

Inferences about the function of genitalia in the genus *Eupithecia*, with description of a new organ (Lepidoptera, Geometridae)

Kauri MIKKOLA

The Finnish Museum of Natural History, P.O. Box 17, FIN-00014 University of Helsinki, Finland

Summary

In the geometrid genus *Eupithecia*, the females usually have a sclerotized half-ring in the ductus bursae, called the colliculum. BOLTE (1990) observed that this structure is lacking in the North American *E. palpata* group. In this group, the males have the 8th sternite (ventral plate) composed of two long rods and a connecting ridge. It is shown that the rods are basally articulated, and seemingly, they have a forceps-like function. In the 7th segment of the female, corresponding paired pouches for reception of the forceps' tips were found. These are named "Bolte's pockets" (*crumillae boltei*). A hypothesis about the interplay between the male ventral plate and the female colliculum is presented : the mainly species-specific plate is an "opener" of the colliculum, a "key". It is suggested that in *Eupithecia*, the recognition function between sexes during the early phase of copulation has shifted from the valvae to these structures. The function of the valvae is probably restricted to a stereotypic grasping at the beginning of the pairing. The later fixing, recognition and isolating functions are performed by the internal lock-and-key mechanisms formed by the aedeagus and vesica of the male and bursa copulatrix of the female, in a way similar to that published for the noctuid genus *Apamea*.

It has recently been shown that the internal genitalia of noctuid moths function as complicated lock-and-key mechanisms (LAFONTAINE & MIKKOLA, 1987 ; MIKKOLA, 1992). In the geometrid genus *Eupithecia* Curtis, 1825, the male vesica and the female bursa show similar structural correspondences (MIKKOLA, 1993). According to PETERSEN (1909), also in these moths, the male must deposit the spermatophore into the female bursa and appendix bursae so that its opening is against the opening of the ductus seminalis. Otherwise, the sperm transfer in the female cannot take place. Such a deposition succeeds only if the genitalia have the same specific characteristics. Thus, the internal genitalia act as isolation mechanisms.

Even though the genitalia of *Eupithecia* are shown in numerous standard works, very little is known about their function. PETERSEN (1909) is virtually the only researcher who has paid attention to the interplay of the male and female genitalia. He reached the pioneering and important concept, referred to above, that the male spermatophore must correspond in shape to the shape of the female bursa.

PETERSEN (1909) never made comments about the significance of the female colliculum, a structure peculiar to the genus *Eupithecia*. This is a dorsal, half-ring-formed sclerotization in the posterior part of the ductus bursae: ventrally the ductus wall is membranous (Fig. 3). Another structure which is typical of the genus *Eupithecia* is the male "ventral plate", the modified 8th sternite. Its shape is more or less species-specific, and therefore, most standard works show it for all species, even though the function of the organ was unknown.

BOLTE (1990) noted that the female colliculum is lacking in the North American *E. palpata* group, and that the ventral plate in the males of these species is composed of two long rods, fork-like. This cue inspired me to try to figure out what the relation of the ventral plate and the colliculum is; the first results are published in this paper. A review of the lock-and-key mechanisms will be published in a separate paper in cooperation with Mr. Klaus Bolte.

Material and methods

For this study, genitalia slides made by Klaus Bolte (see BOLTE, 1990) from the Canadian National Collection, Ottawa, were used. The slides contain both the routine parts and the male vesica everted as well as the male and female abdominal skins. Most slides are stained with chlorazol black, giving a clear separation between membranous and sclerotized parts. The drawings were made using a mirror, so they correspond to the original slides.

