Where the neck leaves the flask it is straight and thick, but farther on it narrows gradually; after 1 $^1/_3$-1 $^1/_2$ mm. it makes a sharp bend, beyond which begins the curved «blade» of the scythe slightly widened near its base, this expansion *(F)* corresponding to the, so called, «lamellate appendix» of other *Gryllidae*, in which it is often strongly developed *(Gryllus, Gryllodes, Liogryllus)*. Beyond the «blade» the neck becomes gradually more narrow until its pointed end.

When spermatophore is *in situ* on the female, only the apical third of the neck enters the genital tract of the female, while the scythe-like curved portion is visible and the flask is directed by its tubercle-bearing end towards the insect reaching sometimes to the middle of the last but one sternite (in the fig. 2 the spermatophore does not extend as far as that).

After taking a spermatophore out of the male genital tract (from its spermatophore pouch) and separating its basal portion, it was possible to discover a special hyaline mucous envelope covering the neck of the flask (fig. 4, *G*) beyond its attenuated end. This envelope has a special function in connecting the neck with the surface of the spermatophylax, while its apical portion may, possibly, correspond to the «stopping» apical apparatus which I described in *Oecanthus* (1915) and Regen (1924) in *Liogryllus* («Verschluss» in Regen's terminology). When the basal portion of a spermatophore is placed into water, an energetic outpouring of spermatozoids is observed, but they apparently do not form connected group or, so called, spermatodesms.

Thus, in *Gryllomorpha dalmatina* the spermatophore fertilisation is highly original compared with other *Gryllidae*, and this shows that one must be very careful in making generalisations and in drawing conclusions.

The facts observed in *Gryllomorpha* tend to smooth out the differences in the principles of the copulatory process and of spermatophore structure between *Gryllidae* and *Tettigoniidae*. It must be not forgotten, also, that in *Tettigoniidae*, and even within the limits of one subfamily *Raphidophorinae* both the simple flask-like (in *Dolichopoda*),

and the compound spermatophores with a spermatophylax (*Tachycines*) may be observed. The subfamily *Gryllinae* of the *Gryllidae* also includes forms with simple flask-like spermatophores (*Gryllus, Gryllodes, Liogryllus*) and others posessing compound spermatophores with a cavity (*Gryllomorpha*).

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