CLOEODES HYDATION, N. SP. (EPHEMEROPTERA: BAETIDAE): AN EXTRAORDINARY, DROUGHT TOLERANT MAYFLY FROM BRAZIL[1]

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ABSTRACT: The baetid mayfly *Cloeodes hydation*, n. sp., is described from larvae and adults from Mato Grosso, Brazil. It is the first species of the genus *Cloeodes* known from Brazil. It is most similar to the Paraguayan species *C. irvingi*. These species are shown to be intermediate in character to what have been considered different subgenera, and thus, subgeneric classification is no longer recognized, and the subgenus *Notobaetis* is suppressed. The new species can live in temporary pools, and it is the first mayfly shown to withstand diel drying conditions.

A baetid mayfly along with the chironomid midge *Apedilum elachistus* Townes were found to be the dominant benthic species in a highly dynamic habitat of small temporary rock pools in central Brazil. The two species were discovered during studies conducted on the Rio Bento Gomes intermittent tropical river system in Mato Grosso, Brazil by an ecological research team headed by Dr. Ulrike Nolte. Upon contacting us with regard to the identification of these mayflies, we found them to be a new, undescribed species of *Cloeodes* Traver, a genus of Baetidae that until recently has been very poorly known, but is proving to be a major group of mayflies in the American tropics and subtropical areas (Waltz and McCafferty 1987a, 1987b; Kluge 1991; Lugo-Ortiz and McCafferty 1993, 1994; Waltz 1993). Although known only from Puerto Rico (Traver 1938) for many years, *Cloeodes* is now known from central Argentina to southwestern United States and southeastern Asia, and it was recently discovered in South Africa (Waltz and McCafferty 1994), indicating a somewhat pantropical distribution pattern.

Besides being the first species of *Cloeodes* discovered from Brazil, the new species, described below, demonstrates some exceptional attributes with respect to known biology of mayflies. Most remarkable is an ability to withstand repeated drying conditions—larvae being able to survive in dried ephemeral pools up to nine hours before rehydration takes place. This observation of drought tolerance, made by Nolte and his colleagues in Brazil, apparently represents the first demonstration of such an adaptation in mayflies. Little is known about the biology of other species of *Cloeodes,* and thus we do not know if this phenomenon is more widespread in the genus, or for that matter, other tropical mayflies. The biology and mode of drought tolerance for the new *Cloeodes* species in Brazil have now been studied in detail,

[1] Received August 22,1994. Accepted September 12,1994.

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and comprehensive ecological and phenological information on the species has been accumulated.

The purpose of this paper is to describe and make available a name for this new species of *Cloeodes*. Although brief habitat characterization is included here along with detailed comparative morphology, the substantial quantitative treatment of life history and ecological data associated with this species will be forthcoming in a paper being prepared by Nolte, Tietböhl, and McCafferty.

Cloeodes hydation, new species

Mature larva. Body length 3.4-4.7 mm (females generally larger than males); terminal filaments 1.5-2.2 mm. Head capsule dorsally brown between compound eyes, with some scattered light flecks and light median longitudinal stripe ranging from very thin and almost imperceptible to broad as in Figure 1, and continuing anteroventrally on frons to about level of antennal sockets; median ocellus small, round, and highlighted by median longitudinal light stripe of head capsule. Frons not developed into intra-antennal process. Antennae nearly half length of body (Fig. 1); scape and pedicel of antennae with few or no small, blunt, spinelike setae. Labrum (Fig. 2) with 1 + 1-3 elongate, dorsal hairlike setae and 4-5 lateral submarginal short, spinelike setae, and with most anterior marginal setae plumose. Right mandible as in Figure 3, with setal tuft at base of molar well developed, and prostheca highly branched apically. Left mandible as in Figure 4, with median process below molar well developed, elongate, and rounded apically. Maxillary palps (Fig. 5) long, slightly exceeding galealaciniae, with slightly discernible indication of segment 3; galealaciniae (Fig. 5) with 1 + 4-5 dorsal setae. Segment 2 of labial palps (Fig. 6) with 5-6 dorsal setae; segment 3 obliquely truncate apically; paraglossae (Fig. 6) with 4-5 inner marginal setae medioapically and 4-7 ventral inner marginal setae; glossae (Fig. 6) with 12-15 inner marginal setae.

