

Order Ephemeroptera

Jean-Luc Gattolliat and Michel Sartori

INTRODUCTION

Ephemeroptera (mayflies) are the most primitive order of pterygote insects. They encompass over 3000 species and over 400 genera constituting about 40 described families (Barber-James et al., in press). Mayflies colonised all kinds of fresh water habitats, from springs to large rivers as well as standing waters such as ponds, dykes and lakes. They are present in all landmass except in Antarctica. The immature stages are strictly aquatic, while the imagos are on the wing. The subimago is a unique stage only found in Ephemeroptera, characterized by possessing functional wings at the penultimate moult. Both imaginal and subimaginal stages are extremely brief (generally from a few hours to a couple of days) as they lack functional mouthparts and are unable to feed. Because of their ancient origin, widespread distribution, and limited dispersal ability, mayflies are excellent candidates for studies of biogeography.

The Arabian Peninsula is *a priori* a rather inhospitable area for aquatic insects as the permanent hydrographic system is very restricted. However, a few natural biotopes such as resurgence of brooklets and pools in wadis constitute suitable habitats for aquatic fauna. Because of the increasing need of water for agricultural and domestic uses, most of these habitats have been modified or destroyed. Artificial constructions such as dams or tanks may constitute substitution habitats for part of the ubiquitous insects living in standing water.

Until the 1990's, the mayfly fauna of the Arabian Peninsula remained almost unknown. Important studies were conducted during the 1990's by Sartori, Thomas and Gillies on material collected mainly by Prof. W. Büttiker in Saudi Arabia, Yemen and Oman. Up to present, this fauna has encompassed eight species belonging to three families (Gillies, 1985; Thomas & Sartori, 1989; Sartori & Gillies, 1990; Sartori, 1991):

Baetidae: *Labiobaetis balcanicus* (Müller-Liebenau & Soldán, 1981) (Saudi Arabia), *Cheleocloeon dimorphicum* (Soldán & Thomas, 1985) (Saudi Arabia), *Cloeon saharense* Soldán & Thomas, 1983 (Saudi Arabia, Sultanate of Oman), *Cloeon smaeleni* Lestage, 1924 (Yemen);

Leptophlebiidae: *Choroterpes (Euthraulius) arabica* Sartori & Gillies, 1990 (Saudi Arabia, Yemen), *Choroterpes (Euthraulius) pacis* Sartori, 1991 (Sultanate of Oman);

Caenidae: *Caenis luctuosa* (Burmeister, 1839) (Saudi Arabia), *Caenis corana* Thomas & Sartori, 1989 (Saudi Arabia).

In addition to these relevant works, only a few reports have been produced. A mention of *Cloeon* spec. from the mountain of Jebel Hafit (South of Al Ain) constitutes the only report of mayflies from the United Arab Emirates (Gillett & Howarth, 2004). *Caenis* spec. has been mentioned in a checklist of insects from Qatar (Abdu & Shaumar, 1985).

From a biogeographic point of view, the Arabian Peninsula is of great importance as it is located at the boundary between the Palearctic and Afrotropical realms. The present fauna could display affinities with both faunas resulting from introgressions from each area. Among the eight species presently reported from the Arabian Peninsula, three are endemic, two species have a distribution including South Eastern Europe, two are also reported from North Africa and one is widely distributed in the Afrotropics.

Here, we document the presence of seven additional species in the United Arab Emirates, of which five are new to science and one which is placed in another subgenus, thus significantly

increasing our knowledge of Ephemeroptera from the Arabian Peninsula. Affinities and distribution for each species are commented upon.

MATERIALS AND METHODS

Holotypes and part of the paratypes are housed in the Museum of Zoology, Lausanne, Switzerland; other paratypes and material deposited in the UAE Invertebrate Collection. If not otherwise indicated, the specimens were collected by A. van Harten. Abbreviations used in text: JLG = J.-L. Gattolliat, NARC = National Avian Research Centre; LT = light trap; MT = Malaise trap; WT = water trap; im. = imago(s); subim. = subimago(s).

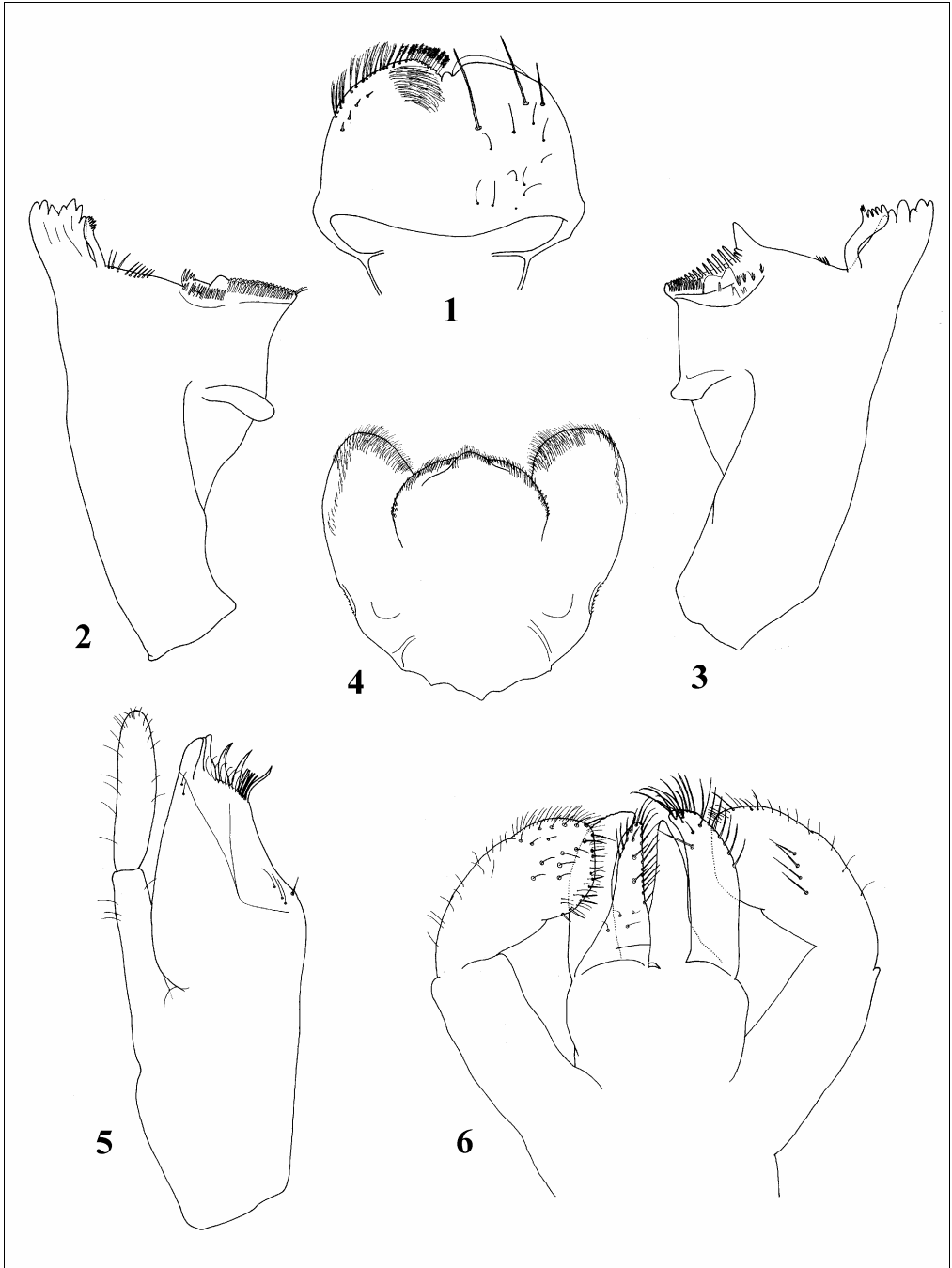
SYSTEMATIC ACCOUNT

Family **Baetidae**

Nigrobaetis arabiensis Gattolliat & Sartori **nov. spec.** (Plates 1-3, Figs 1-12)

Specimens examined: Holotype: Larva, United Arab Emirates, Wadi Wurayah [25°24'N 56°17'E, 165 m], 4.xii.2006, leg. J.-L. Gattolliat. Paratypes: 58 larvae, same data as holotype. 36 larvae, 4 exuviae, Wadi Wurayah (stream), 26.xi.2006, leg. JLG. Other specimens: 19 larvae, al-Hayl, 3.xii.2006, leg. JLG. 61 larvae, Wadi Shawkah (stream), 27.xi.2006, leg. JLG. 3 larvae, Wadi Shawkah (pond), 27.xi.2006, leg. JLG.

