

# AMERICAN MUSEUM NOVITATES

Number 362

Published by  
THE AMERICAN MUSEUM OF NATURAL HISTORY  
New York City

July 27, 1929

59.79 E:15.6

## THE RELATION OF COURTSHIP TO THE SECONDARY SEXUAL CHARACTERS OF THE TWO-LINED SALA- MANDER, *EURYCEA BISLINEATA* (GREEN)

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From October to May, and possibly longer, the adult male two-lined salamander, *Eurycea bislineata bislineata* (Green), may be distinguished from the female by its markedly larger head (Fig. 1), glandular

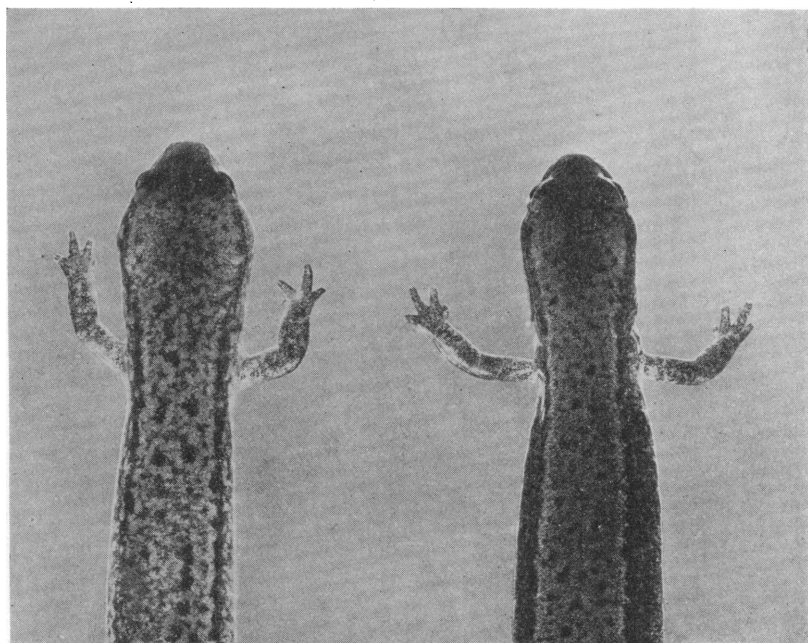


Fig. 1. *Eurycea bislineata bislineata*, male (left) and female (right), showing different head proportions in a courting pair.

area on the chin, and scattering of yellowish or white glands on the lower eyelid, posterior part of upper eyelid and jaws, as well as on temporal region and neck. There is also a difference in the shape of the snout, lips and body. It has not been pointed out previously that the

adult males during this period have elongate monocuspid teeth in both jaws, the premaxillary teeth being directed slightly forward, while the females have shorter bicuspid teeth in both jaws. Adult *Eurycea melano-*

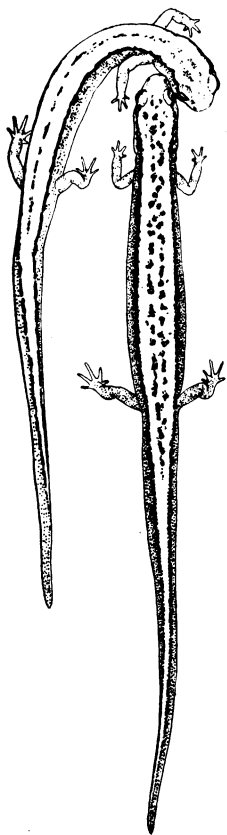


Fig. 2. The courtship of *Eurycea bislineata*. The male with temporal region pressed against the snout of the female.

*pleura* show a similar sexual dimorphism of dentition during the fall but not in July. Possibly all species of *Eurycea* will be found to undergo an annual change of dentition in the adult male from bicuspid to monocuspid teeth and the reverse, but it has been established that the marked sexual dimorphism of *Desmognathus f. fuscus* and *D. f. carolinensis* is permanent throughout the year (Noble and Pope, in press). Correlated with the differences of head form and teeth size there are sexual differences in the elements of the skull.

