

NOTES ON THE SEXOLOGY OF PHILOMYCID SLUGS OF THE GENUS *EUMELUS* RAFINESQUE

GLENN R. WEBB
Ohio (Postoffice), Illinois

It is somewhat paradoxical that a member of this long overlooked genus should become known sexologically before any of the slugs of the genus, *Philomycus*. The Asiatic-Oriental slug *Meghimatium bilineatus* Benson was the first member of the family to be studied sexologically—by Ikeda (1929, 1937).

My data on *Eumelus* are entirely from the study of captive specimens. The slugs were first successfully maintained in glass bowls half-filled with soil, and then were transferred to a large aquarium used as a terrarium (kindly loaned by William I. Chapel of Warsaw, Indiana). Most of the matings noted occurred in the terrarium, but eggs and young have failed to appear. The specimens of *Eumelus wetherbyi wetherbyi* (W. G. Binney) used in the present study were collected by Ross T. Bell, W. Leslie Burger, and myself, in October 1948, at Cumberland Falls State Park, Kentucky. With one exception, the slugs were fully adult when taken. The available specimen of *E. w. ragsdalei* Webb was one of the two paratypes (the other is in the University of Michigan Museum of Zoology Collection) from near Calico Rock, Arkansas, collected on September 13, 1948. In addition to the above specimens, a single specimen of *Eumelus lividus* Rafinesque has been available for observation from specimens collected near Effingham, Illinois by Philip W. Smith and myself.

EUMELUS WETHERBYI WETHERBYI (W. G. BINNEY)

COURTSHIP

The most complete observation on courtship was secured on September 6, 1949, when at 12:07 P.M. a pair were found circling with each following at the tail-tip of the other. Shortly, however, one turned aside toward the right and soon met its pursuer head-on. Each slowly swept its tentacles about the other's foreparts and continued to move so that the atrial pore areas became appressed (The atrial pore is situated just behind and slightly below the right superior tentacle). One of the slugs then exerted a tongue-like lobe from the atrial pore, but the other slug wandered along the side of its mate to its tail-tip. The non-reciprocation of the attempt at mating by this slug elicited no reaction of biting or gnawing by the individual whose advances had been ignored. (The contrary is often the case on such occasions among helicoid snails.) The one slug continued to follow behind the other and pressed the foreparts or occasionally the superior tentacles lightly against the mate's tail-tip. Soon the pair again maneuvered into the head-on position, and reciprocally exerted the atrial pilasters as ellipsoidal, shallow hoods—one end of which extended forward from the atrial region, and the other end extended less distantly toward the right. These hoods or

atrial pads were reciprocally appressed over their greater surface, but each extended so as to lie partly against the curve of the mate's foreparts (Fig. 1). Coition now ensued.

The courtship procedure of this species is distinctive in its pacific character and is in harmony with the intimate gregariousness of the species in its native sandstone-crevice habitat (Webb, 1950). Hostile reactions have never been noted among captive specimens.

COITION

The onset of coition is masked by the bulk of the hood-like pilasters which are pressed together, and also extend about the foreparts of the mate (Fig. 1). Being at first whitish and opaque, the atrial hoods become bluish and less opaque as they become fully expanded. The short external segment of the exerted penis is concealed from view but is apparent in the mating-anatomies secured by killing mating couples in boiling water. Once engaged, the slugs cannot quickly disengage their organs nor can the organs be disengaged in mating-anatomies without dissection. Thus to secure the completely exerted organs of one slug as shown in figure 3, the narrow, external part of the penis was cut, and the severed turgescing, intruded penis was extracted through a longitudinal slit made in the expanded basal spermathecal duct.

Coition was found to last in this mating from 12:43 P.M. to 2:55 A.M. (2 hours, 12 minutes). The first indication of an impending cessation of coitus was at 2:53 A.M. when the slugs exhibited slight movements and exerted the tentacles. After the disengagement of the sex-organs, the snails quietly crawled away. No biting or gnawing or other aggressive action was noted at this time. Such complete pacificism has been evidenced in every mating of more than ten matings of this species which I have seen and is the exception to the usual behavior of mating pulmonate slugs (Gerhardt, 1940; —Quick, 1946; and others). The pair remained in complete quiescence during the period of coition, and no slow crawling or rotation of the united slugs of this species has ever been noted. Only reciprocal coition was evidenced by the three pairs of mating-anatomies studied.

FREQUENCY OF COITION

The specimens of *E. w. wetherbyi* have been observed to copulate frequently. When the stock of specimens had become reduced to three readily-identified individuals, one slug was noted to engage in coitus three times in eight days. This observation is in support of the idea that non-spermatophore forming pulmonate snails engage in coition more frequently than those which secrete indurated spermatophores.

MATING-ANATOMY DATA

Atrium. The glandular part of the atrium forms a narrow belt about the base of the exerted organs, and is not conspicuous in com-

parison with the total bulk of the extruded organs. Below the glandular part, the atrium merges with the hood-forming pilaster which constitutes the bulk of the exerted, turgescient organs. In the retracted condition, the hood forms a somewhat bilobate pilaster. It is very much more voluminous in the fully exerted condition, and one side or lobe is longer than the other, causing the organ to be attached eccentrically to the atrium. One animal exhibited an extra cleft on the major lobe of the atrial pilaster (Fig. 2).