Pronotum (Fig. 1) light, with pair of brown lateral stripes extending from posterior margin but not reaching anterior margin and with several other variable brown dashes or irregular maculae. Mesonotum variously marked with brown (Fig. 1). Minute hindwingpads present. Legs patterned similar to that shown in Figure 1, with median femoral band weaker ventrally especially on mid- and hindfemora, and generally weaker or absent in younger individuals. Trochanters without bristles or long, hairlike setae. Femora with two blunt, sublanceolate setae apically (Fig. 7). Tibiae with arc of fine, hairlike setae transverse and restricted to basal area, and with subtending blunt sublanceolate seta as in Figure 8. Tarsi with ventral row of small, spinelike setae, and with some fine, hairlike setae dorsally.

Abdominal color pattern highly variable. Terga 4, 5, and 8 usually lighter than others; terga 9 and anterior half of 10 usually dark; terga 2 and 6 often darkest; darker terga with light lateral patches. Sterna mostly light, although sterna 9 with dark borders and light medial area in mature specimens; other posterior sterna sometimes variously darkened laterally or anterolaterally. Abdominal segments 5-10 with short series of spines at extreme lateral aspect of posterior margin, becoming continuous with entire posterior row of spines. Terga 3 with 38-48 triangular, median posterior marginal spines (length of spines greater than basal width). Sterna 9 of male with 14-18 spines at median posterior margin. Gills largest anteriorly, becoming progressively smaller posteriorly (Fig. 1). Terminal filaments with darkened band subdistally (Fig. 1).

Male adult. Body length 3.9-4.2 mm; forewing 3.8-4.0 mm; hindwing 0.4-0.6 mm. Body coloration uniformly cream except darker thoracic suture lines and slight abdominal shading laterally on terga. Antennae with scape slightly longer than pedicel, and flagella subequal to or slightly longer than length of turbinate portion of compound eyes. Turbinate portion of compound eyes oval as in Figures 9 and 10, with relatively short but distinctly divergent stalks.

