FIRST REPORT AND NEW SPECIES OF THE GENUS *CLOEODES* (EPHEMEROPTERA: BAETIDAE) FROM AUSTRALIA[1,2]

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ABSTRACT: *Cloeodes fustipalpus*, new species, and *C. illiesi*, new species, are described from larvae from eastern Australia. The two species represent the first report of *Cloeodes* from the continent. *Cloeodes fustipalpus* is distinguished by the irregular labral setation, clublike labial palps segment 3, and abdominal color pattern. *Cloeodes illiesi* is distinguished by the bifid right prostheca with a medially setose branch, reduced maxillary palps, medially bulbous labial palps segment 3, abdominal color pattern, and narrow-elongate gills. Numerous morphological characteristics indicate that *C. fustipalpus* and *C. illiesi* are most closely related to the Afrotropical *C. inzingae* and the Oriental *C. longisetosus* and *C. soldani*. Three biogeographic scenarios are discussed that would explain the world distribution of *Cloeodes*.

Traver (1938) erected the genus *Cloeodes* (Ephemeroptera: Baetidae) for the Caribbean species *C. maculipes* Traver and *C. consignatus* Traver. The genus is distinct among small minnow mayflies because its larvae have edentate tarsal claws (Fig. 6; Waltz and McCafferty 1987b: Fig. 8), a conspicuous subproximal arc of long, fine, simple setae on the tibiae (Fig. 6; Waltz and McCafferty 1987b: Fig. 7), and setal tufts on sterna 2-6 (Waltz and McCafferty 1987a: Fig. 5; Waltz and McCafferty 1987b: Figs. 9, 44). Adults of *Cloeodes* are distinguished by having segment 2 of the male genital forceps basally bulbous and with abundant minute, fine, simple setae (Waltz and McCafferty 1987b: Fig. 34).

Cloeodes has been reported from the Afrotropics, Neotropics, Orient, and southwestern Nearctic (Traver 1938, Waltz and McCafferty 1987ab, 1994, Kluge 1991, Flowers 1991, Lugo-Ortiz and McCafferty 1993, 1994, 1995, McCafferty and Lugo-Ortiz 1995, McCafferty et al. 1997). Herein we report *Cloeodes* for the first time from Australia. The report is based on two new species described from larvae collected from Queensland and New South Wales. The specimens studied are housed in the Purdue Entomological Research Collection, West Lafayette, Indiana.

The discovery of *Cloeodes* in Australia is of considerable biogeographic interest because it is the first genus of Baetidae known to occur throughout the Southern Hemisphere. *Cloeodes* may have been widespread in Gondwanaland during the Jurassic approximately 180 million years ago (mya). Southern Hemisphere landmasses drifting to their present positions would have carried an-

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cestral species of *Cloeodes* with them. The South East Asian distribution could be explained by the northward drifting and abutment of the Indian subcontinent approximately 45 mya. The southern Nearctic distribution of the genus has been explained by northward dispersal during and after the formation of the Isthmus of Panama approximately 6-5 mya, as reviewed by McCafferty (1998). Alternatively, *Cloeodes* may have originated somewhat later on the African-Indian-South American landmass (essentially West Gondwanaland) during the Early Cretaceous approximately 140 mya. This explanation is similar to the first, except that dispersal of the genus from Asia into Australia during the Middle Miocene approximately 15 mya is assumed. A third historical explanation would have *Cloeodes* originating in Africa-South America during the Middle Cretaceous approximately 110-100 mya. At that time, however, the genus might not have been present on the Indian subcontinent, and the presence of *Cloeodes* in the Orient, Australia, and North America would all be attributed to dispersal events beginning in the Eastern Hemisphere when Africa and Eurasia reunited during the middle Miocene approximately 17 mya. Interchange between Africa and Asia in this period is consistent with some other animal groups (e.g., see Cox and Moore 1985).

We cannot at this time be sure which of these three biogeographic explanations is the most likely because only a small number of species of *Cloeodes* are known and cladistic analysis is not possible. Considerable insular evolution of the genus has occurred in South America since the isolation of that continent, as evidenced by the fact that Western Hemisphere *Cloeodes* are a closely related, distinctive grouping (Waltz and McCafferty 1987b). The fact that all species in the Eastern Hemisphere are closely related to each other (see species discussions below) would further suggest that African, Asian, and Australian lineages have dispersed relatively recently, not having been isolated from each other to the extent in which Western and Eastern Hemisphere lineages of the genus have.