Description: Larva. Length: Female body 4.2-4.6 mm; cerci 2.0-2.1 mm; median caudal filament 1.2-1.3 mm; male body 3.7-4.0 mm; cerci 1.9-2.0 mm; median caudal filament 1.0-1.1 mm. General colouration grey brown (Plates 1 and 3). Head uniformly grey brown without vermiform marks on vertex and frons. Turbinate eyes in male larvae chestnut brown. Legs whitish, except distal half of femora grey brown. Abdominal tergites medium grey brown, with distolateral yellowish spot; tergite III with broad lateral yellowish spot and tergite VIII almost completely yellow. In some dark specimens, tergites III and VIII almost completely grey brown. Abdominal sternites 1-4 uniformly yellowish and sternites V-IX light grey brown. Cerci light or dark grey brown (depending on the specimens) but without bands or pattern. Head. Antennae close to each other, with a small interantennal carina (Plate 2). Dorsal surface of labrum (Fig. 1) with about three simple long and stout setae in the distal half and about ten small fine setae scattered on the surface; ventral surface with four small pointed setae near lateral margin; distal margin fringed with two kinds of setae: the thirteen lateral ones long and divided in a brush and the median ones shorter and feathered. Hypopharynx (Fig. 4): lingua covered with minute stout setae and with small rounded median lobe; superlingua with thin setae apically and laterally. Right mandible (Fig. 2) with incisors composed of seven denticles; prostheca with seven denticles, the apical ones shorter than the middle ones; tuft of a few stout setae between prostheca and mola; tuft of setae at apex of mola reduced to a few thin setae. Left mandible (Fig. 3): incisors with six denticles; prostheca with four broad denticles and a comb-shaped structure; a few stout setae between prostheca and mola; tuft of setae at apex of mola absent. Maxillae (Fig. 5) with four broad teeth; crown with two rows of setae, the first one with abundant small setae ending with stouter and longer setae towards the outer margin, and the second with two long stout dentisetae; two thin setae at base of crown, row of three stout setae at base of galea; one single stout seta perpendicular to margin of galea; palp two-segmented with a few thin setae especially along the ovoid second segment, segment I approximately 1.2 x length of segment II. Labium (Fig. 6) with glossae slightly shorter than paraglossae; margins of glossae with stout setae, ventral margin with three stout setae and a few thin setae; paraglossae falcate, with long, stout setae apically



Figs 1-6. Larval structures of *Nigrobaetis arabiensis* nov. spec. 1: Labrum (left: ventral; right: dorsal); 2: Right mandible; 3: Left mandible; 4: Hypopharynx; 5: Right maxilla; 6: Labium.

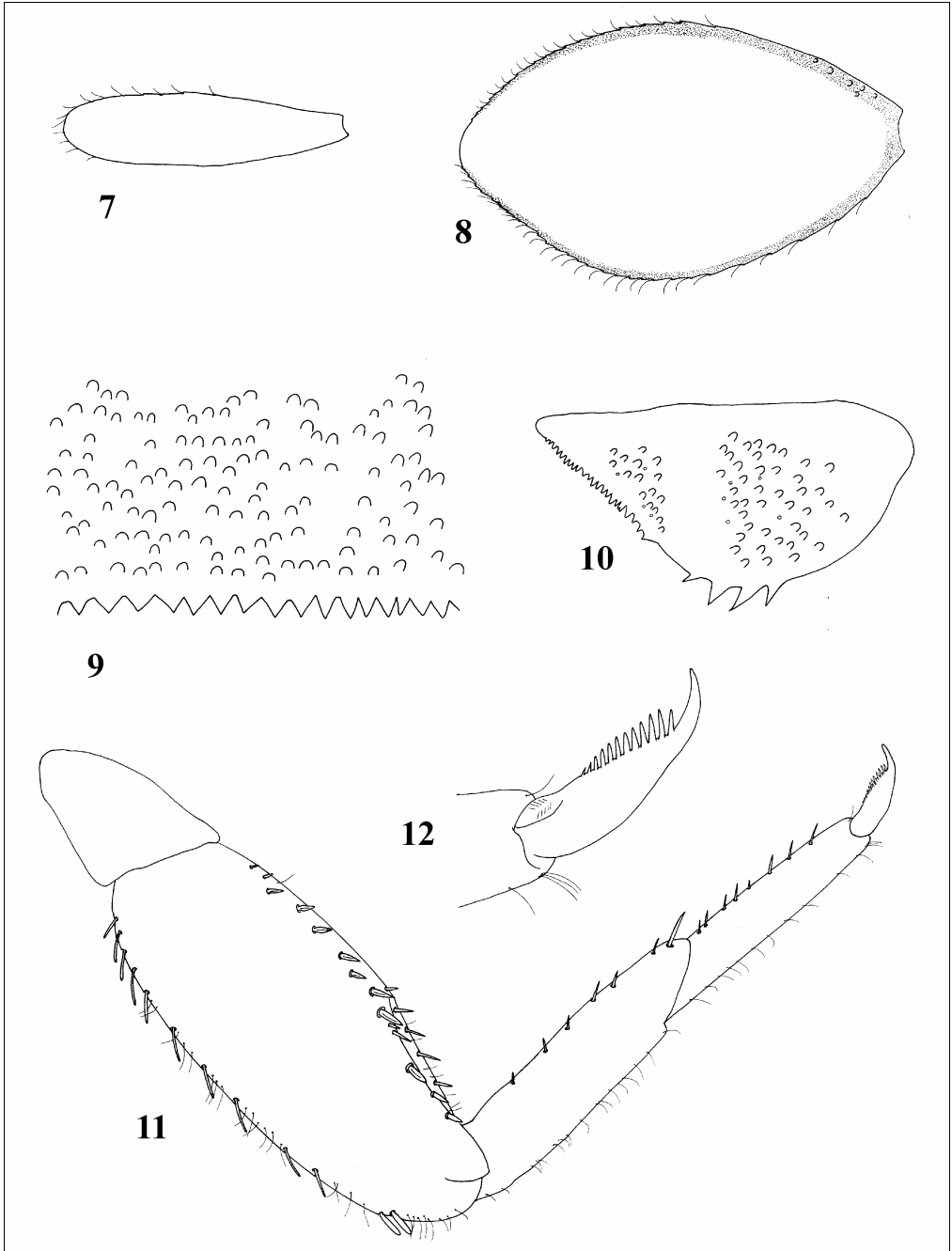
and laterally; labial palp three-segmented; segment I subrectangular, 1.2 x length of segment II and III combined; segment II with a dorsal oblique row of four long pointed setae; segment III truncated, with thin setae more abundant apically and a few small pointed setae apically. Thorax. Forelegs (Fig. 11). Femora dorsally with one row of ten long, stout setae, without another row of setae subparallel to dorsal margin, dorsoapical setal patch formed by 2 stout apically rounded setae; ventral margin with stout pointed setae; anterior face almost bare. Tibiae with only very thin setae dorsally; ventral margin with a few small pointed setae, a single long seta apically; tibiopatellar suture and subproximal arc of setae absent. Tarsi with only a few very thin setae dorsally; ventral margin with a few small pointed setae; tarsal claws (Fig. 12) hooked and slender, with one row of about twelve acute teeth increasing in length toward the apex. Hindwing pads present. Abdomen. Tergites with numerous scale bases, distal margin with broad triangular spines (Fig. 9). Sternites with scale bases; posterior margin without spination. Gills on segments I to VIII, elliptic and serrated all along the margin except apically; tracheation absent (Fig. 8); gill I elongated but much reduced (Fig. 7); gill VII similar to gills II to VI. Paraproct (Fig. 10) with abundant scale bases, margin with about four broad, long and pointed spines; postero-lateral extension with scale bases, margin with numerous triangular small spines.

Imagos: Unknown.

Remarks: A recent attempt was made to reinstate the concept of *Baetis* Leach, 1915 s.l. (sensu Müller-Liebenau, 1969) and gather again the Western Palearctic genera *Nigrobaetis* Novikova & Kluge, 1987, *Alainites* Waltz & McCafferty, 1994 and *Labiobaetis* Novikova & Kluge, 1987 into a broad concept of *Baetis* (Jacob, 2003). Such a concept of *Baetis* is no longer acceptable when we include taxa from other biogeographic regions, as the genus *Baetis* rapidly appears polyphyletic (Monaghan et al., 2005; Gattolliat et al., in press). The genus *Nigrobaetis* is clearly a valid genus with important apomorphies (Waltz et al., 1994; Fujitani et al., 2003; Gattolliat, 2004). *Nigrobaetis* presently includes 16 species. It possesses a wide distribution as it encompasses six species in the whole Palearctic region (Müller-Liebenau, 1969; Kluge, 1983; Soldán & Thomas, 1983), six species in South East Asia (Müller-Liebenau, 1984; Kang et al., 1994), and four in the Afrotropics (Soldán, 1977; Lugo-Ortiz & de Moor, 2000; Gattolliat, 2004). Because of the incomplete knowledge of the fauna of some areas included in the present distribution of the genus, it is obvious that the diversity of the genus is underestimated.