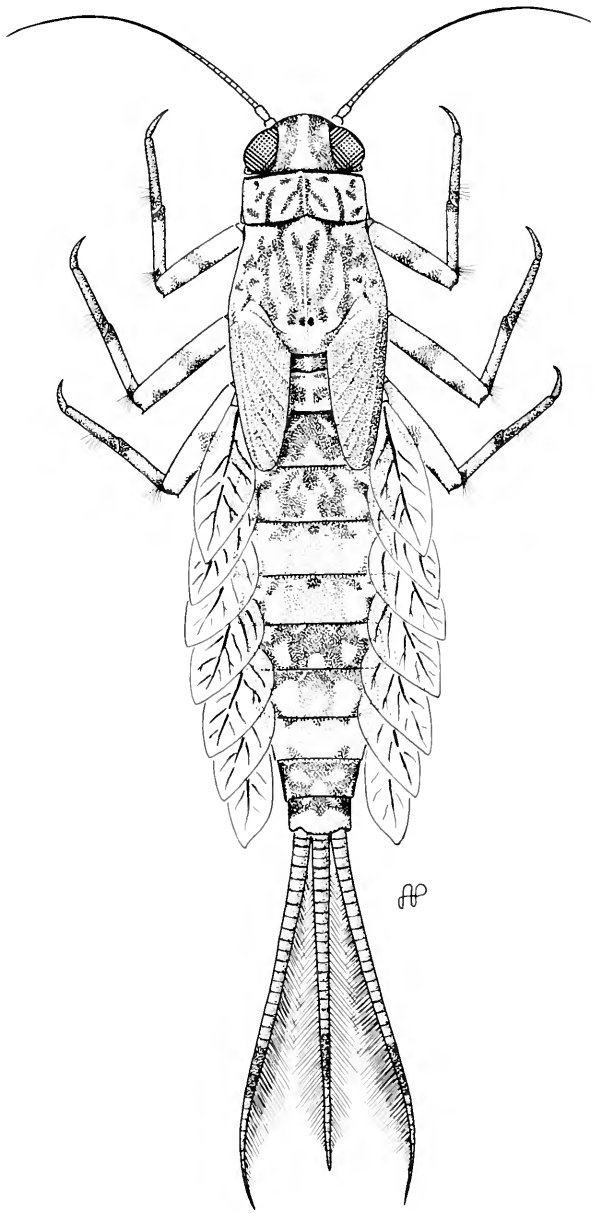


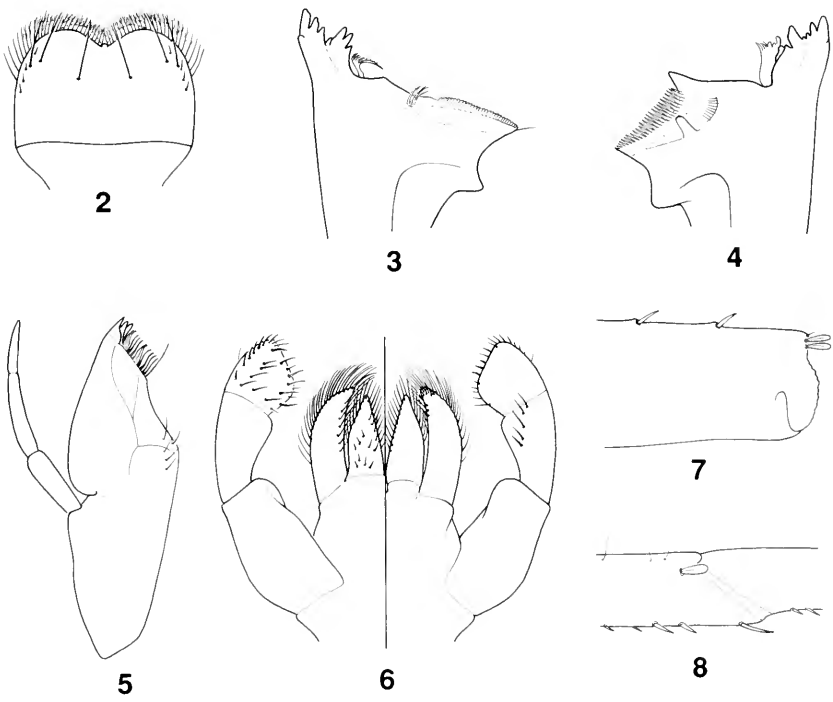
Fig. 1. *Cloeodes hydation* larva.

Wings clear except translucent anterodistally as shown in stippled area of Figure 11. Basal costal margin with low, intermittent, sharp spines as seen in blow-up insert of Figure 11; stigmatic crossveins of forewings either complete or with one or more crossveins incomplete (Fig. 11); marginal intercalaries of forewings beginning in R_1-R_2 cell, and sequenced in each cell as short-long/long-short/short-long/etc. so that juxtaposed intercalaries from different but adjacent cells are either relatively short or long and alternate with next juxtaposed pair (Fig. 11). Hindwings as in Figure 11.

Abdominal terga slightly shaded with triangular patches in extreme lateral aspect. Genitalia as in Figure 12.

Female adult similar to male description above, except lacking turbinate eyes and genitalic characters.

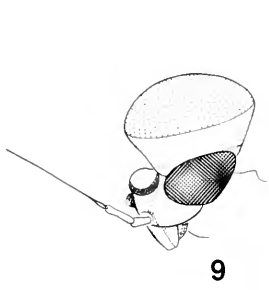
Material. HOLOTYPE: male larva (in alcohol), Brazil, Mato Grosso, Fazenda Campo Alegre, spring pools of tributary of Rio Bento Gomes (15°75′S, 56°55′W), U. Nolte, 11-1992, deposited in the collection of the Entomological Collection of the Federal University of Cuiabá, Mato Grosso, Brazil. PARATYPES: 5 larvae and 3 male adults (some dissected parts slide mounted in euporal), same locale data as holotype, deposited in Purdue Entomological Research Collection (PERC), West Lafayette, Indiana. Other material examined consisted of numerous larvae, additional male adults, female adults, and male and female subimagos, all taken from the

