

THE PROCESS OF MATING IN THE HONEYBEE

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Summary

The author examined from 1948 till 1957 about 2000 drones and 800 queens. He observed 1812 flights of queens. He made a close anatomical and histological study of the wall of 60 mating signs which contained parts of the bulb of the endophallus.

The results are following:

1. At first the author investigated the structure of the reproductive organs of drones (Fig. 1. and Fig. 2.). Then he stated the following function of them: During the eversion of the endophallus the cornua turn upwards (Fig. 3, C) and sideways (Fig. 5, C). Then the cornua bend downwards (Fig. 4, C) and their apices converge (Fig. 6). The cornua are made to bend by the increased pressure inside the organ and as a result of the bursting of the external viscous layer covering the cornua. The sac of the bulb of the endophallus (Fig. 9, S) and the ends of the chitinized plates enter the everting cervix (Fig. 9, Ce) dilating it and, in consequence, rupturing the thin outer layer of its wall, producing one or more long fissures through the hairy areas on each side of it (Fig. 12, Rc). After this part of the endophallus has passed through the narrow part of the cervix, the whole bulb pushes very quickly backwards inside the everting endophallus. The ends of the broad chitinized plates now protrude freely, externally (Fig. 10, Chs), but the pointed ends of the long chitinized plates are wrapped in two folds of the dorsal wall. After complete eversion of the middle portion, and the freeing of the pointed ends of the broad plates the dorsal wall of the sac of the bulb everts. This causes a considerable widening of the slit-like aperture of the endophallus (Fig. 10, Ob), as a result, semen begins to flow out (Fig. 12, Se), from inside the bulb, being pushed out by the mucus and epithelium (Fig. 10, Nbl) which, almost as a whole, is torn off the mucous glands. The cornua weaken their embrace.

After ejaculation, the membranous part of the bulb, which has so far been much dilated (Fig. 11, B) collapses (Fig. 13, B1). It frequently happens that the two mucous glands and seminal vesicles are now pushed into the empty space within the base of the endophallus. (Fig. 13, Gm, Vs).

After the eversion of the chitinized plates (Fig. 15), the full eversion of the endophallus (Fig. 18) is completed quickly and comparatively easily.

2. The author have examined to this time 365 mated queens on their return from the mating flight. In 71% of queens examined, the mating sign contained parts of the bulb of the endophallus; in 23% it consist only of mucus, and in 6% the queens returned with no signs revealed. It was not until they began to lay that they were found to have been inseminated. Position of the mating sign in the abdomen of the queen is shown on Fig. 20 and Fig. 21. In almost all

queens the mating sign is filled only with mucus of the drones mucous glands.

The posterior end of the mating sign either finishes off bluntly (Fig. 22) or with a short or long tread (Fig. 23, Dm). This tread consists exclusively of coagulated mucus and never contains the ejaculatory duct.

The outermost covering of the mating sign (Fig. 29 Ch2) thus consist not of a transparent, yellow layer (Fig. 22, 23, M) which lies closely to the bow of the bulb and also covers partly the chitinized plates.

On transverse sections through the mating sign (Fig. 27) one finds a chitinized layer (Fig. 29, Ch2) which is however 4 times thinner than the chitinized layer in the bulb of the endophallus (Fig. 28, Ch2 + Ch1). No epithelium is to be found in the covering of the mating sign (Fig. 29) as it is in the bulb wall (Fig. 28, Nb) So the covering of the mating sign (Fig. 29 Ch2) is about 8 times thinner, than that in the intact bulb of endophallus (Fig. 29, Ch2 + Ch1 + Nb + Mp).

The outermost covering of the mating sign (Fig. 29 Ch2) thus consist not of the whole bulb wall, but only of the innermost chitinized layer of the bulb covering (Fig. 28, Ch2). This makes it clear that the mating sign is not produced by the endophallus tearing off transversely, but by the longitudinal separation of the wall layers: the mating sign is pushed out backwards from the endophallus.

4. It proved possible, by dissecting off the layers of the bulb wall, to produce a preparation similar to the mating sign that is a preparation consisting of the chitinized plates and the bow of the bulb, covered with a thin chitinized layer. This last structure formed in the unevverted bulb of the endophallus the thin inner chitinized layer of the bulb wall.

The author investigated next the eversion of the endophallus in circumstances more like natural mating. An almost similar body to the natural mating sign can be experimentally detached from the endophallus if complete eversion of the endophallus is prevented. The chitinized plates and the bow of the bulb, are pushed unevverted out of the endophallus (Fig. 30) under the pressure of the continuing eversion the tube of the endophallus is therefore generally undamaged (Fig. 32).

5. The author give an account of the procedure of mating as he believe it to take place.

At the commencement of the mating the base of the endophallus and the cornua are the first organs to be everted. As the cornua bend downwards, and their points become closer, they probably embracing the queens abdomen.