Cloeodes fustipalpus Lugo-Ortiz and McCafferty, NEW SPECIES

Larva. Body length: 5.1-6.0 mm. Caudal filaments length: 2.3-2.5 mm. Head: Coloration light yellow-brown, with faint vermiform markings on vertex. Antennae approximately 1.5x length of head capsule. Labrum (Fig. 1) with submedial pair of long, fine, simple setae and submarginal row of six to eight fine, simple setae of various lengths. Hypopharynx similar to Figure 11. [Left and right mandibles (Figs. 2, 3) with outer incisors worn in material examined.] Left mandible (Fig. 2) with inner incisor with three denticles; prostheca robust, apically denticulate; minute denticles present between prostheca and mola. Right mandible (Fig. 3) with inner incisor with four denticles; prostheca somewhat slender, apically acute; minute denticles present between prostheca and mola. Maxillae (Fig. 4) with three long, fine, simple setae near medial hump; maxillary palps reaching galealaciniae; palp segment 1 approximately 0.50x length of segment 2. Labium (Fig. 5) with glossae and paraglossae equal in length; palp segment 1 approximately 0.80x length of segments 2 and 3 combined; segment 2 approximately 1.20x length of segment 3;

segment 3 bulbous, clublike (medially broader than apical width of segment 2). Thorax: Coloration pale yellow-brown, with complex markings. Hindwingpads absent. Legs (Fig. 6) cream; femora with dorsal row of five to eight long, robust, simple setae, last two almost contiguous and longer than others; tibiae with dorsal row of long, fine, simple setae; tarsi with dorsal row of long, fine, simple setae. Abdomen (Fig. 7): Coloration pale brown and cream; segment 1 cream; segment 2 pale brown, with submedial and sublateral pairs of large, oblong, cream markings; segment 3, 5, and 6 pale brown, with submedial pair of circular cream markings; segment 4 anteriorly and posteriorly pale brown, medially cream; segment 7 anteriorly pale brown, posteriorly cream; segment 8 cream; segment 9 pale brown, with semicircular anteromedial cream marking; segment 10 pale brown. Sterna cream. Gills (Fig. 8) subtriangular, well tracheated, with smooth margin. Paraprocts (Fig. 9) with 18-20 sharp marginal spines, increasing in size apically; abundant scale bases scattered over surface. Caudal filaments whitish; medial caudal filament approximately 0.80x length of cerci.

Adult. Unknown.

Material examined. Holotype: Larva, AUSTRALIA, New South Wales, Chandler R., 26 mi E of Armidale, no date, G. F. Edmunds. Paratypes: Larva, same data as holotype [mouthparts, left foreleg, gill 4, and paraproct mounted on slide (medium: Euparal)]; two larvae, AUSTRALIA, New South Wales, Bellinger R., at Bellinger, II-23-1966, G. F. Edmunds. Additional material: Three exuviae, AUSTRALIA, New South Wales, Serpentine R., New England National Park, II-19-1966, G. F. Edmunds; three larvae, AUSTRALIA, New South Wales, Bellinger R., at Bellinger, II-23-1966, G. F. Edmunds.

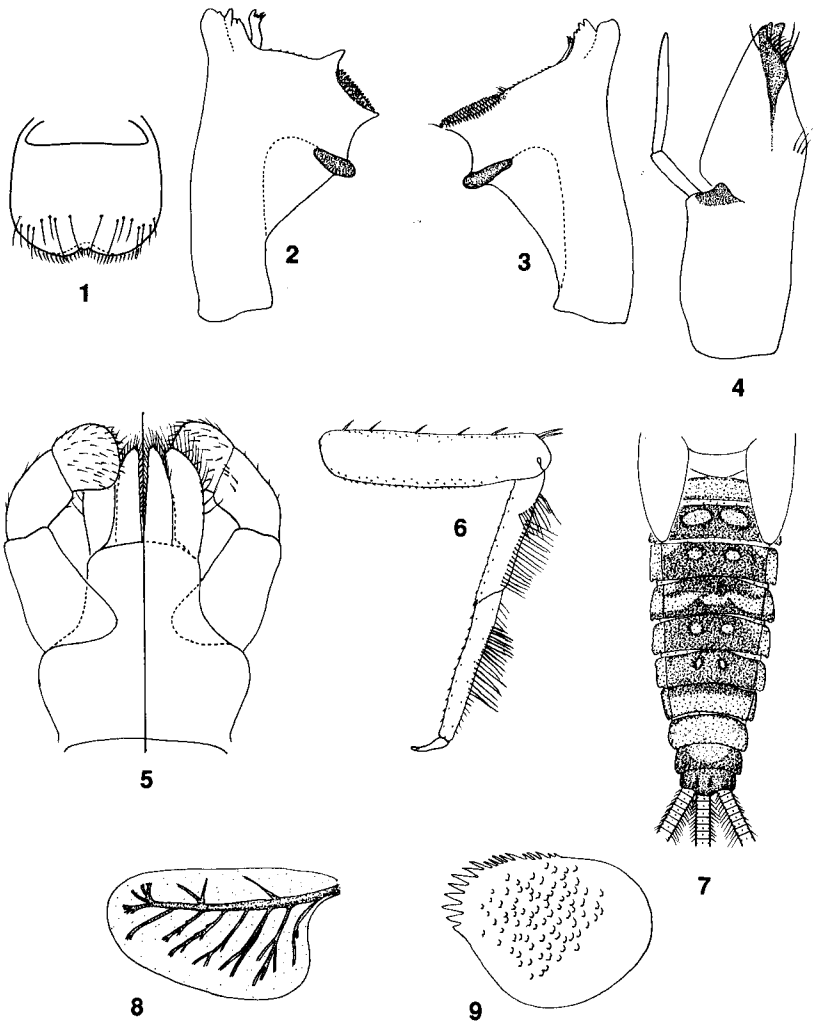
Etymology. The specific epithet is a combination of the Latin words *fustis* (club) and *palpus* (palps). It is in reference to the clublike labial palps.

