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Exuviation of Subimaginal Ephemeroptera in Flight¹

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Before the nuptial flight takes place the unique subimaginal stage of the Ephemeroptera must exuviate to become an imago. However, there are some exceptional forms in which this final exuviation does not occur. In *Plethogenesia* both males and females mate and die as subimagos; while in some other examples, only the male molts to become an imago, as in *Ephoron* and *Tortopus*. The subimaginal stage may last as little as five minutes, in which case it is rather remarkable in that the insect must exuviate twice within a five-minute period. Usually the exuviation of the subimago takes place with the insect resting upon vegetation or the walls of buildings, but some forms exuviate in flight.

McLachlan (1880; Ent. Mon. Mag.) and Grandi (1947; Boll. Ist. Ent. Univ. Bologna, 16: 215) have observed exuviation in flight in *Oligoneuriella rhenana* (Imhoff), and Edmunds (1951; Proc. Ent. Soc. Wash., 53: 330) has reported on the same phenomenon in the life of *Lachlania powelli* Edmunds. Both of these mayflies belong to the remarkable family Oligoneuriidae in which the subimaginal skin is shed from all parts of the body *except the wings*. It is therefore only a partial exuviation and is apparently a special adaptation which allows the exuvium to be shed without interrupting the flight. In the one oligoneuriid, *Lachlania*, that I have observed in its nuptial flight, the mayflies never stopped flying from the time of emergence from the nymphal stage until they dropped to the water in a spent condition more than three hours later. At no time was any individual seen to alight—in fact when specimens were knocked to the ground in my attempt to net them they were unable to get back into the air. It is highly probable that all of the subfamily Oligoneuriinae of the Oligoneuriidae have a partial exuviation in flight, but this may not be true of the Pseudoligoneuriinae (*Pseudoligoneuria* and/or *Chromarcys*).

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Burks (1953; Bull. Ill. Nat. Hist. Surv., 26 (Art. 1): 7, 33, 45-47) has now reported exuviation in flight for four additional genera of mayflies that are not members of the Oligoneuriidae, *Ephoron* (Polymitarcidae, Polymitarcinae), *Tortopus* (Polymitarcidae, Campsurinae), *Caenis* (Caenidae), and *Tricorythodes* (Tricorythidae). The males of *Ephoron* and *Tortopus* and both males and females of *Tricorythodes* shed the subimaginal exuvium from all parts of the body, *including the wings*. This is true also in both sexes of *Caenis* except that the pellicle is retained on the tails. Thus it is obvious that if exuviation takes place in flight the mayfly must stop flying during the time the wings are being pulled free of the subimaginal exuvium. Presumably the insect would have to get high enough in the air to undergo a period of free fall while the wings are freed from the subimaginal pellicle.

Burks (loc. cit.) does not state whether his observations on the males of *Ephoron* apply to *E. album* (Say), *E. leukon* Williamson, or to both. In studying *Ephoron album* in Utah, Edmunds, Nielsen, and Larsen (1956; Wasmann Jour. Biol., in press) found that the male subimago alights for a period of 50 to 80 seconds to shed the subimaginal skin.

The only species of *Caenis* known to occur in Utah appears to be conspecific with the typical *Caenis simulans* McDunnough, which is the species Burks observed in Illinois. On June 30, 1954, I made a field trip to Haynes Lake near Salt Lake City for the purpose of observing subimaginal exuviation in *Caenis simulans*. I was unable to observe any case of exuviation in flight but was able to observe hundreds of specimens of both sexes of *Caenis simulans* exuviating while at rest. The leeward side of my automobile was nearly covered with the cast exuvia.

The difficulty of shedding the exuvium from the wings in flight and my own observations of *Ephoron album* and *Caenis simulans* exuviating while at rest lead me to suspect that Dr. Burks might have been deceived by mayflies dropping the exuvium in flight only after the major part of exuviation had taken place while the mayflies were at rest. Lyman (1955; Ann. Ent. Soc. Amer., 48: 389) has come to a similar con-

clusion from his observations on the exuviation of *Caenis simulans* in Michigan. The males of *Ephoron album* usually fly from their resting place as soon as the wings are free and the cast exuvium is carried into the air where it may continue to cling to the cerci for a minute or two. Thus it is often that one sees the cast skin dropped from the insect in flight. Although I have not observed this in *Caenis simulans*, Lyman (1955: loc. cit.) has reported it, and I have seen the exuvia on the surface of a pond where they were dropped by the flying insects. I am unable to comment on the subimaginal exuviation of *Tortopus* and *Tricorythodes*, but additional observations on these two genera are desirable to determine with greater certainty the method of exuviation of the subimago.