Most of the species can be easily identified by a set of simple characters. The most commonly used are the presence/absence of hindwing pads and the gill number. *Nigrobaetis arabiensis* differs from the Palearctic species *N. aciniger* (Kluge, 1983), *N. digitatus* (Bengtsson, 1912), *N. niger* (Linnaeus, 1761) and *N. rhithralis* (Soldán & Thomas, 1983) and the Afrotropical species *N. harasab* (Soldán, 1977) by the number of gills; from the Afrotropical species *N. colonus* Gattolliat, 2004, *N. cryptus* Gattolliat, 2004 and *N. bethunae* Lugo-Ortiz & de Moor, 2000 by the presence of hindwings. The spination of the paraproct of *Nigrobaetis arabiensis* is quite unusual; it possesses only 4 well developed spines (Fig. 10), while all the other species, except *N. gracilis* (Bogoescu & Tabacaru, 1957) and *N. taiwanensis* (Müller-Liebenau, 1985), possess more than 10 spines of variable sizes but generally smaller than those of *Nigrobaetis arabiensis*. *N. gracilis* and *N. taiwanensis* cannot be separated from *Nigrobaetis arabiensis* by the different characters listed above; however the dorsal margin of their foretibiae presents a row of short stout setae while this margin is bare in *Nigrobaetis arabiensis* (Fig. 11).

Distribution and ecology: According to the present knowledge, *Nigrobaetis arabiensis* is restricted to the eastern mountains of the UAE. Although it has been found only in three



Figs 7-12. Larval structures of *Nigrobaetis arabiensis* nov. spec. 7: Gill I; 8: Gill IV; 9: Distal margin of abdominal tergite IV; 10: Paraproct; 11: Foreleg; 12: Tarsal claw.

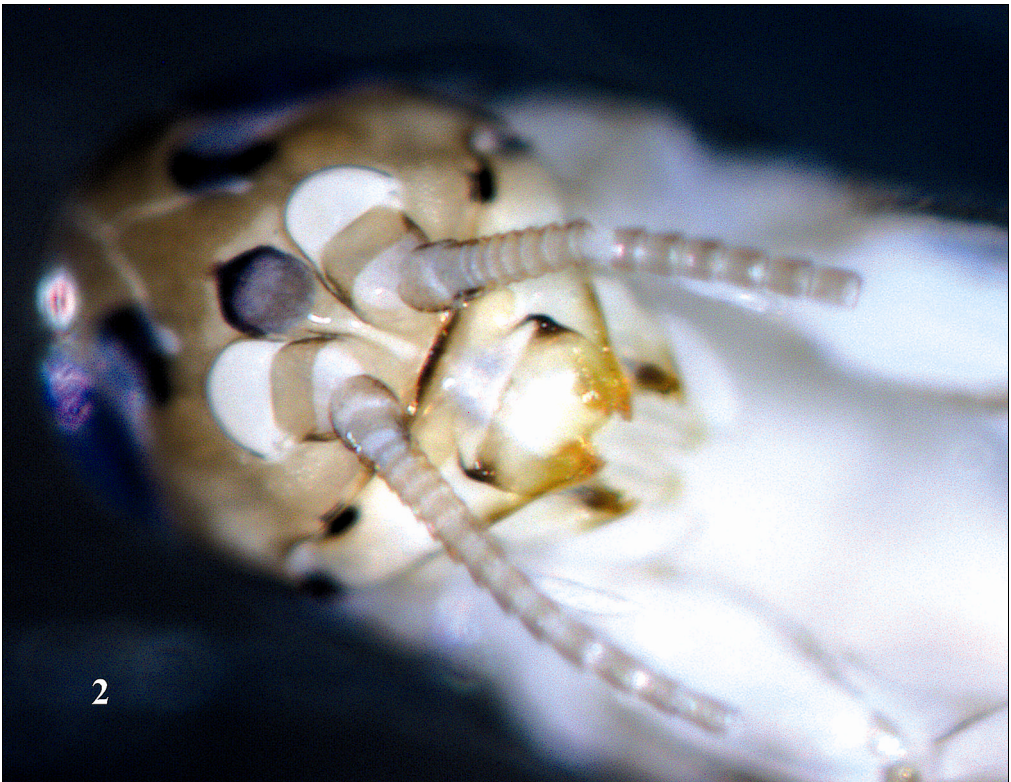
wadis of restricted size, it may be more widespread and may also occur in similar habitats at least in the Sultanate of Oman.

Etymology: This species is named after the Arabian Peninsula, from which it probably is endemic.

***Cheleocloeon soldani* Gattolliat & Sartori nov. spec.** (Plates 4-7, Figs 13-24)

Specimens examined: Holotype: Larva, United Arab Emirates, Wadi Wurayah [25°24'N 56°17'E, 165 m], 4.xii.2006, leg. J.-L. Gattolliat. Paratypes: 43 larvae, same data as holotype. 1 ♂ im., same locality as holotype, 26.ii.2006, leg. JLG. 23 larvae, Wadi Wurayah (stream), 26.xi.2006, leg. JLG. Other material: 11 larvae, Wadi Shawkah (stream), 27.xi.2006, leg. JLG. 1 larva, Wadi Shawkah (pound), 27.xi.2006, leg. JLG.

Description: Larva: Female length: Body 4.4-5.2 mm. Cerci 1.8-2.4 mm. Median caudal filament 1.7-2.3 mm. Male length: Body 3.6-4.7 mm. Cerci 1.6-2.2 mm. Median caudal filament 1.5-2.1 mm. General colouration light brown (Plates 4 and 5). Head uniformly brown with well developed vermiform marks on vertex and frons. Turbinate eyes in male larvae honey brown. Legs whitish without any patterns or markings. Abdominal tergites medium brown with comma shaped yellowish central marks; tergites IV, V, VII, VIII and X whitish sometimes with a central brown spot. Abdominal sternites uniformly whitish. Cerci whitish without markings. Head. Dorsal surface of labrum (Fig. 13) with 4 long disto-lateral setae and one long submedial seta and a few thin setae scattered over the surface; distal margin bordered with long bifid setae apico-laterally and simple broad feathered setae apico-medially; ventral surface with 6 small pointed setae apico-laterally. Hypopharynx (Fig. 16) with superlingua trilobate covered only with minute setae apico-laterally and with short stout setae laterally. Right mandible (Fig. 14) with two partially fused sets of incisors, outer and inner sets with 4 denticles; prostheca slender, with 5 minute denticles apically; tuft of very abundant thin setae between prostheca and mola; tuft of setae at the apex of the mola present; basal half with thin setae dorsally. Left mandible (Fig. 15) with one set of incisors, with 6 denticles; stout prostheca with 3 denticles and a comb-shaped structure; tuft of abundant thin setae between prostheca and mola; tuft of setae at the apex of mola absent; basal half with thin setae dorsally. Maxillae (Fig. 17) with 4 teeth, none of them opposed to the others; 1 row of setae subequal in length to teeth, some of them longer apically, 2 stout bifid dentisetae in the middle of the row; 3 setae at the base of the crown; one long stout seta perpendicular to margin of galea; palp 2-segmented; longer than galealacinia, segment I approximately 0.8 x length of segment II. Labium (Fig. 18) with glossae slightly shorter than paraglossae; margin of glossae with short stout setae slightly longer apically, arc of long setae ventrally; paraglossae falcate, distal margin with long stout setae, row of long stout setae on both ventral and dorsal faces; labial palp 3-segmented stout; disto-medial projection of segment II laterally straight and apically rounded, with numerous small thin setae apically; segment II with oblique row of 4 setae dorsally; segment III subconical, slightly longer than broad, with pointed stout setae. Thorax. Forelegs as in Figure 22. Femora slender, with dorsal and ventral margins parallel; dorsal margin with a row of about 8 short pointed setae, mainly in proximal half; without row of setae subparallel to dorsal margin; dorso-apical setal patch formed by 2 blunt setae; anterior face without setae; ventral margin with a few pointed setae of same size as setae of dorsal margin. Tibiae dorsally without setae; subproximal arc of setae present (Fig. 23); ventral margin with long pointed setae; tibio-patellar suture absent. Tarsi with only scarce thin setae dorsally; ventral margin with a row of about 20 pointed simple setae, subequal in length; tarsal claws (Fig. 24) hooked and elongated, about 0.45 x length of tarsi, with one row of 6 reduced teeth proximally and 7 stout teeth apically; subapical setae absent.



Plates 1-2. Larval structures of *Nigrobaetis arabiensis* nov. spec. 1: Body (lateral view). 2: Head (ventral view).