Discussion. *Cloeodes fustipalpus* is distinguished from other members of the genus by the irregular setation of the labrum (Fig. 1), clublike segment 3 of the labial palps (Fig. 5), and abdominal color pattern (Fig. 7). The abdominal color pattern varies somewhat among specimens, but the most consistent is the one shown in Figure 7.

Cloeodes fustipalpus appears to be related to the Oriental species *C. longisetosus* (Braasch and Soldán) and *C. soldani* (Müller-Liebenau), the Afrotropical species *C. inzingae* (Crass), and *C. illiesi*, new species, from Australia (see below). The larvae of all these species have a bulbous labial palp segment 3 (Figs. 5, 15; Crass 1947: Fig. 9a; Braasch and Soldán 1980: Fig. 12; Müller-Liebenau 1983: Fig. 3b), well-developed rows of long, fine, simple setae on the tibiae and tarsi (Fig. 6; Braasch and Soldán 1980: Figs. 2, 3; Waltz and McCafferty 1994: Fig. 2), and lack hindwingpads.

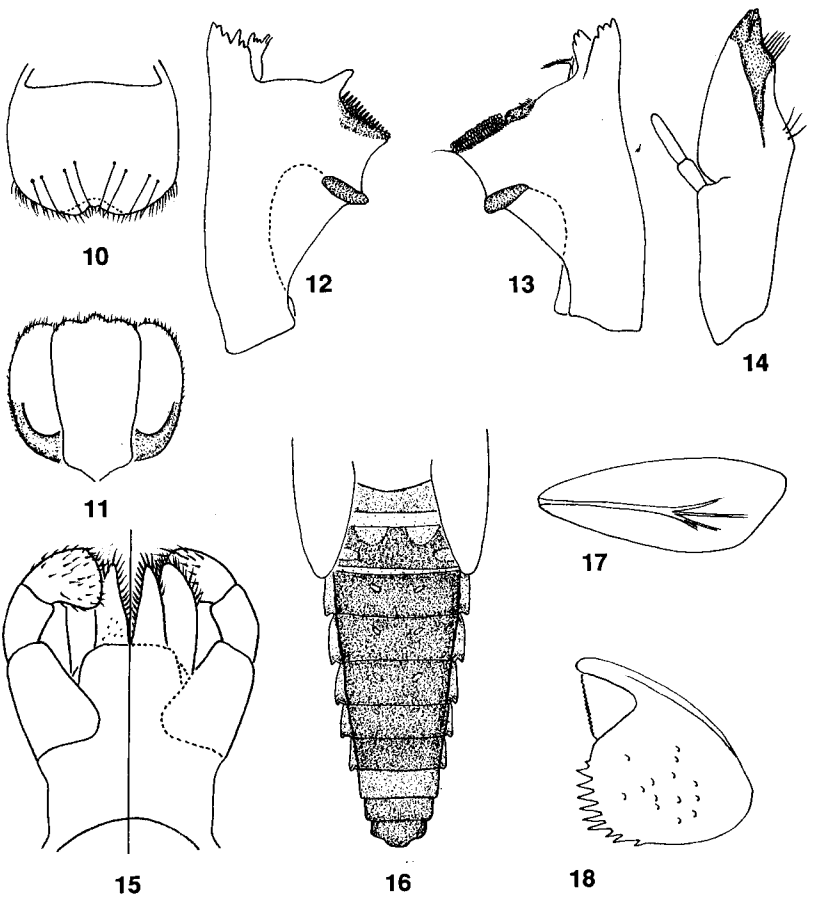
Cloeodes illiesi Lugo-Ortiz and McCafferty, NEW SPECIES