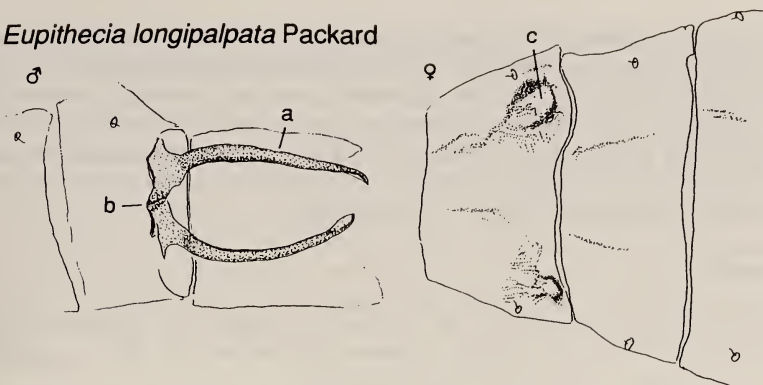
Results

According to McDUNNOUGH (1949) the *E. palpata* group contains 22 species in North America. As BOLTE (1990) reported, the male ventral plate in the *E. palpata* group is fork-like with two more or less thin rods and with a narrow transversal ridge connecting the rods basally (Figs 1,2). In most species, like *E. longipalpata* Packard, 1876 (Fig. 1), the tips of the rods are dorso-ventrally flattened, and spatulate. The rods are usually asymmetric (noted also by McDUNNOUGH, 1949), the left one being straighter and extending further. The stoutness and length of the rods show specific variation.

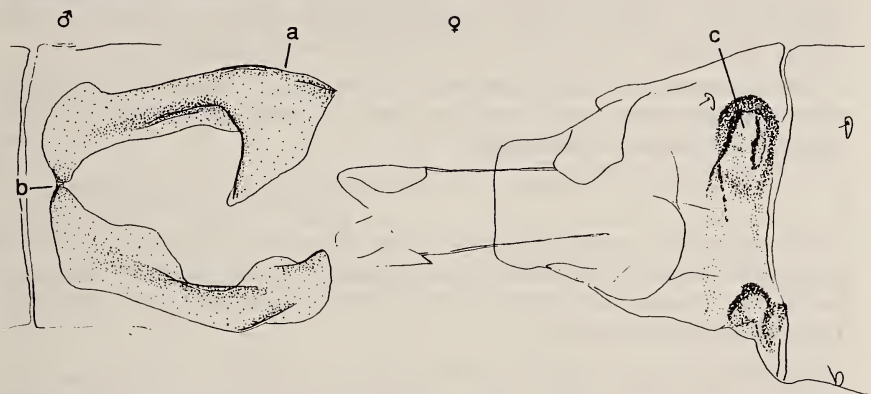
In *E. miserulata* (Grote, 1863), the plate is strongly modified (Fig. 2). The rods are strong and flat, and the tips are bent inward; they are strongly asymmetric, the left one being much larger.

In addition to what BOLTE (1990) described, the connecting ridge is not contiguous, but there is a longitudinal crack between the lateral parts, seemingly an articulation surface, suggesting that the ventral plate could

1. *Eupithecia longipalpata* Packard



2. *Eupithecia miserulata* Grote



Figs 1, 2. Ventral views of the tips of abdomina of males (to the left, caudal direction to the right) and females (to the right, caudal direction to the left) of *Eupithecia*. The sclerotized parts are shown with heavy line and dense stippling. a = the male ventral plate (8th sternite), b = articulation of the sclerites. c = Bolte's pocket. 1) *Eupithecia longipalpata* Packard (slides CNC/GEO 5192 and 5207) ; 2) *E. miserulata* Grote (slides CNC/GEO 5659 and 5595).

function like forceps. This observation led me to search the female genitalia for the grasping points of the tips of the forceps. What was found was a pair of specialized pockets, laterally in the 7th sternite of the female skin. They are usually asymmetric (but because they are soft structures this cannot always be observed) corresponding to the male ventral plate, i.e. with the right pocket larger. The structure is described here and named **Bolte's pockets** (crumillae boltei) in honour of Klaus Bolte who published the outstanding monograph of the Canadian *Eupithecia* species (BOLTE, 1990), and who observed the connection between the structure of the ventral plate and the absence/presence of a colliculum.

DESCRIPTION : Paired depressions of cuticula of female 7th sternite, antero-medial of the stigmata, near 6th/7th intersegmental membrane. Right pocket usually larger than left. Bottom of pocket scaleless, seemingly covered by sensory hairs, in *E. miserulata* bottom of pocket partly sclerotized. In fresh specimens the pockets are covered by scales of the surrounding skin. Size of pockets varies according to size of tips of ventral plate of male. Altered shape and enlarged size is found in *E. miserulata*.

