Intersexuality in Ephemeroptera: description of four specimens and comments on its occurrence in a parthenogenetic species

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Intersexes of *Ameletus lineatus* Traver, *Baetis tricaudatus* Dodds, and *Paraleptophlebia moerens* (McDunnough) are described. All specimens are masculinized females. The *B. tricaudatus* and *P. moerens* specimens have typical female features with male-like eyes. The *A. lineatus* intersex has a relatively large number of male-like characters and a greater degree of maleness of these characters. The latter species is also parthenogenetic.

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On trouvera ici la description d'intersexes d'*Ameletus lineatus* Traver, de *Baetis tricaudatus* Dodds et de *Paraleptophlebia moerens* (McDunnough). Tous les spécimens sont des femelles masculinisées. Les intersexes de *B. tricaudatus* et de *P. moerens* ont des caractéristiques typiques des femelles et des yeux semblables à ceux des mâles. L'intersexe d'*A. lineatus* possède un bon nombre de caractéristiques à tendance mâle et est plus «male» que les intersexes des deux autres espèces. Cette espèce est reconnue comme parthénogénétique.

[Traduit par la revue]

Introduction

In sexually dimorphic species an unusual condition occasionally arises whereby an individual exhibits morphological characteristics of the opposite sex. Such a condition may range from only a small portion of the body to nearly the entire organism, making the latter individuals sometimes difficult, if not impossible, to sex. These teratological conditions in which an individual of a sexually dimorphic species displays male and female characters can be a case of either gynandromorphism or intersexuality.

A gynandromorph exhibits a character or characters that resemble those of the opposite sex and the cells of affected characters have the genetic constitution of that particular sex (de Wilde and de Loof 1973). For example, a female exhibiting male genitalia would have the female genotype in all of its body cells except those of the male genitalia, which would have the male genotype.

On the other hand, an intersex typically exhibits a character or characters that are intermediate between a male and female. All of the cells of an intersex, including those of the intermediate characters, are of the same genotype, that of the particular specimen (de Wilde and de Loof 1973).

Lestage (1922) reported the earliest known teratology (an intersex) for Ephemeroptera and reports have appeared sporadically since then. Soldán and Landa (1981) have reviewed the literature on teratologies in Ephemeroptera and have also included descriptions of specimens collected by themselves.

Four intersex specimens of Ephemeroptera, collected from a first-order stream in Pennsylvania (U.S.A.), are herein described and illustrated. We speculate on the mechanisms causing this teratology and discuss its occurrence in a parthenogenetic species.

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Methods and materials

Intersex specimens were identified from among specimens collected by hand in an emergence trap (Masteller 1977) during a study of emergence in Sixmile Creek, a first-order stream in Erie County, Pennsylvania, U.S.A. (79°57′ W, 42°07′ N). Upon capture, specimens were immediately preserved in 80% ethanol.

The sex of these specimens was determined from fully formed characters. After descriptions were completed, the abdomen and thorax of each specimen were dissected to locate parasites that could have caused the intersexuality.

All specimens described here are deposited in the personal collection of P.M.G.

Results

Four intersexes were identified from among the 18 731 specimens of mayflies collected in an emergence trap during the period of 1977–1981. These four specimens represent three species: *Ameletus lineatus* Traver, *Baetis tricaudatus* Dodds, and *Paraleptophlebia moerens* (McDunnough) (two specimens).

All four specimens are masculinized females, i.e., females with male-like characters.