Larva. Body length: 3.9 mm. Caudal filaments length: unknown. Head: Coloration yellow-brown to medium brown, with faint vermiform markings on vertex. Antennae approximately 1.5x length of head capsule. Labrum (Fig. 10) with submedial pair of long, simple setae and submarginal row of three to four long, fine, simple setae. Hypopharynx as in Figure 11. Left mandible (Fig. 12) with six denticles; prostheca robust, apically denticulate; minute denticles between prostheca and mola absent. Right mandible (Fig. 13) with outer incisor with four denticles; inner incisor with three denticles; prostheca slender, bifid, one branch medially with minute, fine, simple setae; minute denticles between prostheca and mola absent. Maxillae (Fig. 14) with



Figs. 1-9. *Cloeodes fustipalpus*, new species, larva. 1. Labrum. 2. Left mandible. 3. Right mandible. 4. Right maxilla. 5. Labium (left-ventral; right-dorsal). 6. Left foreleg. 7. Abdomen (dorsal). 8. Gill 4. 9. Paraproct.

three long, fine, simple setae near medial hump; maxillary palps not reaching galealaciniae; palp segment 1 approximately 0.60x length of segment 2. Labium (Fig. 15) with glossae and paraglossae equal in length; palp segment 1 as long as segments 2 and 3 combined; segment 2 approximately 0.74x length of segment 3; segment 3 bulbous, apically flattened. Thorax: Coloration pale to medium yellow-brown, with complex markings. Hindwingpads absent. Legs (similar to Fig. 6) cream; femora with dorsal row of five to seven long, robust, simple setae, last two almost contiguous; tibiae with dorsal row of long, fine, simple setae; tarsi with dorsal row of long, fine, simple setae. Abdomen (Fig. 16): Coloration pale brown and yellow-brown; segment 1 yellow-



Figs. 10-18. *Cloeodes illiesi,* new species, larva. 10. Labrum. 11. Hypopharynx. 12. Left mandible. 13. Right mandible. 14. Right maxilla. 15. Labium (left-ventral; right-dorsal). 16. Abdomen (dorsal). 17. Gill 6. 18. Paraproct.

brown; segment 2 pale brown, with submedial anterior pair of large yellow-brown oblong markings and sublateral oblong yellow-brown markings; segments 3-6 pale brown, with submedial anterior pair of small subtriangular yellow-brown markings; segment 7 pale brown; segment 8 yellow-brown; segment 9 pale brown, with faint medial streak; segment 10 pale brown. Sterna cream to yellow-brown. Gills (Fig. 17) narrow-elongate, poorly tracheated, with smooth margin. Paraprocts (Fig. 18) with 9-10 sharp marginal spines; scale bases scattered over surface. Caudal filaments whitish.

Adult. Unknown.

Material examined. Holotype: Larva, AUSTRALIA, Queensland Province, nr. Cairns, Cascade Falls, sea level, 20°C, X-13-1966, J. Illies [mouthparts, left foreleg, and paraproct mounted on slide (medium: Euparal)].

Etymology. This species is named after the late renowned entomologist-limnologist Joachim Illies, who collected it.

Discussion. *Cloeodes illiesi* is distinguished from other members of the genus by the bifid right prostheca with a setose branch (Fig. 13), reduced maxillary palps (Fig. 14), medially bulbous labial palps segment 3 (Fig. 15), abdominal color pattern (Fig. 16), and narrow-elongate gills (Fig. 17). Its possible relationships to other species of *Cloeodes* are discussed above under *C. fustipalpus.*

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THE BIONOMICS OF GRASSHOPPERS, KATYDIDS AND THEIR KIN. S.K. Gangwere & M.C. & M. Muralirangan, eds. 1997. CAB International. 529 pp.

This volume consists of twenty chapters authored by an international group of twenty eight scientists and is written from a broad, comparative biological, behavioral, and evolutionary approach best expressed by the term bionomics. It focuses on history and recent developments in grasshopper and plague locust biology as well as the biology of katydids, crickets, and other Orthoptera, an insect group of exceptional economic and biological interest.

INSECT ECOLOGY, 3rd ed. P.W. Price. 1997. J. Wiley & Sons. 874 pp.

Moving from the dynamics of plant-insect interactions, predation, parasites and hosts, as well as mutualistic relationships, including pollination ecology, this book examines the themes central to understanding the role of insects in our environment. It describes the various levels of insect interaction, from trophic relationships, populations, and communities, while unfolding the infinite variety of insect species and their visible legacy in the fossil record. This new edition includes discussion on the nature of ecological theory and how it is advanced, the evolutionary perspectives on population dynamics, the existence and study of vacant ecological niches, latitudinal gradients in species richness, and conservation of biodiversity.