Penis. Everting from the outer face of the atrial hood, on the side opposite from the atrial pore, the penis is initially dense, smooth, and stalk-like; but it gradually expands to completely fill the ample cavity of the basal spermathecal duct. Upon reaching the contraction at the upper end where the mid-spermathecal duct (isthmus) inserts, the penis recurves downward into the lower part of the spermathecal-duct expansion.

None of the anatomies confirm the existence of a verge and the seeming verge in this species (Webb, 1950) results from the contracted membranes of the lower penis forming a projecting verge-like mass below the upper chamber. Expanded, the membranes of the fully exerted penis form a somewhat bell-shaped, truncate penis-tip on which the lumen of the uneverted upper chamber of the penis opens centrally. Were a verge present, the walls of the upper cavity of the penis would not be completely continuous with the remainder of the penis—as clearly is the case. As yet no species of philomyxid slug is known to have a verge although further study of the family may yet reveal one. In this regard, it seems useful to mention that the basal penis of *Philomyxus carolinianus* (Bosc) sometimes projects freely verge-like into the lumen of the atrium, and is not homologous to a verge but may be homologous to the condition in *Meghimatium* in which a ligula is said to extend from the penis and to project conspicuously into the atrium (Simroth, Hoffmann, according to Ikeda, 1929).

In *Eumelus w. wetherbyi* (Fig. 3), the upper chamber of the penis seems to act as a storage space for the seminal material, which is transferred into the basal spermathecal duct (Fig. 5). The changed form of the transferred seminal material indicates it has not been formed into a spermatophore during its storage (for an unknown period) in the upper chamber of the penis. In some specimens of *E. lividus* Rafinesque, and of the present species, the upper chamber of the penis is prolonged into a slight caecum beyond the point at which the vas deferens inserts. No part of the vas deferens seems derived from a helicoid-type of epiphallus, and the upper chamber of the penis, including the caecum, seems comparable to the terminal part of the penis in the snail *Haplotrema concavum* (Say) and its allies.

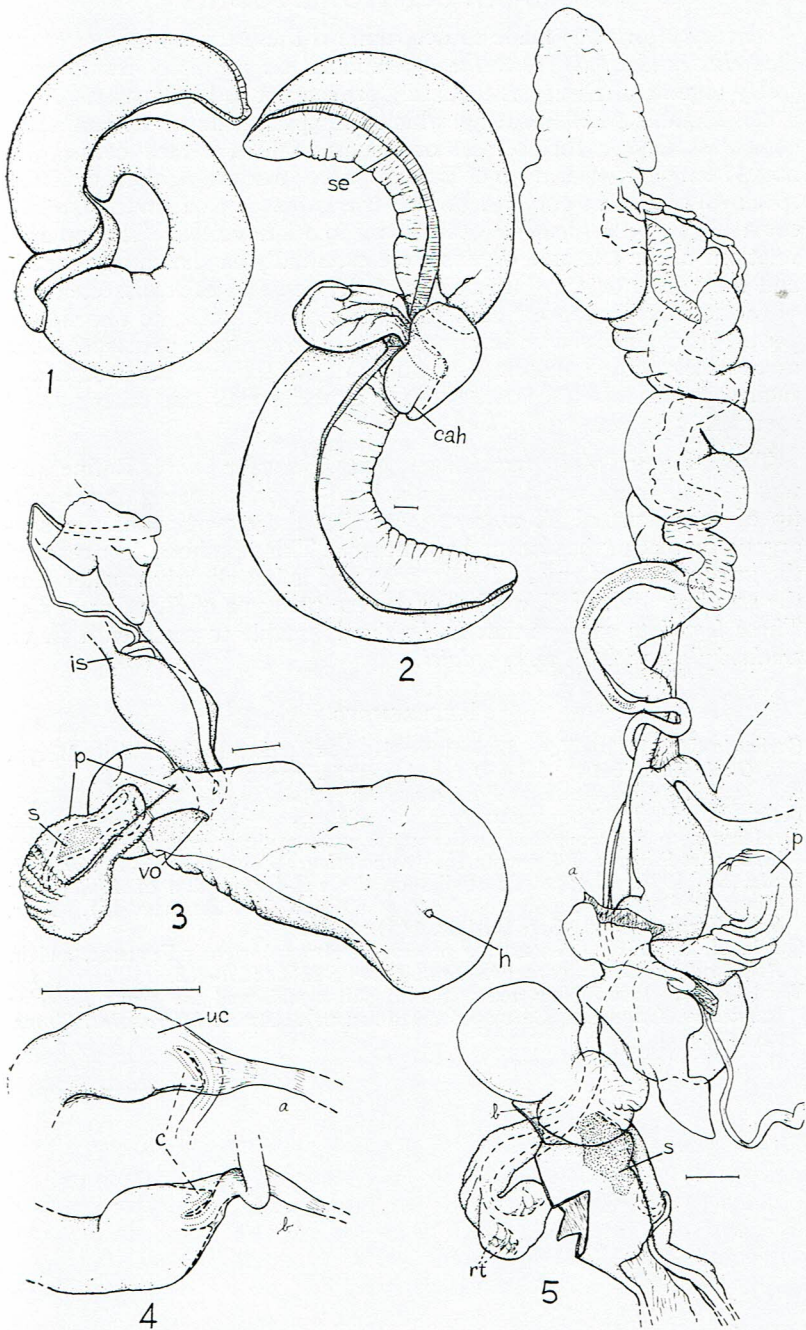
The pronounced recurvature of the exerted penis agrees with its shape in the retracted condition, and probably is correlated with