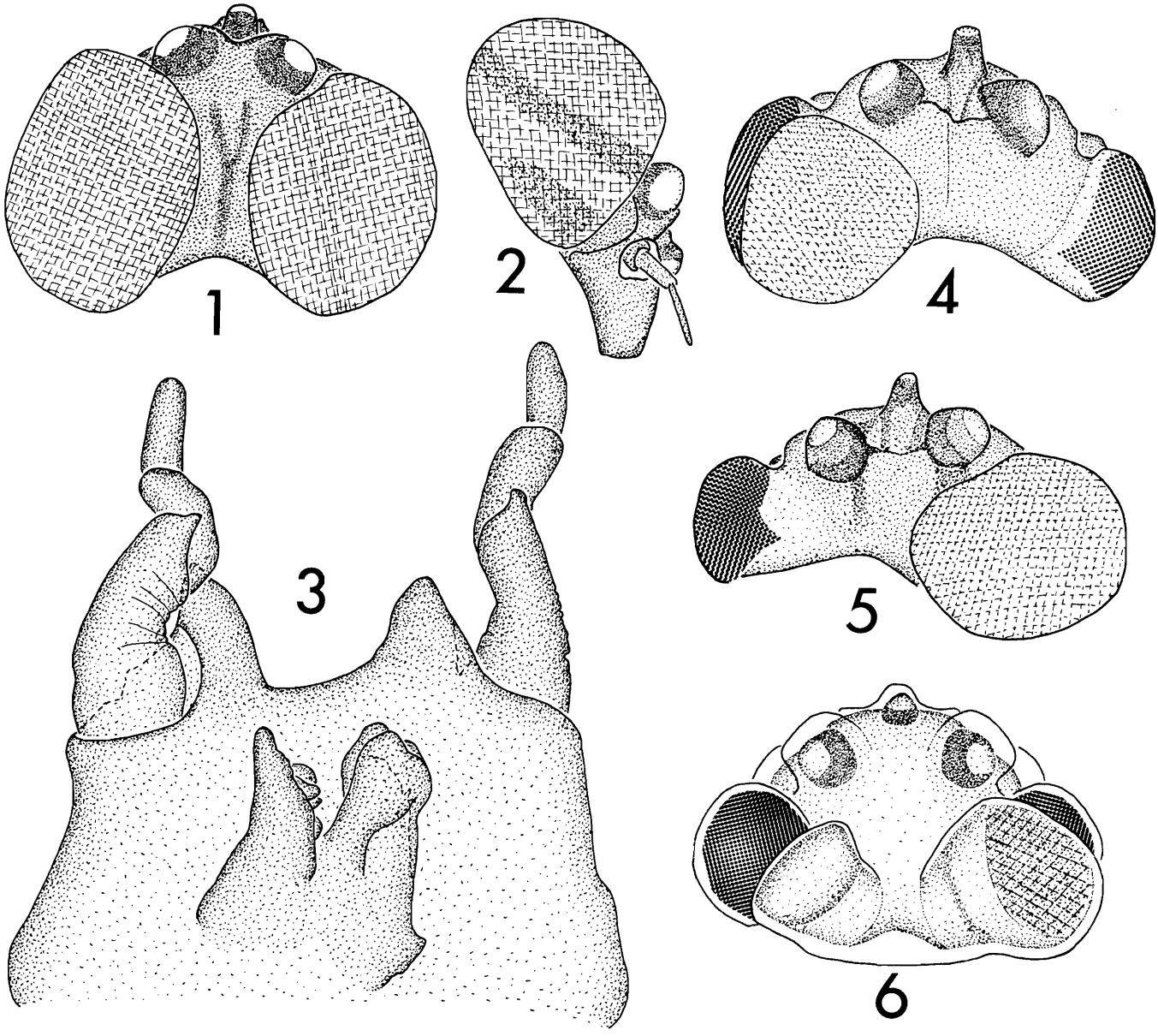
Descriptions of these intersexes follow. We report only those characters that vary from previously published descriptions of each species.

Siphlonuridae

Ameletus lineatus *Traver (Figs. 1–3)*

This *A. lineatus* specimen exhibits a relatively large number of male-like characters. Since no male specimen, either larval or adult, has ever been reported for *A. lineatus* (Grant and Masteller 1984), the following description is in comparison with that of a female imago.

Female imago—Head with dark brown "Y" on vertex (Fig. 1). Upper portion of eyes nearly symmetrically developed; light gray, purplish transverse band across center of eye in lateral



FIGS. 1–3. *Ameletus lineatus*. Fig. 1. Dorsal view of head. Fig. 2. Lateral view of head. Fig. 3. Dorsal view of genitalia. FIG. 4. *Paraleptophlebia moerens*, collected 1978-06-12, dorsal view of head. FIG. 5. *Paraleptophlebia moerens*, collected 1979-06-09, dorsal view of head. FIG. 6. *Baetis tricaudatus*, dorsal view of head.

view (Fig. 2); oval in dorsal view, separated by ca. 1/3 width of an upper portion. Lower portion of eyes dark gray, lowermost area black. Thorax brown. Ratio of segments in forelegs, 1.1:1.0:0.3:0.5:0.5:0.3:0.2. Abdomen with posterior margin of sternum 7 narrowly sclerotized; inner surface of terga covered with thin layer of eggs, abdomen mostly empty. Genitalia (Fig. 3): 2 acutely pointed, asymmetrical projections on apex of styliger plate; two 3-segmented forceps, distorted; right penis acutely pointed at apex with irregular projections on inner margin; left penis bluntly rounded at apex, rounded protuberances anteromesally and anteriorly.

Edmunds et al. (1976) listed the adult male characters of *Ameletus* as abdomen often lighter than that of female; eyes large, contiguous dorsally; forelegs nearly as long as body; and basal tarsal segment 1/3–1/2 times length of segment 2. In comparison, this intersex specimen is darker than the female imagos collected at the same time; the eyes have an upper portion, but they are not contiguous dorsally; the length of the forelegs is less than the body length; and the basal tarsal segment of the forelegs is 3/5 times the length of segment 2.

The only distinctly female characters of this intersex are the presence of eggs and the sclerotization on the posterior margin of sternum 7. Female imagos of *A. lineatus* differ from the intersex in having a pair of narrow, parallel, brown lines on the vertex and uniformly gray eyes with the purplish transverse band across the center.

The genitalia were permanently mounted on a slide (slide no. PMG-1984-PA35).