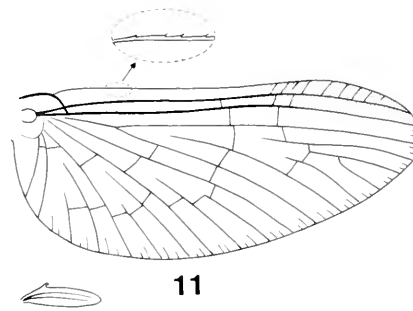


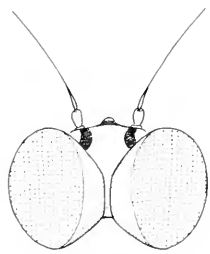
Figs. 2-8. *Cloeodes hydation* larva. 2. Labrum, dorsal. 3. Right mandible. 4. Left mandible. 5. Maxilla. 6. Labium (left: ventral, right: dorsal). 7. Forefemora, apex. 8. Foretibia, apex.

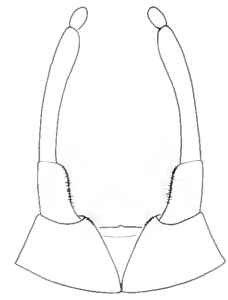
same locality and numerous larvae taken subsequently from the adjacent spring tributary of the Rio Bento Gomes itself. The non-type material examined is deposited in PERC.

Etymology. The specific epithet "hydation" is a noun in apposition taken from the Latin meaning little water, an allusion both to the habitat of the species and its propensity for drought tolerance.









Figs. 9-12. *Cloeodes hydation* male adult. 9. Head, lateral. 10. Head, dorsal. 11. Fore-and hindwing. 12. Genitalia, ventral.

DISCUSSION

Waltz and McCafferty (1987b) divided the genus *Cloeodes* into two subgenera: *Notobaetis* Morihara and Edmunds and *Cloeodes* s.s. Only the rather distinctive species *C. penai* (Morihara and Edmunds) was included in *Notobaetis. Cloeodes hydation* larvae share many of the distinctive characteristics originally associated with *C. penai* and *Notobaetis:* relatively long antennae, relatively long maxillary palps, and obliquely truncate apices of labial palps. *Cloeodes hydation* larvae, however, also possess a characteristic that was associated with *Cloeodes* s.s. larvae, i.e., the absence of serrate margined bristles on the femora. In addition, the adults of *C. hydation* also possess charac-

teristics that were attributed to one or the other subgenus—sharing the more anteriorly placed paired marginal intercalaries in the forewings and a low stalk of the turbinate portion of the compound eyes with *C. penai,* but having incomplete stigmatic crossveins in the forewings and a somewhat basally positioned costal process of the hindwings, which are typical of species placed in *Cloeodes* s.s. We have also discovered that the Paraguayan species *C. irvingi* Waltz and McCafferty (known only from larvae) demonstrates some intermediacy between *C. penai* and other species that had not been recognized before. In particular, the apices of the labial palps are atypical of all other species previously placed in *Cloeodes* s.s., the length of the antennae is intermediate between the two extremes found, and the length and segmentation of the maxillary palps are intermediate between the longer, three-segmented condition of *C. penai* and *C. hydation* and that of the shorter, two-segmented condition found in most other species. Given the distribution of character states discussed above, the intermediacy of *C. hydation* and *C. irvingi,* especially the intermediate combination of character states found in the adults of *C. hydation,* and the fact that the antennal length character differs even in the two very closely related species *C. hydation* and *C. irvingi,* we can no longer justify maintaining two subgenera in the genus, and we therefore suppress the subgenus *Notobaetis.*