Discussion

In the functional anatomy of the genitalia of species of *Eupithecia* (Geometridae) and those of the genus *Apamea* (Noctuidae) (cf. MIKKOLA 1993), the following basic differences can be observed :

1. The valvae of *Eupithecia* are soft and stereotypic, usually without specific characteristics. Those of *Apamea* are strongly sclerotized and, although they are basically quite uniform, they usually have clear specific characteristics.
2. The 8th sternite of male *Eupithecia* is a specialized, mostly species-specific structure, while the corresponding sternite in *Apamea* has an X-shaped sclerotization, similar in all species.
3. In most species of *Eupithecia*, except those of the *E. palpata* group, there is a colliculum, which is not known in the genus *Apamea*. There seems to be no doubt that the ventral plate in the *E. palpata* group acts as a tool grasping the female in her Bolte's pockets during the early phase of copulation. In Fig. 3, a hypothesis is presented to demonstrate how the ventral plate may interact with the colliculum.

The colliculum in the female's ductus bursae is a double half-ring with the dorsal side rigidly sclerotized and the ventral side membranous, laying tightly

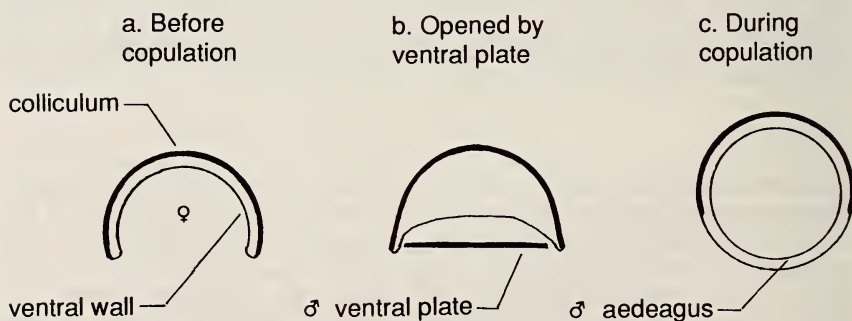


Fig. 3. Hypothetical mode of interplay between the male ventral plate and the female colliculum (transections through ductus bursae; ventral direction downward). a : Before copulation with the ventral wall of ductus bursae against colliculum; b : The ductus is opened by the male ventral plate; c : When the male aedeagus is inserted into the ductus, the colliculum effectively disappears.

against the dorsal side. When *Eupithecia* bursae are inflated by injection, this point is particularly difficult to pass with a syringe needle (K. Bolte, pers. comm.) which is the same as what the male is doing with its aedeagus during copulation. The male ventral plate is usually more or less wedge-shaped. I have found some evidence concerning corresponding measurements and shapes of the ventral plate and the colliculum. Therefore, I propose that the ventral plate is a tool for the opening of the colliculum. In the early phase of copulation, it would slide ventrally of the ductus bursae, widen the distance between the lateral walls of the colliculum and thus open the ductus bursae. Once the aedeagus has gained entry to the ductus, the colliculum structure is no longer apparent. Therefore, its function must be restricted to the early phase of the copulation.

How exactly the interplay between the ventral plate and colliculum occurs, remains to be demonstrated. The former is contiguous with the abdominal scale-covered skin, and the latter is situated under the skin. It may be that the end of the abdomen is telescopic in both sexes. The colliculum of the female may well come out from the abdominal skin to be covered only by a thin inter-segmental skin. The dorsal surface of the ventral plate probably slides into the colliculum, which would require a telescopic abdomen from the male. This problem can only be solved by following and perhaps filming the early phase of the copulation.

Because the colliculum is needed only in the early phase of the copulation, the process being loosely species-specific, I propose that the valvae in the genus *Eupithecia* have lost parts of their function to the ventral plate/colliculum combination. Their function is most probably restricted to grasping the female in the first phase of copulation. In the genus *Apamea*, the valvae would have both grasping and recognition functions; they have retained the “loosely species-specific” function. The significance of the valvae and ventral plate would be at the end, when the male has inserted the aedeagus and vesica into the ductus bursae and bursa copulatrix of the female. Thereafter, the latter structures are undertaking the fixing and sperm-transferring, and, in the case of non-conspecific copulations, isolating functions (LAFONTAINE & MIKKOLA, 1987 ; MIKKOLA, 1992).

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Autor(en)/Author(s): Mikkola Kauri

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