The bulb, which only becomes filled with sperm and mucus during the cornua are the first organs to be everted. As the cornua bend downwards, (Fig. 7), and is now pushed slowly thence trough the everting cervix. The partially everted penis is introduced into the actively opened sting chamber of the queen, the point of the chitinized plates now forming the end of the endophallus (Fig. 10) — reaching into the bursa copulatrix. As eversion proceeds, the points of the lateral chitinized plates push out of the endophallus, and the sac of the bulb begins to evert (Fig. 10, S). As a result, an opening is formed (Fig. 10, Ob) which leads to the lumen of the bulb, and out of this opening the sperm is ejected (Fig. 12, Se) under strong pressure. The semen is quided by the lateral chitinized plates into the vagina (Fig. 21, V), and from there past the depressed valvefold into the oviduct (Fig. 21, Ol). The viscous macus which follows can only move slowly, and does not normally extend as far as the oviducts.

The further eversion of the endophallus encounters resistance in the narrow sting chamber. The endophallus pushes against the queen's abdomen, and the bulb wall is everted under increasing pressure from within. Its contents — the chitinized plates filled with mucus, and the bow of the bulb — are pushed out of the wall uneverted (Fig. 30). The separation takes place along the surface of a preformed chitinized layer in the bulb wall. The endophallus separates undamaged from the mating sign (Fig. 31, Ms) and with it the separation of the queen and drone is accomplished. When the mating is finished, the endophallus is fully everted, but it has lost its chitinized plates and the bow of the bulb (Fig. 32).

As soon as the queen is again in the mating position with another drone, the mating sign becomes attached to the hairs of the shield-shaped area (basal area) of the everting endophallus, which point backwards. One may assume that the chitinized plates do not become detached from the endophallus in all drones and then only a lump of mucus remains in the queen's sting chamber.

EXPLANATION OF FIGURES

1 Reproductive organs of 21 days old drone; 2 Noneverted endophallus after filling up the bulb; 3—19 Stages in the eversion of the endophallus; Fig. 8 and Fig. 13 A are in section; 20, 21. Reproductive organs of the queen immediately after mating flight; 22, 23 Mating sign; 24 Chitinized plates with the bulb, prepared from the endophallus; 25, 26 Cross-section through partly everted endophallus (as in Fig. 4); 27 Cross-section through mating sign; 28 Section through bulb wall of drone; 29 Section through wall of mating sign (Fig. 28 and Fig. 29 photomicrographs taken with polarizing microscope); 30, 31 Separation of the mating sign from the endophallus; 32 Endophallus after the separation of the mating sign.

KEY TO ABBREVIATIONS

B	— bulb of endophallus,	Oc	— external opening of the cervix,
B1	— the part of the bulb which is strengthened by the chitinized plates and the bow of the bulb,	Od	— opening of the ejaculatory duct; gonopore,
B2	— thin-walled part of the bulb,	Ol	— lateral oviduct,
Bc	— bursa copulatrix,	Om	— median oviduct,
Bp	— bursal pouch,	Ov	— ovary,
Br	— vestibulum of the endophallus,	Pb	— burst of the bulb's end,
C	— cornua,	Pd	— posterior end of the ejaculatory duct,
Cf	— fissure in the sticky surface layer of the cornua,	Pv	— penis valve,
Ce	— cervix, of endophallus,	Qa	— spiny area,
Ce1	— longitudinal fold of cervix,	R	— gutter,
Ch	— chitinized layer of the bulb wall,	Rp	— shield-shaped area; ventral basal area (plate),
Ch1	— chitinized layer next to the epithellum,	Rc	— fissures in the outer layer of the cervix,
Ch2	— chitinized layer next to the bow of the bulb,	Rs	— spermatheca,
Ch1	— long chitinized plates,	S	— sack of the bulb,
Chs	— broad chitinized plates,	Se	— semen,
De	— ejaculatory duct,	Ss	— connective substance,
Dm	— thread-like end of the mating sign (mucus),	St	— sting,
Dr	— spermathecal duct,	T	— testis,
Fl	— fimbriate lobe,	Ta	— triangular area
G	— hill of vestibulum,	Ivp	— areas on transverse corrugations of the cervix,
Gm	— mucous glands,	V	— vagina,
K	— sticky surface layer of the cornua,	Vd	— vas deferens,
Lp	— lamina parameralis,	Vf	— valve-fold,
M	— covering of the mating sign,	Vs	— vesicula seminalis,
Mp	— basal membrane,	Wb	— doming of the bulb wall, surrounding the pointed ends of the long plates,
Ms	— mating sign,	Wc	— stretching of the bulb wall for the chitinized plates,
Muc	— mucus,	Wz	— bow of the bulb; reinforcing layer.
Nb	— epithelium,		
Ob	— posterior opening of bulb,		

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