function as suggested below. The papillae are rather uniformly present over the expanded part of the penis, and are also borne on the obliquely revolving ridges present (seven ridges are evident in my material). The papillae seem slightly more prominent in my mating-anatomies of *E. w. wetherbyi* than in the mating-anatomy of my paratype of *E. w. ragsdalei*.

Female-Organs. The cavernous, thickened, and longitudinally-rugose basal part of the spermathecal duct receives nearly all of the eversible part of the penis except the short, non-papillose segment extending between the animals and into the very short vagina. When containing the penis, the basal spermathecal duct is distended so that it is membranous. The absence of a definite muscular band at the narrowed upper end of the penis, where the isthmus inserts, seems to confirm the impression that the recurvature of the intruded penis results from an intrinsic recurvement such that the penis can be gradually everted into the basal spermathecal duct without being forced against the isthmus area and thereby deflected downward. If this deflection were the case, a sphincter muscle would seemingly have to be present. The densely papillose surface of the penis would greatly interfere with any force tending to thrust it into the vaginoid, basal, spermathecal duct. By merely everting the penis into the expanded basal spermathecal duct, guided by slight torsion-causing membranes, this problem is met in seeming agreement with the facts—the retracted penis is recurved and no sphincter muscle is evident at the base of the isthmus. The papillosity would aid the eversion of the penis by anchoring the already everted part and abetting the eversion of the remainder. The eversion of the upper chamber seemingly is prevented by slight membranes (Figs. 4-5).

Vagina. The extremely short vagina opens to the exterior on the atrial-hood adjacent to the penis, and almost immediately unites internally with the basal spermathecal duct.

Plate I. (Opposite page.) Figs. 1-3: *Eumelus wetherbyi wetherbyi* (W. G. Binney); other figures as given below. The scale line equals 2 mm. Body coloration is not shown. Fig. 1: Dorsal view of a mating pair—drawn from a photograph. Fig. 2: Lateral view of a pair of mating anatomies, camera lucida drawing. Fig. 3: The exerted sex organs and the lower genitalia with the penis cut and rejoined as shown by the double line. This figure and figures 4 and 5 were drawn from slide projections. Fig. 4, (a): *E. lividus* Rafinesque showing the upper cavity of the retracted penis and the short caecum. Fig. 4, (b): The same of *E. w. wetherbyi*. Fig. 5, (a): The genital system and exerted organs of *E. w. ragsdalei* Webb, paratype. The retentor threads within the penis are shown. Fig. 5, (b): *E. w. wetherbyi*. The inserted penis tip is shown. Symbols used: c, caecum; cah, cleft of atrial hood; h, hole formed by a dissecting pin; is, isthmus of the spermathecal system; p, penis; rt, retentor threads preventing the eversion of the upper penis; s, semen; se, sole edge of the foot; uc, upper cavity of the penis; vo, vaginal orifice.



CROSS-COPULATION STUDIES

Every effort was made to determine if these three kinds of slugs, *Eumelus lividus*, *E. w. wetherbyi*, and *E. w. ragsdalei* would mate freely together. Such has definitely proven not to be the case. After a considerable period, during which the specimens of *E. wetherbyi* copulated among themselves, one successful inter-race coitus was noted between the paratype of *E. w. ragsdalei* and the smallest available specimen of *E. w. wetherbyi* (which was collected as a juvenile). The courtship was not seen—the pair being found in coitus. The external relations of the exerted organs were essentially as shown in figure 1, and the united organs (with most of the penis of each dissected free of the basal spermathecal duct and extended artificially to one side to permit study) are shown in figure 5. *E. w. ragsdalei*, paratype, is the more nearly entire anatomy shown (a). Coitus was reciprocal, and each slug had ejected some seminal material into the other's basal spermathecal duct.

The individual of the remaining species, *Eumelus lividus* Rafinesque, was several times noted transiently head-on or following at the tail-tip of specimens of *E. w. wetherbyi*, but the exertion of the sex-organs or mating has never been noted. This specimen has reached the greatest size of any *E. lividus* seen and is but slightly smaller than the smallest adult of *E. wetherbyi*, or the paratype of *E. w. ragsdalei*. These few data suggest that *E. lividus* is unable to mate with *E. w. wetherbyi* or with *E. w. ragsdalei*.

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