From January to April, 1929, many males of *Eurycea bislineata* displayed during the evening a courtship activity in a series of covered crystalizing dishes half filled with water. The period is initiated by an awakening interest of the males in each other and in the females. The males push every salamander in their vicinity with their snouts, but show a continued interest only in the females. The latter are at first passive and allow themselves to be pushed about for short distances. The males nose any part of the female's body and often lift the female up by pushing their snouts under the cloaca or chest. The sexes rub snouts and cheeks, but the most distinctive pose is a sharp bending of the male's head around the snout of the female, reminding one greatly of the head pose of newts, *Triturus viridescens*, in amplexus (Fig. 2).

The second phase of the courtship may begin after an hour of the male's activity but it usually occurs later. The female, which either through her own activity or that of the male, has her snout pressed against his temporal region or his side, slips posteriorly and on reaching his hind limbs straddles his tail with her forelimbs. Her chin is brought close against the base of his tail at a point about a centimeter or more from the legs. This point is immediately posterior to the highest point of

his tail. When the female's chin touches his tail, the male steps forward wagging the base of his tail sharply to right and to left. At every bend the female turns her head sharply in the opposite direction. The pair continue their walk about the aquarium, the grotesque wagging of the male's tail contrasting to the ordinary movements of the tail during locomotion in the other salamanders. If other males are prevented from nosing the pair the walk may continue with short interruptions for over an hour (Fig. 3). If a female loses her position she will regain it and continue the straddle walk without a preliminary thrusting of her snout against the body of the male.

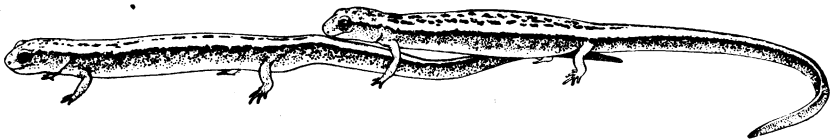


Fig. 3. The courtship of *Eurycea bislineata*. The female straddling the tail of the male, presses her chin against the tail base. Hedonic glands are present in the skin of the male, apparently serving as the source of attraction.

On April 3, four females and five males which had been actively courting during the evening were allowed to remain over night in the observation dish. The next morning two stalked spermatophores were found floating on the surface. Whether or not they had been torn loose from the glass bottom of the aquarium after deposition could not be determined. The spermatophores resembled closely those of *Desmognathus fuscus* as described by Noble and Weber (1929, Amer. Mus. Novit. No. 351), but the base was truncated obliquely to the vertical axis, and the head was longer (Fig. 4). No spermatophores were found within the cloacas of the females although Noble and Weber have shown that these are regularly carried within the cloacal lips of the female from October to February.



Fig. 4. The spermatophore of *Eurycea b. bislineata*,  $\times 20$ .

How the male *Eurycea bislineata* recognizes the female is not clear from these observations, but it is obvious that differential behavior of the two sexes plays a part in both phases of the courtship. The head, body, and particularly the tail base of the male is a distinct source of attraction for the female. An examination of the integument of these regions in

serial sections has revealed a distinctive type of gland which has not been previously described from these parts of the body. This gland is distinguished from poison glands in *Eurycea bislineata* by having a central lumen and tall columnar cells. The cytoplasm is finely granular or pasty but never coarsely granular. It stains in Mallory's a bluish purple not reddish purple to red as the secretion of the poison glands. These new glands, which may be called hedonic glands, differ from mucous glands in never having a stringy or flocculent secretion or a homogeneous cytoplasm. They stain pink in hematoxylin and eosin, not blue as the mucous glands. They are usually larger than mucous glands but readily distinguished at all sizes except during the early growth stages.