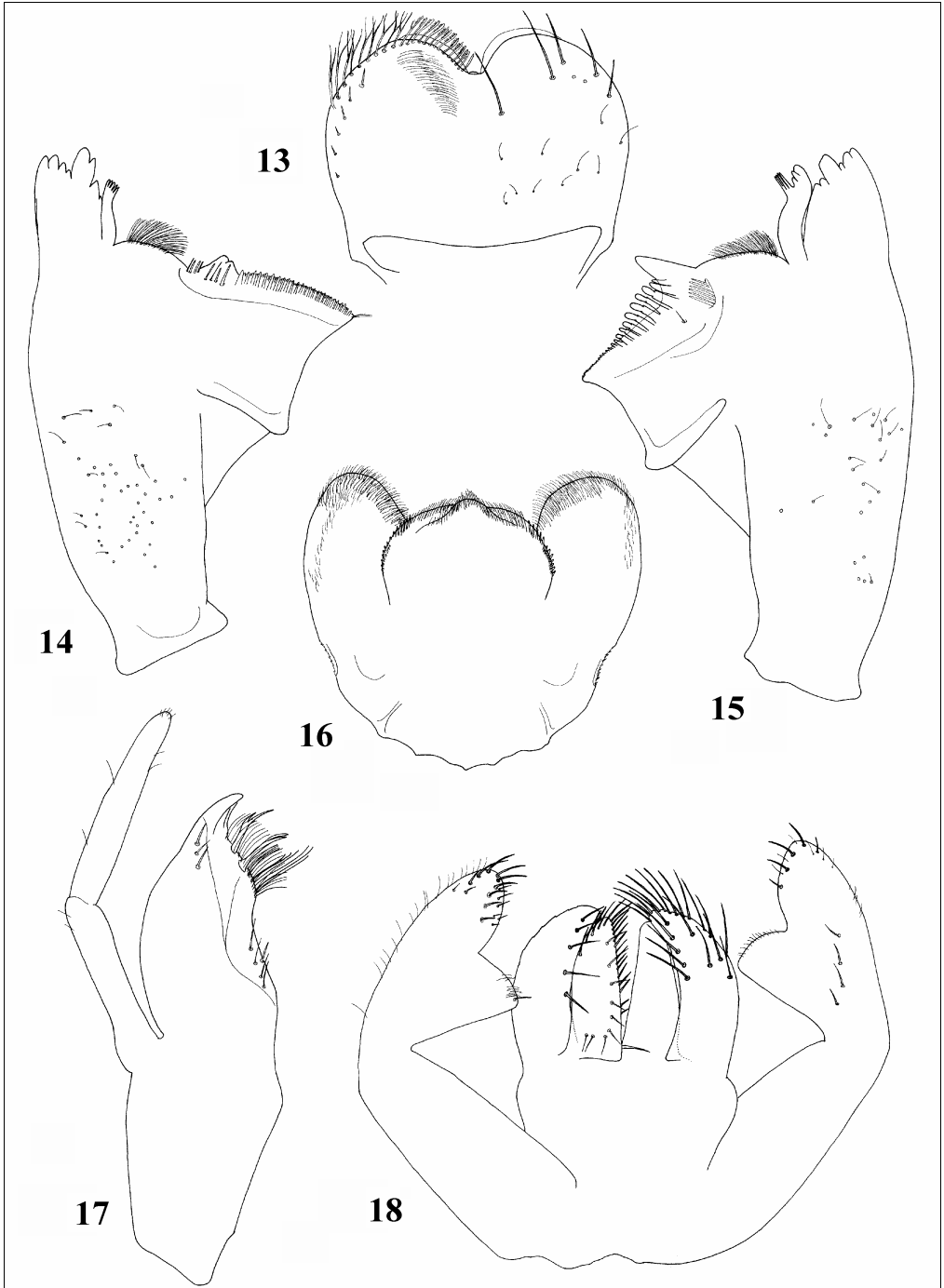
Plate 3. Larval structures of *Nigrobaetis arabiensis* nov. spec.: Body (dorsal view).

Hindwing pads present in male, absent in female. Abdomen. Tergites (Fig. 20) shagreened with W-shaped scale bases, with very sparse setae; posterior margin with regular triangular spines. Single gills (Fig. 19) on segments I to VII, poorly tracheated, slightly serrated distolaterally. Gill I elongated, only slightly shorter than other gills but much slender. Paraproct (Fig. 21) with about 35 W-shaped scale bases, margin with about 8 long, stout and pointed spines and a few small ones; posterolateral extension with about 5 W-shaped scale bases, margin with about 10 spines. Cerci with abundant extremely thin setae on the inner margin; median caudal filament similar to cerci except with extremely thin setae on both margins.

Male imago: Length: body 4.2 mm; forewings 3.8 mm. Head. Turbinate eyes honey brown, upper surface darker with dark brown margin (Plate 6). Thorax. Honey brown with dark brown sutures (Plate 6). Hindwings elongated with an erected costal spur and two longitudinal veins. Legs uniformly whitish. Hindwings present. Abdominal tergites brownish darker laterally without any pattern. Male gonopods (Plate 7) with a broad first segment, almost completely fused with the second; second segment slightly expanded apically; third segment short and ovoid. Triangular genital plate present between the gonopods.

Female imago: Unknown.

Remarks: The genus *Cheleocloeon* Wuillot & Gillies, 1993 was established for two distinctive species of Baetidae from West Africa, clearly separated from other Afrotropical genera by the second segment of the labial palp having a strongly produced and pointed distolateral process (Wuillot & Gillies, 1993). Three species were attributed to *Cheleocloeon* in subsequent revisions of the genus (Lugo-Ortiz & McCafferty, 1997a; 1998) and two new species were described (Gillies, 2001; McCafferty, 2001). A new species from Madagascar was also attributed to this genus (Lugo-Ortiz & McCafferty, 1997b), but recent molecular studies have shown this attribution is erroneous (Monaghan et al., 2005). With 7 species, *Cheleocloeon* therefore constitutes a small but widely distributed genus: *C. carinatum* Wuillot, 1993 and *C. yolandae* Wuillot, 1993 in West Africa (Wuillot & Gillies, 1993); *C. excisum* (Barnard, 1932) and *C. falcatum* (Crass, 1947) in South Africa; *C. littorale* McCafferty, 2000 and *C. sigiense* Gillies, 2001 in African Great Lakes area (Gillies, 1998; McCafferty, 2001). *C. dimorphicum* Soldán & Thomas, 1985 is the only species described out of the Afrotropical realm. Since originally described from Morocco (Soldán & Thomas, 1985), a subsequent record of this species from Saudi Arabia should be considered as



Figs 13-18. Larval structures of *Cheleocloeon soldani* nov. spec. 13: Labrum (left: ventral; right: dorsal), 14: Right mandible; 15: Left mandible; 16: Hypopharynx; 17: Right maxilla; 18: Labium.

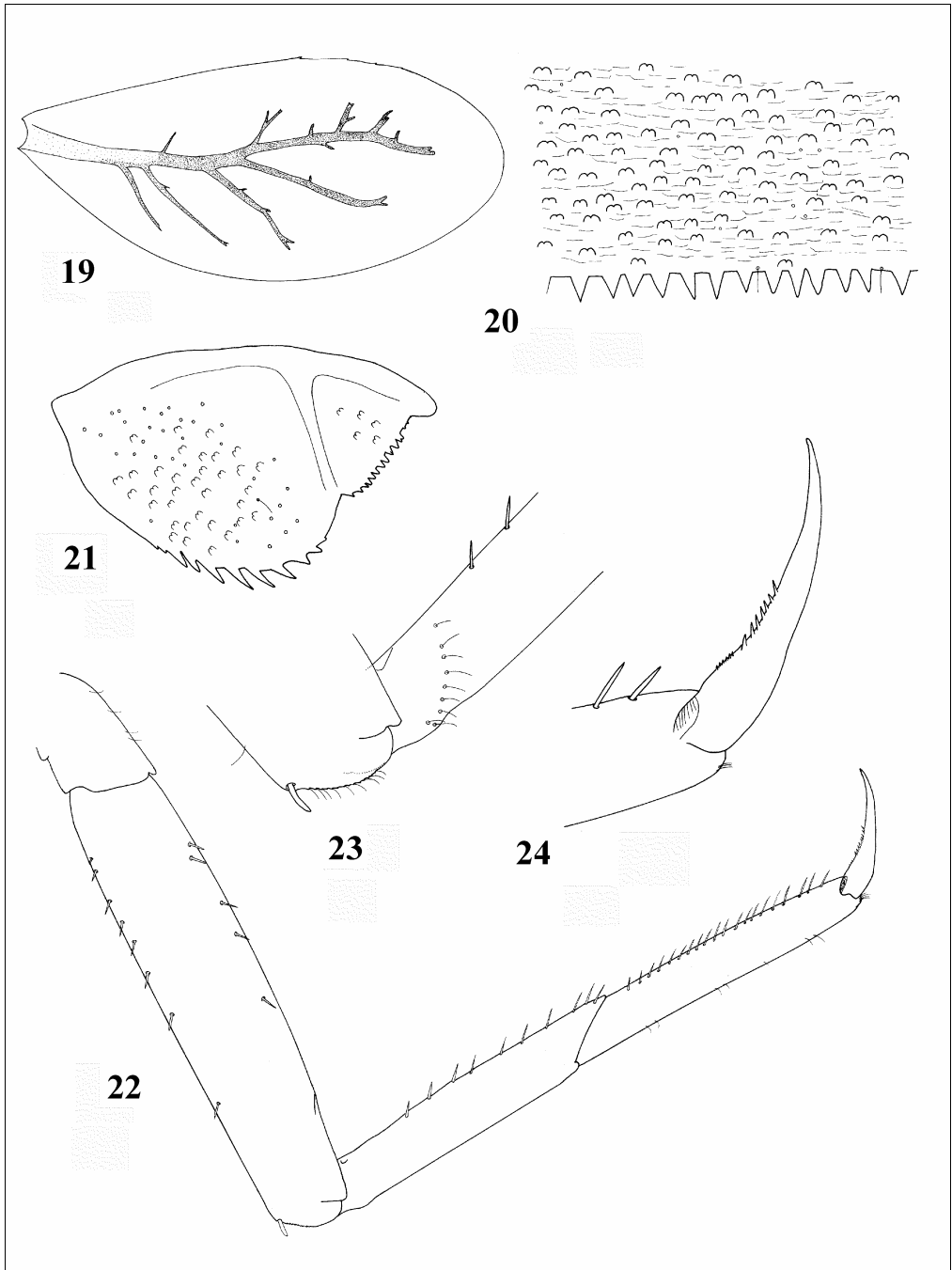


Plates 4-5. Structures of *Cheleocloeon soldani* nov. spec. 4: ♂ larva (dorsal view); 5: ♀ larva (dorsal view).

