

**RELATIONSHIPS OF *EDMUNDSIUS* DAY  
(EPHEMEROPTERA: SIPHLONURIDAE), WITH NOTES  
ON EARLY INSTAR LARVAE AND EGGS**

M. D. MEYER<sup>1</sup>, W. P. MCCAFFERTY<sup>1</sup>, & E. L. SILLDORFF<sup>2</sup>

<sup>1</sup>Department of Entomology, Purdue University, West Lafayette, Indiana 47907

<sup>2</sup>Department of Ecology, Evolution, and Marine Biology, University of California,  
Santa Barbara, California 93106

*Abstract.*—The presence of the synapomorphic copulatory pouch in the alate females of the California genus *Edmundsius* Day confirms its placement in the Siphonuridae *sensu stricto*. Superficially similar larval maxillae in *Edmundsius* and the Japanese genus *Dipteromimus* McLachlan (Dipteromimidae) are apparently convergent. The presence of the synapomorphic double gills 1 and 2 in the mature larvae of *Edmundsius* furthermore indicates placement in the Siphonurinae *sensu stricto*. Young larvae can only be distinguished from those of *Siphonurus* Eaton by the key character involving relative lengths of the claws, and the first description of the egg of *Edmundsius* shows it to be similar to those of *Siphonurus*.

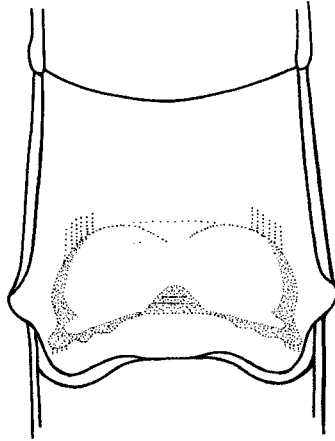
*Key Words.*—*Edmundsius*, higher classification, egg, copulatory pouch.

---

Many of the traditional subfamilies of Siphonuridae and certain generic complexes within Siphonurinae have recently been placed as separate families in the suborder Pisciforma (McCafferty 1991b), or superfamily Siphonuroidea (Kluge et al. 1995). For example, in the Holarctic Region, Ameletidae and Acanthametropodidae previously constituted a generic complex in Siphonuridae and a separate subfamily of Siphonuridae, respectively (e.g., see Edmunds et al. 1963). The previous siphonurid subfamily Isonychiinae, however, is now recognized as the family Isonychiidae in the suborder Setisura, or superfamily Heptagenioidea (McCafferty 1991a, b). Transitions in higher classification with respect to the North American fauna were outlined in McCafferty (2001).

Kluge et al. (1995) removed the monobasic Japanese genus *Dipteromimus* McLachlan from the Northern Hemisphere family Siphonuridae *sensu stricto* and placed it in a new family Dipteromimidae. These authors continued to include the monobasic California genus *Edmundsius* Day, the Holarctic genus *Parameletus* Bengtsson, the monobasic northeastern North American genus *Siphonisca* Needham, and the essentially Holarctic genus *Siphonurus* Eaton in the recently restricted concept of Siphonuridae. Kluge et al. (1995) furthermore placed *Siphonurus* in the restricted concept of a subfamily Siphonurinae, and placed *Parameletus* and *Siphonisca* in a new subfamily Parameletinae. The authors had not been able to study material of *Edmundsius*, and could not place it definitively in one of those subfamilies, but surmised it would be found to be a member of the Siphonurinae *sensu stricto*.

Day (1953), however, had suggested that his genus *Edmundsius* was possibly related to *Dipteromimus* because the maxillary palps were similar in the two genera. This was based on the more complete description of *Dipteromimus* that had been given by Uéno (1931). Edmunds (personal communication) had continued to recognize this possibility in the absence of other comparative data, and had remained open to the possibility that *Dipteromimus* and *Edmundsius* were sister lineages.