The hedonic glands are very large on the dorsum of the tail base in *Eurycea bislineata* but they are not visible here in the living animal, nor usually distinguishable on the sides of the body, nor on the legs where they also occur. The whitish glands on the eyelids and in the temporal region of the male, when examined microscopically, are found to be hedonic glands. Sections show that no such glands occur in the female anywhere on the head, body or tail. The mental gland of the male appears to be a mass of hypertrophied hedonic glands although they are slightly translucent, not yellowish white, as the larger hedonic glands on the head are. The temporal glands of the male newt differ in some detail from the hedonic glands of *Eurycea bislineata* but there is some histological evidence that these glands are homologous structures.

Hedonic glands of the type found in *Eurycea bislineata* are of general occurrence in the Plethodontidæ, and homologous structures seem to occur in the Salamandridæ. They appear as visible structures on the lower eyelids of the male *Desmognathus f. fuscus* and *D. f. carolinensis*. They form a small but distinct dorsal protuberance at the base of the tail of the male *Eurycea multiplicata*. This glandular mass develops even in the male larva of the latter species before metamorphosis and is probably homologous with the less glandular tail spine of *Salamandra caucasica*. The enlarged glands scattered over the head and body of the male *Typhlomolge* have been found to be hedonic glands. Usually the hedonic glands are not visible except for the hypertrophied mass which forms the mental gland. I have found hedonic glands in the male *Desmognathus phoca*, *D. f. fuscus*, *D. f. carolinensis*, *Leurognathus m. intermedia*, *Plethodon cinereus*, *P. jordani*, *Hydromantes italicus*, as well as the species mentioned above. No glands were found in the integument of females of *D. quadra-maculatus*, *D. phoca*, *D. f. fuscus*, *D. f. carolinensis*, *P. cinereus*, or *Eurycea bislineata*. A detailed report on these glands is in preparation,

but in the present instance it is important to emphasize their wide occurrence in male plethodontids for it would seem to follow that the method of courtship is similar throughout these forms. Only in *Aneides lugubris* and *A. æneus* have apparently homologous glands been found in both sexes. These glands are widely spread over the lower sides of body and ventral surfaces of both sexes and are readily visible in the living animal as yellowish spots. The histological differences between the larger of these glands and the hedonic glands of *Eurycea* will be given elsewhere; in the meantime, it may be pointed out that these glands of *Aneides* are neither poison nor mucous glands. It seems probable that they function in courtship or possibly in keeping the sexes together.

Lastly, it may be pointed out that although I have had more than fifty courting *Eurycea bislineata* in aquaria during the past months, and have frequently observed two or three males nosing the same female, I have never seen a male bite another individual or show any disposition to use his dagger teeth as weapons. Thus, while the hedonic glands are closely correlated with the courtship activities, and the forwardly directed premaxillary teeth may also serve as stimulating organs during the first period of courtship, the elongated maxillary and mandibular teeth seem to play no part in any phase of the process.

#### SUMMARY

1.—Courtship in *Eurycea bislineata bislineata* consists of two phases: during the first period the male noses the female and frequently presses his temporal region across her snout; during the second, the female presses her chin against his tail base while the pair walk about, the male wagging his tail base in a characteristic manner, and the female turning her head in the opposite direction at each bend.

2.—The spermatophore of *E. b. bislineata* is stalked and resembles that of *Desmognathus fuscus*.

3.—Hedonic glands are widely distributed over the sides of the head and body and over the dorsal surface of the tail and limbs of the male *E. b. bislineata*. Similar glands are found in the integument of all male plethodontids but absent from all females except *Aneides* where some may have a modified structure.

4.—The hedonic glands apparently serve as a source of stimulation and attraction to the female.

5.—The adult male *E. b. bislineata* has elongate monocuspid teeth in both jaws during fall, winter, and spring; the female, shorter bicuspid ones.

6.—The elongate maxillary and mandibular teeth apparently have no function in the courtship.