provisional as long as the material is not compared to *C. soldani* (Thomas & Sartori, 1989). *C. carinatum*, *C. yolandae* and *C. littorale* can be easily separated from the other species of *Cheleocloeon* by the labial palp having a strongly produced and pointed disto-apical process (Wuillot & Gillies, 1993). Conversely, *C. sigiense* presents a relatively poorly developed labial process. The shape of the labial process of *C. soldani* (Fig. 18) seems most similar to those of *C. dimorphicum* and *C. excisum*. Both the ventral and dorsal margins of the femora as well as the ventral margin of the tibiae possess only a few reduced setae in *C. dimorphicum* (Fig. 7 in Soldán, 1985) whereas those setae are much more abundant and developed in *C. soldani* (Fig. 22). The hindwings or hindwing pads are present in male and absent in female of all species except in *C. carinatum* and *C. yolandae* (absent in both male and female).

In addition to the characters discussed above, the reduced number of spines of the paraproot (Fig. 21) and the tarsal claws with both poorly developed and well developed teeth (Fig. 24) allow the identification of *C. soldani*.

Distribution and ecology: *Cheleocloeon soldani* is only known from the UAE. As is the case with *Nigrobaetis arabiensis*, it probably also occurs in adjacent countries such as the Sultanate of Oman. *Cheleocloeon soldani* has been collected in the same wadis as *Nigrobaetis arabiensis*; however it colonizes mainly the lentic part of the streams such as



Figs 19-24. Larval structures of *Cheleocloeon soldani* nov. spec. 19: Gill IV; 20: Distal margin of abdominal tergite IV; 21: Paraproct; 22: Foreleg; 23: Foretibia (detail); 24: Tarsal claw.



Plates 6-7. Structures of *Cheleocloeon soldani* nov. spec. 6: Head and thorax of ♂ imago (ventral view); 7: ♂ genitalia (ventral view).

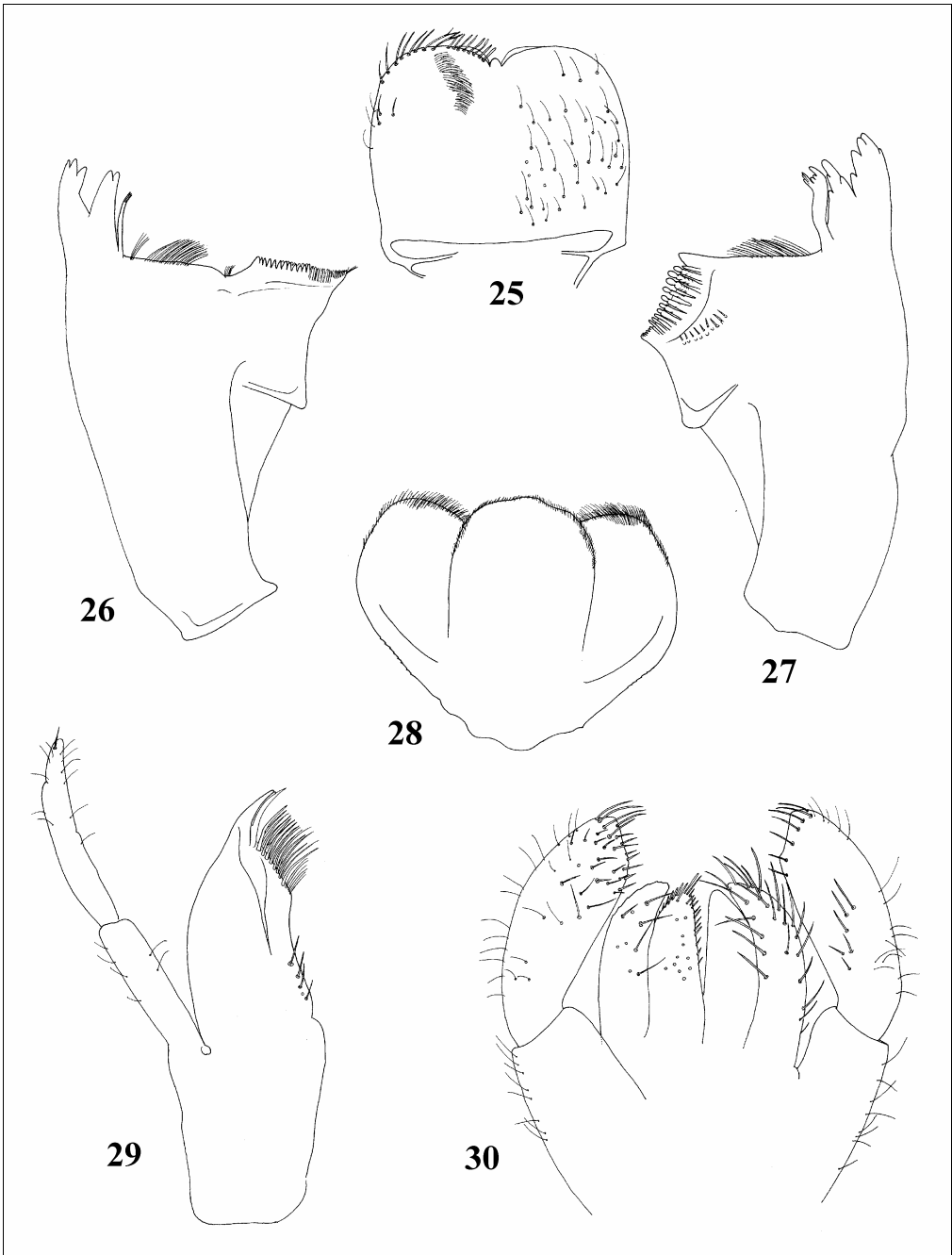
pools. It is therefore generally less abundant than *Nigrobaetis arabiensis*. Like *Nigrobaetis arabiensis*, *C. soldani* has never been collected in artificial standing water such as dams or tanks. In a natural water body, it can be sympatric with *Cloeon*.

Etymology: We are pleased to dedicate this species to our colleague and friend Tomáš Soldán (Ceské Budejovice, Czech Republic) for his contribution of the knowledge of mayflies by collecting and describing species from the most remote parts of the world.