### 1

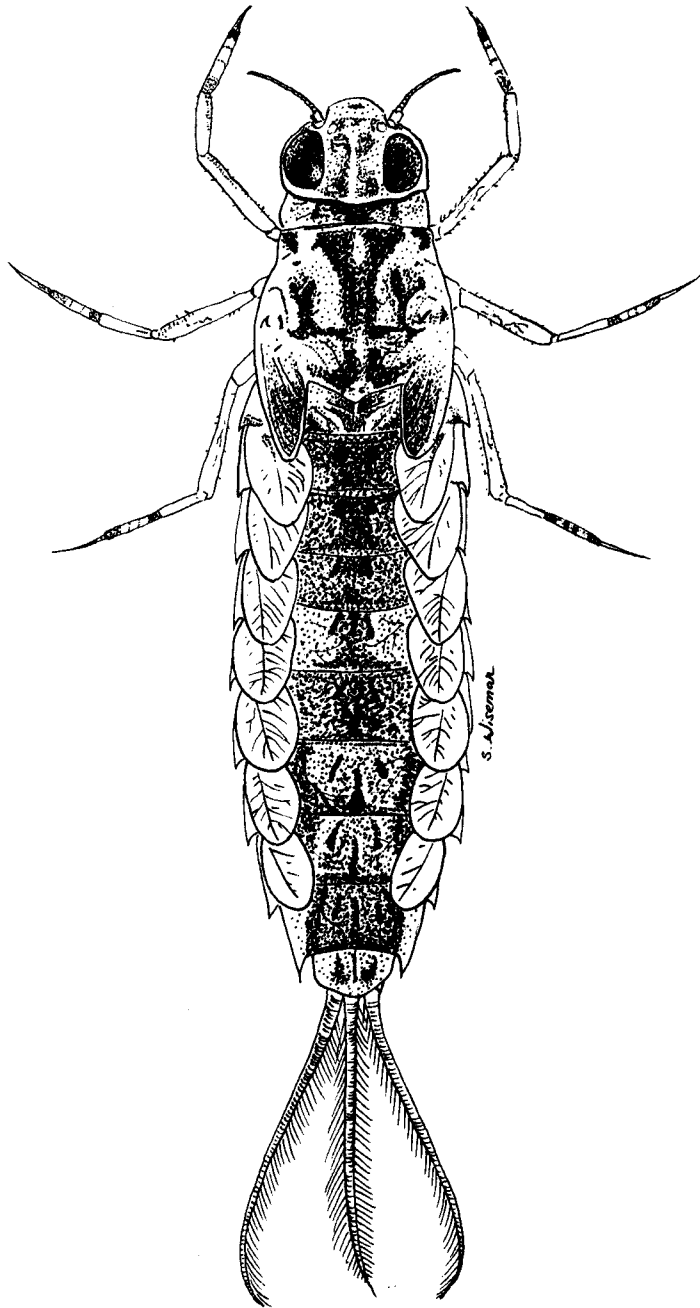
Figure 1. *Edmundsius agilis* female adult, abdominal sternum 7 with underlying outline of copulatory pouch.

We have recently studied Day's (1953) original larval, male and female subimagos and adult material, in addition to considerable new collections of larvae in different developmental phases from three counties in California. This has allowed us to confirm the family classification of *Edmundsius* and determine its subfamilial relationships based on the characters introduced by Kluge et al. (1995), to note important differences between early and late instar larvae, and to provide the first description of the egg stage.

#### HIGHER CLASSIFICATION

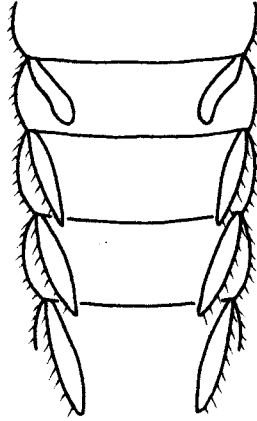
One of the characteristics that Kluge et al. (1995) identified as being associated with the restricted concept of Siphonuridae can clearly be deemed a defining synapomorphy. It involves the presence of a sclerotized copulatory pouch (Fig. 1) [see also Figs. 9–14 (Kluge et al. 1995)] that is associated with the female adult. We have not seen this structure in any other alate females of Ephemeroptera, and therefore consider it a unique attribute of the Siphonuridae. We confirmed the presence of this pouch in the alate female specimens of *Edmundsius* that we examined. As these specimens had been in alcohol preservative for some years, some clearing of the ventral abdominal cuticle had occurred and the pouch was easily observed through the outer wall of abdominal sternum 7. We also noted the presence of the pouch in the female subimago, although Kluge et al. (1995) had emphatically claimed that the copulatory pouch could only be found in adults and not subimagos. Our examination of *Siphonurus* subimagos that had been preserved in alcohol for some time also indicated the presence of the copulatory pouch, and we presume this to be the case for the other Siphonuridae. It may be that the longer times of preservation and associated clearing of our subimagos makes them more amenable to observing internal structures through the integument.

