

## GYNANDROMORPHISM AND DIFFERENTIAL MOLTING IN A MAYFLY (EPHEMEROPTERA)<sup>1,2</sup>

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**ABSTRACT:** A gynander of *Ephoron leukon* is described from the Tippecanoe River, Indiana, and constitutes the first report of the phenomenon in the family Polymitarcyidae. It is the first non-baetid gynander known to have a male head, the first mayfly gynander known to have bilateral sexual differentiation of the thorax but not the head, and the first mayfly gynander known to have complete bilateral sexual differentiation of the abdomen. Differential molting of the gynander is evident and is related to the fact that females of *E. leukon*, unlike males that reproduce as adults, are reproductively mature as subimagos, so that two different life stages may be represented simultaneously in an individual gynander.

The detection of gynandromorphism in mayflies is generally correlated with the sampling of great numbers of individuals (Soldan and Landa 1981). Such was the case when our extensive sampling of *Ephoron leukon* Williamson in 1984, on the Tippecanoe River in north-central Indiana, revealed one striking gynander among thousands of normal individuals.

Mayfly gynandromorphism has been documented occasionally in the literature over the past 63 years. Agnew (1979) indicated that some gynanders have been erroneously referred to as intersexes. Mayflies with known deviations of sex-related characters were recently reviewed and elaborated by Soldan and Landa (1981).

This report of a gynander of *E. leukon* is significant for several reasons. It represents the first report of gynandromorphism, or any other sexual aberrancy, in the family Polymitarcyidae. The phenomenon has been described previously for the families Siphonuridae, Baetidae, Oligoneuriidae, Heptageniidae, Leptophlebiidae, Potamanthidae, Ephemeridae, and Ephemerellidae. Our discovery is of further interest in this regard because *E. leukon* is the only representative, among known gynanders, of a group of mayflies in which the female, unlike the male, reproduces as a subimago and does not undergo a molt from the subimago to adult stage. Therefore, in addition to a description of development and distribution of primary and secondary sexual characteristics on the individual, the relative degree or symmetry of molting (or, in essence, adulthood) is of particular interest. Moreover, the gynander of *E. leukon* does not fit certain morphological

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mosaic and bilateral patterns that are expressed by other mayflies and that were elucidated by Soldan and Landa (1981) as typifying mayfly gynandromorphism.

Our description of the gynander of *E. leukon* primarily concerns the deviations from normal bisexual individuals. For comparative descriptions and figures of normal individuals see Ide (1937). Possible causes of mayfly gynandromorphism have been discussed by Agnew (1979) and Soldan and Landa (1981). If gynandromorphism in *E. leukon* is attributable to an X chromosome being lost in one cell line of the zygote (giving rise to both XX female and XO male karyotypes), then this loss may have happened in an early stage of cleavage because of the preponderance of male tissue in our gynander.

The head of the gynander, viz. the compound eyes, is entirely male. The thorax and abdomen, however, are fully bilaterally differentiated in sexual orientation, with right being male and left female.

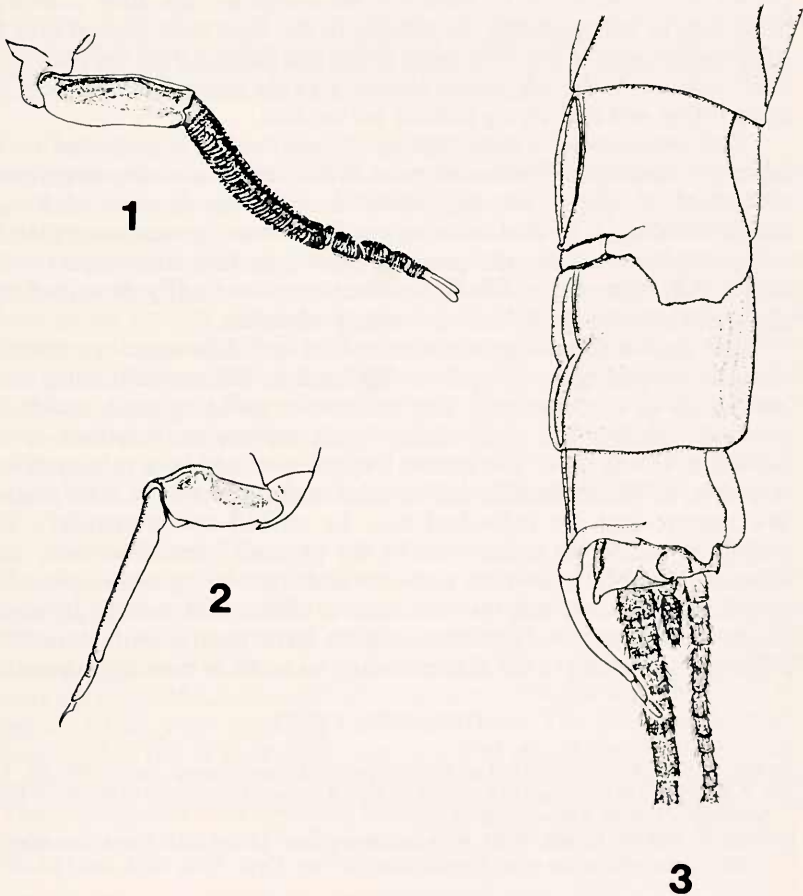
Differences in the right, male foreleg and left, female foreleg are illustrated in Figs. 1 and 2. Males and females of *E. leukon* differ with respect to the ratio of forewing to hindwing length. The forewings of females are longer relative to body length and are almost three times the length of the hindwings; the forewings of males are relatively shorter and only about twice the length of the hindwings. The right forewing of the gynander is 9mm and the right hindwing 4mm, whereas the left forewing is 11 mm and the left hindwing 3mm.