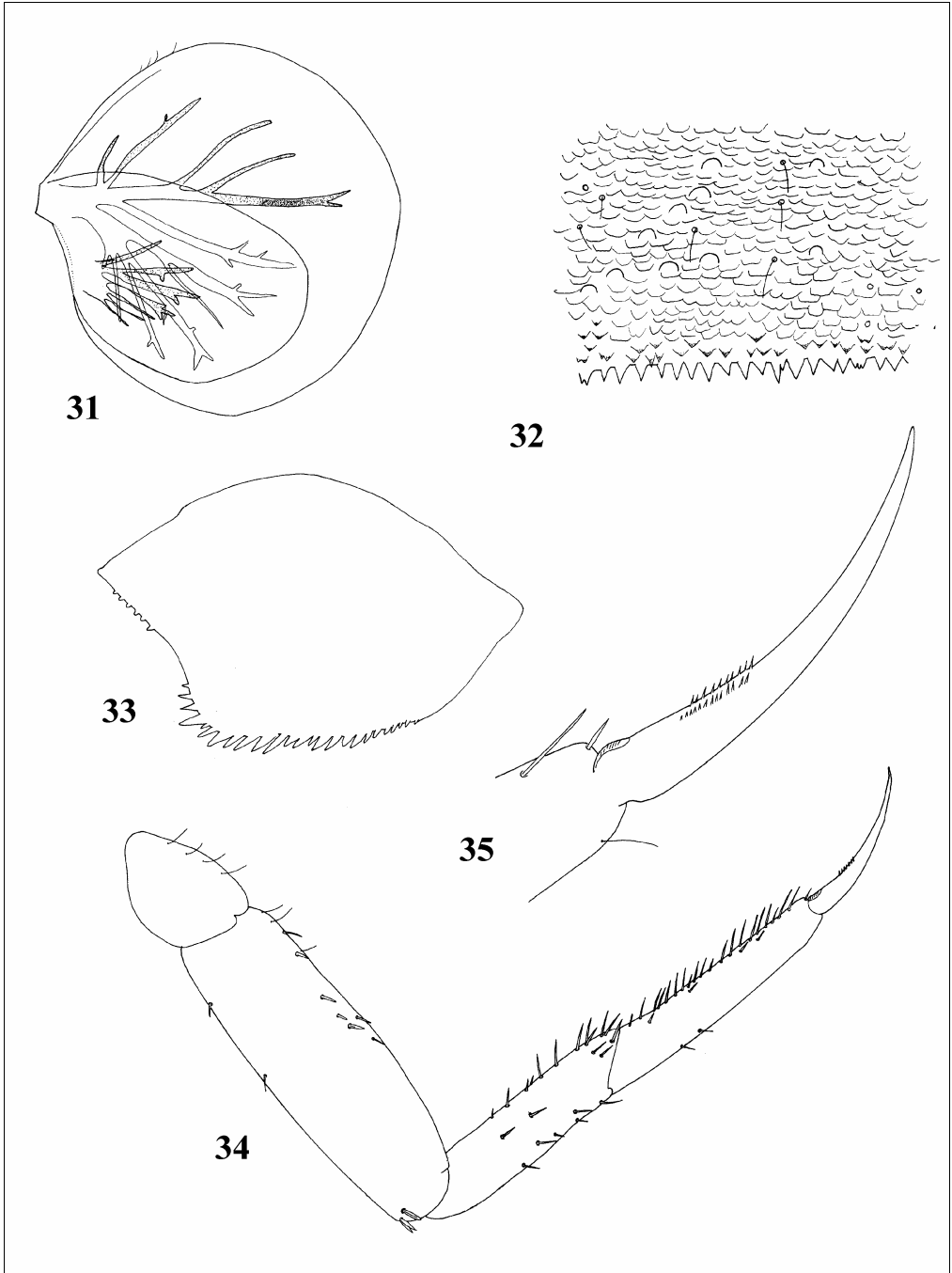
***Cloeon vanharteni* Gattolliat & Sartori nov. spec.** (Plates 8-11, Figs 25-35)

Specimens examined: Holotype: ♀ larva, United Arab Emirates, al-Ajban [24°36'N 55°01'E, 60 m], 2.xii.2006, leg. J.-L. Gattolliat. Paratypes: 2 larvae same data as holotype. 4♂ im., 10♂ subim., 1♀ im., 4♀ subim., al-Ajban, 9.xi-7.xii.2005, LT; 4♂ im., 4♀ im., 6-22.v.2006, LT. Other material: 12♂ im., 19♂ subim., 5♀ im., 12♀ subim., al-Ajban, 7-28.xii.2005, LT; 3♂ im., 7♂ subim., 28.xii.2005-29.i.2006, LT; 7♂ im., 4♀ im., 26.ii-2.iv.2006, LT. 1♀ subim., near Mahafiz, 23.iv.2005, at light, leg. A. van Harten & K. Szpila; 1♂ im., 5♀ im., 2♀ subim., 29.xii.2005-7.i.2006, LT. 1♂ im, 1♂ subim., 3♀ im., 1♀ subim., Sharjah Desert Park, 3.xii.2006, leg. JLG; 1♂ im., 1♂ subim., 25.i-22.ii.2005, LT; 2♂ subim., 22.ii-9.iii.2005, LT; 2♂ im., 9-21.iii.2005, LT; 2♂ im., 2♀ im., 21-29.iii.2005, LT; 1♂ im., 5♂ subim., 3♀ im., 29.iii-6.iv.2005, LT. 1♂ subim., 1♀ subim., 13.xi-11.xii.2005, LT; 1♂ im., 5♂ subim., 3♀ im., 11.xii.2005-18.i.2006, LT; 4♂ im., 2♂ subim., 1♀ im., 1♀ subim., 25.ii-25.iii.2006, LT. 3♂ im., 1♂ subim., NARC, near Sweihan, 1.ii-14.iii.2005, LT; 2♂ im., 14-28.iii.2005, LT. 2♀ im., Wadi Madaq, 27.ii-2.xii.2005, LT.

Description: Larva. Length: female body 7.0 mm. Cerci 4.2 mm. Median caudal filament 3.5 mm (measurement of a single submature female larva). General colouration yellowish and medium brown (Plate 8). Head medium yellowish brown without darker pattern. Antennae whitish. Thorax yellowish brown without pattern. Legs whitish, without pattern. Abdominal tergites yellowish to medium brown: tergites I, IV, IX and X yellowish brown, tergite II medium brown with a central yellowish stripe and a broad lateral yellowish dot, tergites III and VI medium brown except for a centro-distally yellowish mark, tergites V and VII yellowish with a faded medium brown pattern, tergite VIII medium brown with symmetrical yellowish dot. Abdominal sternites generally whitish, sometimes medium brown in dark specimens. Cerci whitish with brown stripes every 4 segments and an additional broad brown band subapically. Head. Dorsal surface of labrum (Fig. 25) with abundant long, fine setae, not arranged in a row; ventral surface with row of 3 pointed setae; distal margin bordered with stout setae, a few of them bifid. Hypopharynx (Fig. 28) with lingua slightly pointed medially, covered with small fine setae; superlingua weakly expanded laterally, covered with fine setae longer apically. Right mandible (Fig. 26) with two well separated sets of incisors, outer with three denticles and inner with two denticles; prostheca with extremely fine denticles; tuft of very abundant long, subequal setae between prostheca and mola. Left mandible with two sets of incisors, outer with four to five denticles and inner with four denticles (Fig. 27); prostheca with 3 well developed denticles and a comb-shaped structure; tuft of abundant setae between prostheca and mola. Maxillae (Fig. 29) with four long, slim teeth, none of them opposed to others; apex of galea-lacinia with one row of fine setae and one row of stout setae and two dentisetae; row of four stout setae at basis of galea; palp 2-segmented with a few thin setae, segment I approximately 0.8 x length of segment II. Labium (Fig. 30) with glossae subequal to paraglossae; margin of glossae with short, stout setae; paraglossae falcate with long and stout setae ventrally and dorsally; labial palp 3-segmented; segment I 0.8 x length of segment II and III combined; segment II almost fused to segment III, with a dorsal longitudinal row of 6 pointed setae progressively longer apically; segment III as broad as segment II and apically tapered, distal margin with stout pointed setae, apical ones longer. Thorax. Forelegs (Fig. 34). Femora dorsally with very scarce small and pointed setae; dorsoapical setal patch of three



Figs 25-30. Larval structures of *Cloeon vanharteni* nov. spec. 25: Labrum (left: ventral; right: dorsal); 26: Right mandible; 27: Left mandible; 28: Hypopharynx; 29: Right maxilla; 30: Labium.



Figs 31-35. Larval structures of *Cloeon vanharteni* nov. spec. 31: Gill IV; 32: Distal margin of abdominal tergite IV; 33: Paraproct; 34: Foreleg; 35: Tarsal claw.

medium setae; anterior and posterior margins bare; ventral margin with very few short, pointed setae. Tibiae dorsally with medium stout setae, subapically with one curved seta; ventral and lateral margins with a few medium pointed setae. Tarsi with only scarce stout setae dorsally; ventral margin with row of about 20 medium pointed setae; row of short, pointed setae laterally; tarsal claws slender and elongated (Fig. 35) about 0.7 times length of tarsi, with 2 rows of about 10 minute teeth, subapical setae absent. Abdomen. Tergites (Fig. 32) shagreened with scale bases and a few setae; posterior margin with short pointed spines. Sternites without scale bases but with numerous very long, thin setae; posterior margin of sternites I to V smooth, without spines; posterior margin of sternites VI to IX with small spines. Lateral margin of abdominal segment VIII with about 4 slender spines; lateral margin of abdominal segment IX with about 6 slender spines; other lateral margins without spines. Gills I to VI (Fig. 31) with two lamellae, upper lamella reduced, tracheation poorly developed only marked apically on the lower lamella; gill VII simple, triangular and broader than the others. Paraproct (Fig. 33) with damaged surface, margin with about 25 medium spines; margin of posterolateral extension with five short blunt spines. Cerci yellow with abundant thin setae on the inner margin in basal half; median caudal filament similar to cerci except thin setae on both margins.

Female imago: Length: body 6.8-8.1 mm; forewings 5.6-6.3 mm; cerci 10.0-12.0 mm. Colouration of head and thorax yellowish with brown sutures (Plate 9). Thorax. Forewings (Plate 9) uniformly hyaline with costal and subcostal areas opaque; veins and cross veins not coloured; pterostigma with 2 to 3 cross-veins. Legs uniformly whitish. Abdominal tergites uniformly whitish without any pattern or colouration. Abdominal sternites uniformly whitish.