In any case, the shared presence of the female copulatory pouch clearly places *Edmundsius* in family Siphonuridae, rather than Dipteromimidae. A characteristic of the genus *Dipteromimus* that might qualify as an autapomorphy is the development of



2

Figure 2. *Edmundsius agilis*, larval habitus.



### 3

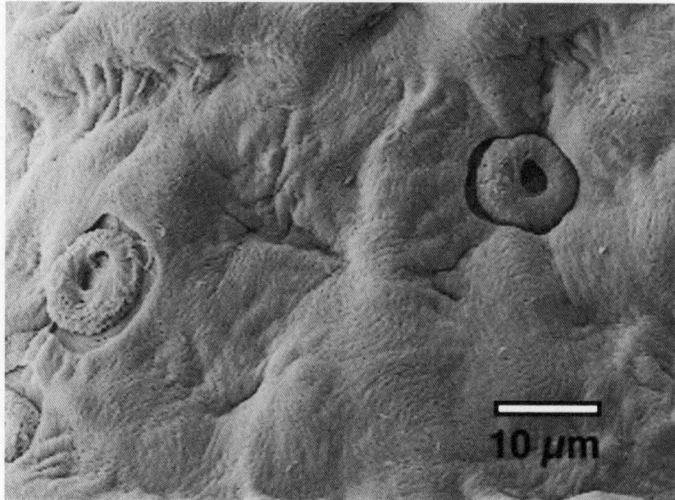
Figure 3. *Edmundsius agilis*, early instar larva, base of dorsal abdomen.

a median process on the subanal plate of the female adult as described by Kluge et al. (1995). *Edmundsius* does not share such a characteristic. As Day (1953) had pointed out, *Edmundsius* and *Dipteromimus* do share a maxilla that has a relatively long palp compared to the galealacinia. We interpret this as a case of convergence, however, mainly because the long palps are fundamentally different in the two genera. In *Edmundsius*, segment 3 of the maxillary palp is very short compared to elongated segments 1 and 2, and in *Dipteromimus*, segment 2 is shortest [Fig. 9 (Day 1953) and Fig. 28E (Uéno 1931)].

With respect to subfamilial placement of *Edmundsius*, it is significant that middle to late instar larvae of *Edmundsius* share the double gills 1 and 2 with those of *Siphonurus*, and this could be interpreted as a defining synapomorphy for the subfamily Siphonurinae. We also have confirmed that *Edmundsius* female adults do not have abdominal sternum 8 medially extended anteriorly between the lobes of the copulatory pouch [Figs. 12–14 (Kluge et al. 1995)], a characteristic that could be interpreted as synapomorphic for the subfamily Parameletinae, being present in *Parameletus* and *Siphonisca*. We therefore are able to place *Edmundsius* in the subfamily Siphonurinae *sensu stricto*.

#### LARVAL VARIABILITY

Although mature larvae and adults of *Edmundsius* can be identified using the keys of Edmunds et al. (1976) and Edmunds & Waltz (1996), young larvae of *Edmundsius* and *Siphonurus* cannot be distinguished in existing keys to North American genera in the same way. Middle to late instar larvae of *Edmundsius* have oval abdominal gills 1 and 2 (Fig. 2), whereas middle to late instar larvae of *Siphonurus* have subtriangular gills 1 and 2 [Fig. 11.35 (Edmunds & Waltz 1995)]. These particular characteristics, however, are not applicable to young instar larvae because gill 1 and 2 are not developed (Fig. 3). The secondary characteristic of mid- and hindclaws being much longer than the foreclaws in *Edmundsius* (Fig. 2) does hold up in early to late instar larvae and can be used to



## 4

Figure 4. Scanning electron micrograph of egg chorion of *Edmundsius agilis*. (Scale bar represents 10  $\mu$ m).

distinguish them from early to late instar larvae of *Siphonurus*. The latter have mid- and hindclaws that are only slightly longer than the foreclaws.