This specimen was collected 1980-05-06, early in the emergence period of *A. lineatus* for that year.

Leptophlebiidae

Paraleptophlebia moerens *(McDunnough) (Figs. 4–5)*

Two intersex specimens were collected; each is described separately.

Female imago (collected 1978-06-12, Fig. 4)—Eyes asym-

metrically developed. Left eye with upper portion large, facets clearly visible and arranged in rows; lower portion as in male imago. Right eye as in normal female imago, without development of upper portion. Right lateral ocellus male-like, wide, base brown. Left lateral ocellus female-like, narrower, base dark brown, located further from base of median ocellus than right ocellus. Abdomen with inner dorsal surface of terga covered with a thin layer of eggs; most of abdomen empty, no eggs in oviducts near opening.

Female imago (collected 1979-06-09, Fig. 5)—Eyes asymmetrically developed. Right eye with upper portion large, facets clearly visible, arranged in rows; lower portion as in male imago. Left eye as in normal female imago, without development of upper portion. Ocelli and abdomen as in above female imago, except both oviducts completely filled with eggs to opening.

The development of the upper portion of the eyes in both specimens is considerable, but less than that of a normal male imago of comparable size. The paucity of eggs in the abdomen of both females may be due to prior oviposition.

The specimen collected 1978-06-12 emerged during the middle of the emergence period of *P. moerens* for that year; the specimen collected 1979-06-09 emerged during the end of the first third of the emergence period for that year.

This is the first report of an intersex in the Leptophlebiidae.

Baetidae

Baetis tricaudatus *Dodds (Fig. 6)*

Female subimago—Eyes (Fig. 6) asymmetrically developed, male-like. Right eye with upper portion large, facets clearly visible and arranged in rows. Left eye with upper portion smaller, facets not developed. Lower portion of eyes as in female subimago except dorsal margin which resembles male subimago. Abdomen with inner dorsal surface of terga covered with a thin layer of eggs, most of abdomen empty.

The development of the upper portion of the eyes in the female specimen is much smaller than in a male subimago of comparable size.

The abdomen of female subimagos of *B. tricaudatus* is typically full of eggs, except for the apical three segments.

This specimen was collected 1978-05-08, during the middle of the emergence period of *B. tricaudatus* for that year.

Discussion

Our *A. lineatus* specimen is unusual with its relatively large number of male-like characters and the degree of maleness of these characters. Grimeland (1963) described an intersex of *A. inopinatus* Eaton which was typically female except for an elongated ninth sternum; paired, unsegmented forceps; and paired penes. Grimeland (1963) and Soldán and Landa (1981) considered this specimen to be a gynandromorph, but we believe it to be an intersex because of the intermediately developed male genitalia. Bengtsson (1930) collected a female imago of *A. inopinatus* with deformed forceps but provided no description or illustration of the forceps. Fizaine (1931, Fig. 5) illustrated a female imago of *A. inopinatus* with partially developed forceps.

Soldán and Landa (1981) observed no case of symmetrical arrangement of characters in their material. Our specimen of *A. lineatus* has male-like characters on both sides of its body, but these characters are not perfectly symmetrical. This specimen also exhibited male-like forelegs. Soldán and Landa (1981) did not observe any male characters on the thorax of those intersex specimens they examined.

The identity of an intersex of *A. lineatus* may prove useful in the future, if a male is found, to correlate the sexes. Linsley (1937) reported how the sexes of *Andrena porterae* Cockerell (Hymenoptera) were originally described as separate species. A stylopized intersex female of *A. porterae*, described by Linsley, supported the view that the male and female were, indeed, the same species.

The distribution of male characters on the *P. moerens* and *B. tricaudatus* specimens was restricted to the head, as is typical of most mayfly intersexes, but the distribution was not the same on the two *Paraleptophlebia* specimens. Codreanu and Codreanu (1931, Plate XII, Figs. 1–6), in an excellent series of illustrations, showed the varying degrees of intersexuality that can occur between normal male and female imaginal eyes of *Baetis rhodani* (Pictet).

Causes of intersexuality among insects include "strength" of sex-determining genes in racial intercrosses and interspecific hybrids, gene balance in polyploids, chromosomal mutations, temperature (de Wilde and de Loof 1973), and parasites (Wigglesworth 1972). Among mayflies, only parasitism has been implicated as a cause of intersexuality (Soldán and Landa 1981).

We dissected the intersexes after descriptions were recorded, but found no mermithids or parasites of any kind. Soldán and Landa (1981) indicated that mermithids leave the larva before it matures.

Some of the other causes of intersexuality may be discounted. None of our specimens were unusually early or late in their emergence times, so extreme temperature is improbable. Causes involving mating could be excluded for the parthenogenetic *A. lineatus*. We cannot discount some of the other mechanisms since a genetic study of these specimens was not undertaken.

We believe that the capture of these intersexual specimens was primarily due to our collection procedure, which allowed us to collect a large number of specimens of each species.

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