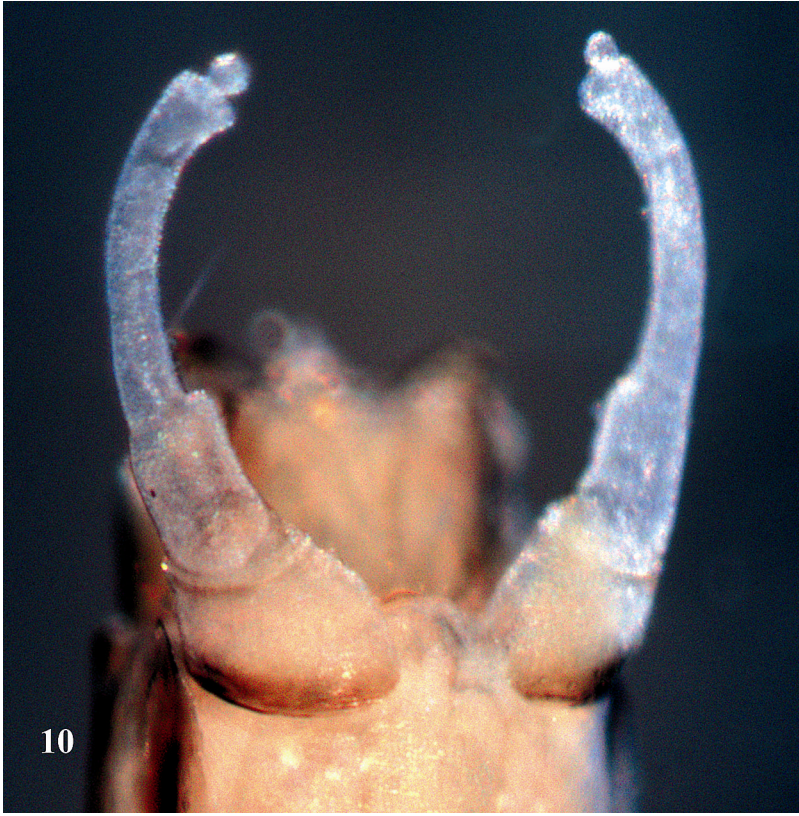
Male imago: Length: body 5.9-7.2 mm; forewings to 4.5-5.7 mm; cerci 13.0-15.5 mm. Head and thorax dark amber brown. Turbinate eyes honey brown, broad and short (Plate 11). Forewings as female. Legs uniformly whitish. Abdominal tergites without any pattern; tergites I to VIII light brown, tergites IX and X medium brown. Abdominal sternites uniformly whitish. Male genitalia (Plate 10) with segment I of gonopods clearly separated from segment II, apex of segment I broader than basis of segment II; segment II apically expanded; segment III short and rounded. Poorly developed genital plate triangular and apically flattened.

Remarks: With more than 60 valid species and a world wide distribution including all the different biogeographic areas except the Neotropics (and Antarctica), *Cloeon* Leach, 1815 is the most successful genus of Baetidae. It colonized any kind of still and standing waters (from the smallest fresh water tank to the shore of lakes, and the still part of rivers and streams). In some isolated islands, it is the only mayfly recorded (Azores, Mauritius, Samoa). In *Cloeon*, both larvae and imagos possess reliable characters for specific identification. *Cloeon vanharteni* present affinities to the *simile* species group (sensu Sowa, 1980) but can be easily separate from other Afrotropical and Palearctic species by the following combination of characters: absence of colouration of the costal and subcostal areas of the female forewing (Plate 9), absence of abdominal pattern in the imaginal stage (Plate 9); male gonopods with the first and second segments well separated and with the second segment apically expanded (Plate 10); the poorly developed upper gills (Fig. 31), the reduced size of the teeth of the tarsal claws (Fig. 35), the relatively broad labial palp (Fig. 30), the presence of 4 to 6 unusually slender lateral spines on abdominal segments VIII and IX.

Characters to separate the two species of *Cloeon* collected in the United Arab Emirates are mentioned below. *Cloeon vanharteni* can be easily separated from the other species of *Cloeon* mentioned from the Arabian Peninsula. In *Cloeon smaeleni*, the female forewing has characteristic colouration and larvae have tarsal claws with long teeth (Gattolliat & Rabeantoandro, 2002); *Cloeon saharensense* is rather similar at the imaginal stage to *Cloeon*



Plates 8-9. Structures of *Cloeon vanharteni* nov. spec. 8: ♀ larva (dorsal view). 9: ♀ imago (lateral view).



Plates 10-11. Structures of *Cloeon vanharteni* nov. spec. 10: ♂ genitalia (ventral view); 11: ♂ imago (dorsal view).

vanharteni, but the two species can easily be separated at the larval stage by the number of segments of the maxillary palp, the degree of development of the upper lamella of the gills and the presence/absence of lateral spines on abdominal segments VIII and IX (Soldán & Thomas, 1983).

Distribution and ecology: *Cloeon vanharteni* has been only found in a limited number of localities where it generally co-occurs with the other species of *Cloeon* described below. Unlike all the other species of mayflies from the UAE, this species is restricted to low altitude and seems to be absent from the mountainous area of the eastern part of the country. Larvae were collected in a single locality, in a large but shallow pond with sandy bottom. Adults were caught by light traps amazingly mainly in artificial places devoted to vertebrate (cheetahs, bustards and oryx) breeding and conservation. These areas possess several biotopes suitable for the development of *Cloeon* but are generally difficult to prospect. Unlike the other species of *Cloeon*, *C. vanharteni* was never collected at the imaginal or larval stage in natural pounds or pools in streams; it is also not present in dams and tanks. It is therefore difficult to know exactly the original habitat of this species.

As mentioned above, imago of *Cloeon vanharteni* and *C. saharensis* are rather difficult to separate, we can not therefore excluded that part of the material from Saudi Arabia, identified as *C. saharensis* in Sartori & Gillies 1990, belongs in fact to *C. vanharteni*. According to the kind of habitat colonised by *C. vanharteni*, its distribution is probably not restricted to the UAE.

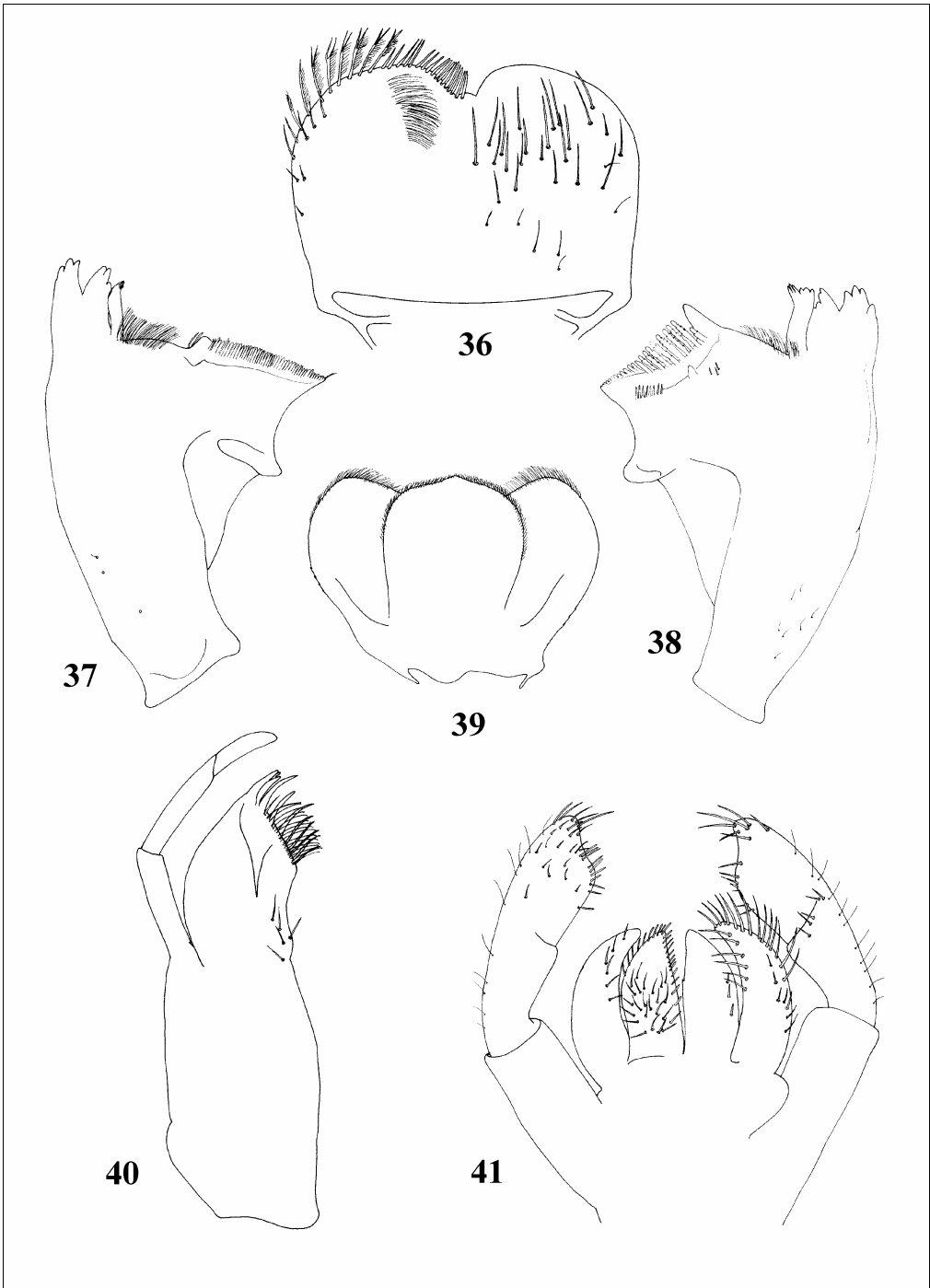
Females are oviparous.