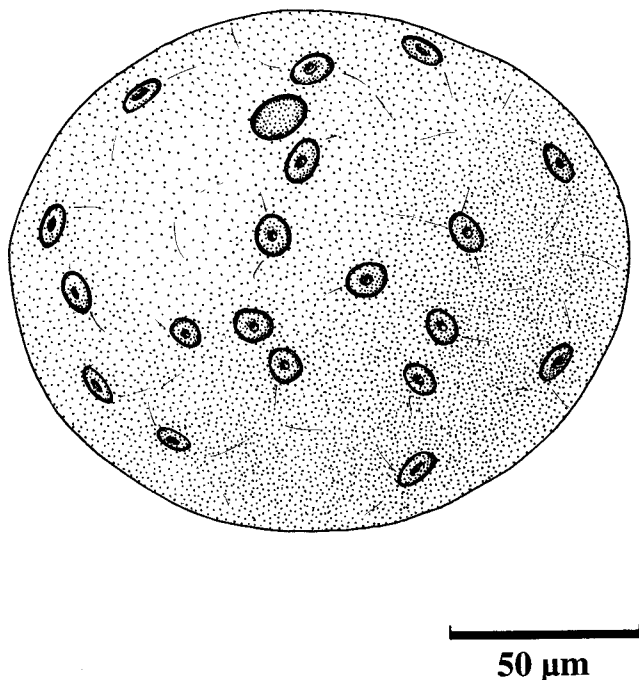
## DESCRIPTION OF THE EGG

The egg of *Edmundsius* (Figs. 4–5) is ovate and approximately 210  $\mu$ m in length and 150  $\mu$ m at its greatest width. The chorion has randomly scattered attachment discs, or what Koss & Edmunds (1974) more specifically have referred to as fiber coils with terminal fiber clusters. As such, the egg of *Edmundsius* appears very similar to those described and illustrated for *Siphonurus croaticus* Ulmer by Studemann et al. (1988). They are also generally similar to all of the *Siphonurus* eggs treated by those authors, as well as Kluge et al. (1995). This may possibly add credence to the classification of *Edmundsius* in the subfamily Siphonurinae, although there is no indication whether such a chorion is synapomorphic or symplesiomorphic at this time.

## MATERIAL EXAMINED

The following material of *E. agilis* Day were deposited in the following collections: The California Academy of Sciences, San Francisco, CA (CAS); Natural History Museum of Los Angeles County, Los Angeles, CA (NHLA); the Purdue Entomological Research Collection, West Lafayette, IN (PERC); and the University of California at Santa Barbara, Santa Barbara, CA (UCSB).

*Madera Co*: Willow Cr, VII-1951, WC Day, larvae (NHLA), larvae, male adult & subimago (PERC), male & female adults, male & female subimagos (CAS); North Willow Cr, VI-2001, X-2001, 7800', EL Silldorff, larvae (PERC). *Mariposa Co*: unnamed tributary of Cascade Cr, IX-2000, VIII-2001, 6440'–7200', EL Silldorff, larvae (PERC); unnamed tributary of Cascade Cr in Yosemite Natl Prk, IX-2000, 6400', EL Silldorff, larvae (PERC); unnamed tributary of Illilouette Cr, VIII-2001, EL Silldorff, larvae (PERC); unnamed tributary of Crane Cr in Yosemite Natl Prk, IX-2000, EL Silldorff, larvae (UCSB).



5

Figure 5. Whole egg of *Edmundsius agilis*. (Scale bar represents 50  $\mu$ m).

*Fresno Co*: Providence Cr, VI-2002, SD Cooper & DB Herbst, larvae (UCSB); Bull Cr, VI-2002, SD Cooper & DB Herbst, larvae (UCSB).