The abdomen, as seen dorsally, is curved to the left posteriorly owing to the right, male side being more elongate than the left, female side. The right testes is developed, whereas the left ovary is developed. Eggs are held in the abdomen, but only about half as many as are found in normal females. Externally (Fig. 3) the egg valve is developed on the left only. Genital forceps and the subgenital plate are developed only on the right. The right lobe of the penes is fully developed, but the left lobe is atrophied. The median terminal filament is reduced as in normal males; however, the right caudal filament is much thicker and longer than the left caudal filament, demonstrating again bilateral sexual differentiation.

The gynander of *E. leukon* demonstrates several exceptions to the characterization of mayfly gynanders discussed by Soldan and Landa (1981). Previously, gynanders with a male head had been found only in two specimens of Baetidae, which were essentially males with ovaries. Also previously, bilateral differentiation of the thorax had only been found in individuals with bilaterally differentiated heads. The entire abdomen is bilaterally differentiated in the *E. leukon* gynander, whereas other mayfly gynanders have mosaic-like distribution of sexual characterization or are non-sexually differentiated with respect to pregenital abdominal segments.

The combination of male head and median terminal filament and otherwise fully bilateral sexual differentiation found in the *E. leukon* gynander is evidently unique among the approximately 36 or more mayfly gynanders that have been reported (Soldan and Landa 1981).

The gynander of *E. leukon* was fixed just as molting from the subimago to adult had commenced. Although molting was not complete, it is evident



Figures 1-3. *Ephoron leukon* gynander. 1. Right foreleg, 2. Left foreleg, 3. Ventral posterior abdomen.

that differential molting with respect to bilateral sexual orientation was involved. The head, legs, and abdomen had not begun to slough any subimaginal pellicle, however, the thoracic nota and wings demonstrated differential molting, with only the right, male side having sloughed the subimaginal pellicle. There was no loosening of the subimaginal pellicle on the left, female side of the thorax. Molted and non-molted sides were clearly divided by the median notal suture.

The abdomen, although possessing the subimaginal pellicle entirely (which is characterized by cuticular microtrichia), did differ somewhat from right to left regarding the cuticle. In the right male pleural area the subimaginal pellicle was very loose fitting and distinct from the underlying adult pellicle. In the left female pleural area the subimaginal pellicle was close fitting and underlying pellicle not evident.

The presence of a subimago in extant insects is restricted to the relatively small order Ephemeroptera. Within that order only a very small percentage of species are specialized to reproduce as male adults and female subimagos, *E. leukon* being one. Moreover, gynandromorphism is rare in Ephemeroptera, and possibly even more rare with respect to the family Polymitarcyidae. Given these rarities, the mayfly described here could certainly be considered a curiosity of nature.

The combination of gynandromorphism and differential reproductive maturity depending on sex in *E. leukon* leads to differential molting in the individual, as demonstrated, and technically speaking gives rise to the possibility of two life cycle stages being represented together in one individual at one time. The mature individual would be a subimago with respect to its female portion and an adult with respect to its male portion. We suggest such an individual may be termed an "interstage." This biological oddity, as represented by the gynander described here, may, however, never fully develop, since the abdomen, being devoid of median longitudinal sutures, may be incapable of differential molting in correspondence to its bilateral sexual orientation. In contrast to thoracic molting, subimaginal molting of the abdomen may be an all or nothing proposition.

#### LITERATURE CITED

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