Similarities and differences between *C. hydation* and *C. penai* can be seen from the discussion above. Those species are also strikingly different in size, coloration, and many other more subtle characters. The only species with which *C. hydation* could be confused is *C. irvingi.* The color pattern is somewhat similar in certain individuals of the two species, but color pattern is also similar in some other species of *Cloeodes* (see Waltz and McCafferty 1987b), and we do not consider it a critical character. The dorsal background color is distinct in the two species, with that of *C. hydation* being cream, or beige, and that of *C. irvingi* being brown. *Cloeodes irvingi* also appears to be a bit larger than *C. hydation;* however, the approximately 1 mm difference in the two could certainly be within a range of variability. The most dramatic structural difference between the two species is the larval antennal size. Antennae are about twice the frontal length of the head capsule in *C. hydation* and about one and one half times the length of the frontal head capsule in *C. irvingi.* We assume from the close similarity of the two species that they are closely related, possibly sister species. We also assume that adults of the two will prove to be similar. The striking biological adaptations of *C. hydation* could possibly also be found in *C. irvingi,* but little is known of the habitat of the latter species.

Cloeodes hydation was originally taken in samples from small temporary rock pools adjacent to a tributary to the Rio Bento Gomes, an intermittent lowland tropical river in the southern part of the state of Mato Grosso, Brazil.

This river is one of the principal tributaries (one of approximately 200-250 springs) discharging into the northern Pantanal. The degree to which the tributary and pools are intermittent is dependent on local precipitation, which varies considerably during the year. Subsequent to *C. hydation* being taken from the rock pools, it was also found in both depositional and erosional habitats in the tributary itself. During the rainy season (December to April), the species goes through several generations in the pools, while in the tributary it occurs throughout the year. Generation time can be extremely short (18 days), and larvae are able to withstand temporary daily drying conditions in these pools. As pointed out above, details of physical and chemical habitat parameters as well as details of behavior and phenology will be treated in a subsequent paper.

ACKNOWLEDGMENTS

We thank Ulrike Nolte (currently guest lecturer and researcher, Universidade Federal de Mato Grosso, Brazil) for providing specimens and invaluable data, Arwin Provonsha (biological illustrator, Purdue University, West Lafayette) for providing drawings of the new species, and Bob Waltz (Head, Division of Entomology, Indiana DNR, Indianapolis) for some of the material preparation, and commenting on the manuscript. This paper has been assigned Purdue Agricultural Research Program Journal No. 14353.

LITERATURE CITED

Kluge, N. 1991. Cuban mayflies of the family Baetidae (Ephemeroptera) 1. Genera *Callibaetis, Cloeodes*, and *Paracloeodes*. Zool. Zh. 12: 128-136. [in Russian]

Lugo-Ortiz, C. R. and W. P. McCafferty. 1993. Genera of Baetidae (Ephemeroptera) from Central America. Entomol. News 104: 193-197.

Lugo-Ortiz, C. R. and W. P. McCafferty. 1994. New records of Ephemeroptera from Mexico. Entomol. News 105: 17-26.

Morihara, D. K. and G. F. Edmunds, Jr. 1980. *Notobaetis:* a new genus of Baetidae (Ephemeroptera) from South America. Int. Rev. Ges. Hydrobiol. 65: 605-610.

Traver, J. R. 1938. Mayflies of Puerto Rico. J. Agr. Univ. Puerto Rico 22: 5-42.

Waltz, R. D. 1993. *Cloeodes binocularis* (Ephemeroptera: Baetidae) a new combination for a Neotropical species of *Pseudocloeon* s. auctt. Entomol. News 104: 233-234.

Waltz, R. D. and W. P. McCafferty. 1987a. Generic revision of *Cloeodes* and description of two new genera (Ephemeroptera: Baetidae). Proc. Entomol. Soc. Wash. 89: 177-184.

Waltz, R. D. and W. P. McCafferty. 1987b. Revision of the genus *Cloeodes* Traver (Ephemeroptera: Baetidae). Ann. Entomol. Soc. Am. 80: 191-207.

Waltz, R. D. and W. P. McCafferty. 1994. *Cloeodes* (Ephemeroptera: Baetidae) in Africa. Aquat. Insects 16: 165-169.