#### ACKNOWLEDGMENTS

We thank L. Sun (West Lafayette, IN) for his assistance with the egg illustration and SEM image, and S. Wiseman (Santa Barbara, CA) for the larval habitus drawing. This research was supported in part by a NSF grant DEB-9901577.

#### LITERATURE CITED

- Day, W. C. 1953. A new mayfly genus from California (Ephemeroptera). *Pan-Pac. Entomol.*, 29: 19–24.
- Edmunds, G. F. Jr. & R. D. Waltz. 1996. Ephemeroptera, pp. 126–163. *In* Merritt, R. W. & K. W. Cummins (eds.). *An introduction to the aquatic insects of North America*. Kendall/Hunt, Dubuque, Iowa.
- Edmunds, G. F. Jr., R. K. Allen & W. L. Peters. 1963. An annotated key to the nymphs of the families and subfamilies of mayflies (Ephemeroptera).(?) *Univ. Utah Biol. Ser.*, 23(1):1–49.
- Edmunds, G. F. Jr., S. L. Jensen & L. Berner. 1976. *The Mayflies of North and Central America*. Univ. Minnesota Press, Minneapolis.
- Kluge, N., D. Studemann, P. Landolt & T. Gonser. 1995. A reclassification of Siphonuroidea (Ephemeroptera). *Bull. Soc. Entomol. Suisse*, 68: 103–132.
- Koss, R. W. & G. F. Edmunds. 1974. Ephemeroptera eggs and their contribution to phylogenetic studies of the order. *Zool. J. Linn. Soc.*, 55: 267–349.
- McCafferty, W. P. 1991a. The cladistics, classification, and evolution of the Heptagenioidea (Ephemeroptera). pp. 87–102. *In* Alba-Tercedor, J. & A. Sanchez-Ortega (eds.). *Overview and strategies of Ephemeroptera and Plecoptera*. Sandhill Crane Press, Gainesville, Florida.

- McCafferty, W. P. 1991b. Toward a phylogenetic classification of the Ephemeroptera (Insecta): a commentary on systematics. *Ann. Entomol. Soc. Am.*, 84(4): 343–360.
- McCafferty, W. P. 2001. The gentle quest: 200 years in search of North American mayflies. pp. 21–35. *In* Domínguez, E. (ed.). *Trends in research in Ephemeroptera and Plecoptera*. Kluwer Academic/Plenum, New York.
- Studemann, D., P. Landolt & I. Tomka. 1988. Morphology and taxonomy of imagines and eggs of central and northern European Siphonuridae (Ephemeroptera). *Bull. Soc. Entomol. Suisse*, 61: 303–328.
- Uéno, M. 1931. Contributions to the knowledge of Japanese Ephemeroptera. *Annot. Zool. Japan*, 13: 189–231.

*Received 22 Apr 2003; Accepted 19 Sep 2003.*

PUBLICATIONS OF THE  
PACIFIC COAST ENTOMOLOGICAL SOCIETY

continued from page 99

Volume 3. *Revisionary Studies in the Nearctic Decticinae* by David C. Rentz and James D. Birchim. 173 pages. Published July 1968. Price \$4.00\* (plus \$0.75 postage and handling).

Volume 4. *Autobiography of an Entomologist* by Robert L. Usinger. 343 pages. Published August 1972. SPECIAL PRICE \$5.00 (plus \$1.00 tax, postage, and handling for California orders; \$0.70 postage and handling for non-California U.S. orders, or \$1.70 for foreign orders). No members discount at this special price.

Volume 5. *Revision of the Millipede Family Andrognathidae in the Nearctic Region* by Michael R. Gardner. 61 pages. Published January 21, 1975. Price \$3.00\* (plus \$0.75 postage and handling).

\*For California orders only, add appropriate sales tax currently in effect in your county. If requested, members of the Society can receive a 20% discount on the price of the memoirs, except for vol. 4.

Send orders to:

Pacific Coast Entomological Society  
c/o California Academy of Sciences  
Golden Gate Park  
San Francisco, California 94118-4599  
U.S.A.