Etymology: We have the pleasure to dedicate this species to Antonius van Harten who conducts the research of the entomological fauna of the UAE and offered the first author the great opportunity to discover this country.

***Cloeon arenorum* Gattolliat & Sartori nov. spec.** (Plates 12-15, Figs 36-47)

Material examined: Holotype: Larva, United Arab Emirates, Wadi Shawkah (pool) [27°08'N 56°01'E, 305 m], 27.xi.2006, leg. J.-L. Gattolliat. Paratypes: 93 larvae, same data as holotype. 7♂ im., 1♀ im., same locality, 31.x-27.xi.2006, WT; 6 larvae, 1♀ subim., in stream, 27.xi.2006, leg. JLG; 9 larvae, in pond, 27.xi.2006, leg. JLG. Other material: 2♂ im., al-Ajban, 26.ii-1.iv.2006, MT; 4♂ im., 1♂ subim., 7♀ im., 1.iv-2.v.2005, MT; 1 larva, 2.xii.2006. leg. JLG. 1♂ subim., 6♀ im., 2♀ subim., Bithnah, 31.xii.2005-2.ii.2006, LT. 2♂ im., 6♂ subim., 6♀ im., near Mahafiz, 29.xii.2005-7.i.2006, LT. 1♀ im., Fujairah, 24.ii-5.iii.2005, LT; 3♂ im., 35♂ subim., 3♀ im., 29♀ subim., 5.iii-6.iv.2005, LT; 15♂ im., 28♂ subim., 3♀ im., 13♀ subim., 6.iv-2.v.2005, LT; 1♂ im., 2♂ subim., 2♀ subim., 5.vi-2.vii.2005, LT; 2♂ im., 1♀ subim., 13.xi-8.xii.2005, LT: 1♂ im., 1♂ subim., 9♀ im., 3♀ subim., 8.xii.2005-2.i.2006, LT; 1♂ im., 30♂ subim., 12♀ subim., 2-30.i.2006, LT. 4 larvae, al-Hayl, 3.xii.2006, leg. JLG. 1♀ im., Hatta, 8-26.iv.2006, LT. 213 larvae, Khor Fakkan (Dam), 30.xi.2006, leg. JLG. 2♂ im., 4♂ subim., 1♀ subim., Sharjah, 27.iv-5.vi.2005, LT; 1♂ im., 1♂ subim., 1♀ subim., 12-28.vi.2005, LT. 3♂ im., 3♀ im., Sharjah Desert Park 18-25.i.2005, LT; 10♂ im., 25.i-22.ii.2005, LT; 1♂ subim., 1♀ im., 22.ii-9.iii.2005, LT; 5♂ im., 10♀ im., 21-29.iii.2005, LT; 3♀ im., 29.iii-6.iv.2005, LT; 2♀ im., 13.xi-11.xii.2005, LT; 1♂ im., 2-30.i.2006, LT; 7 larvae, 1♀ subim., 29.xi.2006, leg. JLG. 2♂ subim., NARC, near Sweihan, 28.xii.2005-22.i.2006, LT. 147 larvae, 2♂ subim., Wadi Ghail, 29.xi.2006, leg. JLG. 13 larvae, Wadi Hatta, 30.xi.2006, leg. JLG. 99♂ im., 4♂ subim., 47♀ im., Wadi Safad, 20.xii.2005-2.i.2006, LT; 5♂ im., 5♂ subim., 9♀ im., 3♀ subim., Wadi Safad, 2-26.i.2006, WT; 2♂ im., 1♀ im., 31.i-21.ii.2006, LT; 1♂ im., 1♀ im., 14-21.v.2006, LT. 1 larva, Wadi Wurayah (stream), 26.xi.2006. leg. JLG; 107 larvae, Wadi Wurayah, 4.xii.2006, leg. JLG.

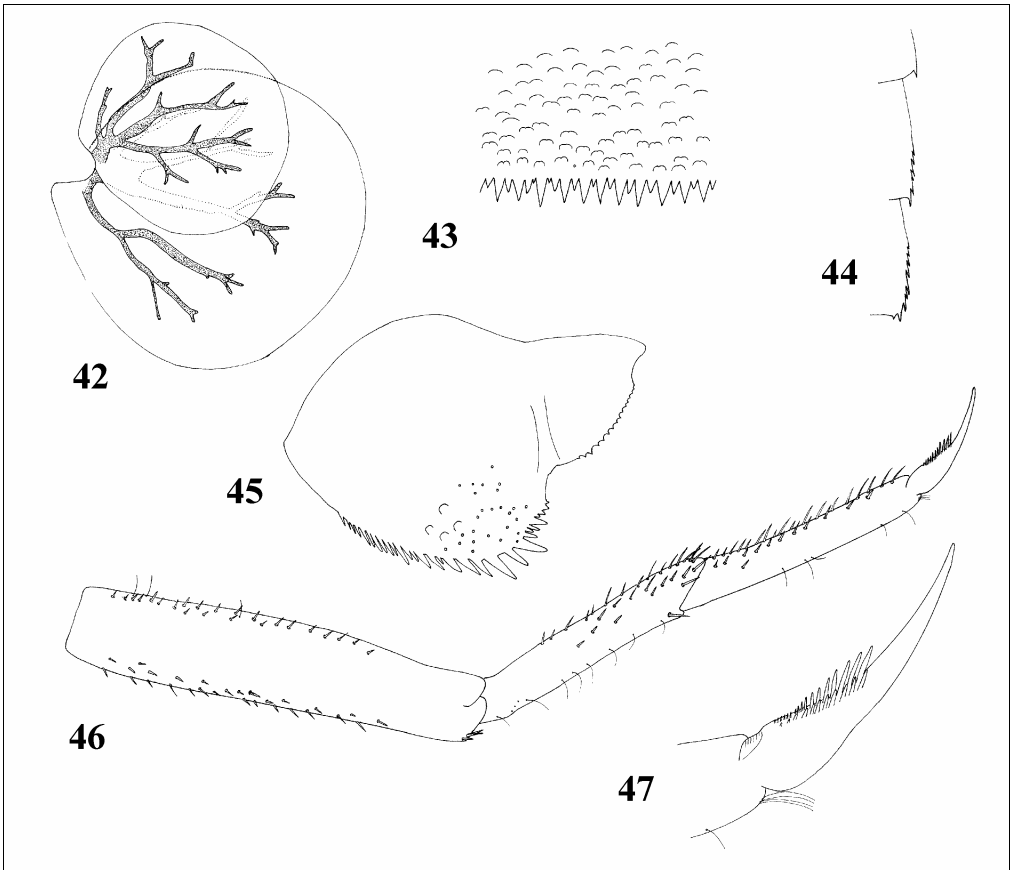
Description: Larva. Length female: Body 5.4-7.3 mm. Cerci 4.2-6.8 mm. Median caudal filament 3.5-5.7 mm. (only in one locality body length is more than 6 mm). Length male: Body 4.3-6.8 mm. Cerci 3.3-7.2 mm. Median caudal filament 2.5-5.5 mm. (only in one locality



Figs 36-41. Larval structures of *Cloeon arenorum* nov. spec. 36: Labrum (left: ventral; right: dorsal); 37: Right mandible; 38: Left mandible; 39: Hypopharynx; 40: Right maxilla; 41: Labium.

body length is more than 5 mm), General colouration medium brown (Plate 12). Head medium amber brown with a central yellow band and sometimes yellow pattern around eyes. Antennae yellowish. Turbinate eyes in male larvae honey brown. Thorax medium brown with yellow dots. Legs whitish; femora with a medium brown band subapically, tibiae and tarsi with a medium brown band subproximally. Abdominal tergites medium brown with one central and two lateral yellow dots. Abdominal sternites generally whitish, sometimes medium brown in dark specimens. Cerci whitish with brown stripes every 4 segments. Head. Dorsal surface of labrum (Fig. 36) with abundant long, stout setae not arranged in a row; ventral surface with 6 medium pointed setae; distal margin laterally with bifid setae feathered on only one margin, other setae simple, medium and stout. Hypopharynx (Fig. 39) with broad, slightly pointed lingua covered with short fine setae, superlingua only slightly expanded. Right mandible (Fig. 37) with two partially fused sets of incisors, outer with three denticles and inner with three denticles; stout prosthema with thin denticles; tuft of abundant setae between prosthema and mola. Left mandible (Fig. 38) with two partially fused sets of incisors, outer set with four denticles and inner with three denticles; prosthema with 3 denticles and a comb-shaped structure; tuft of abundant setae between prosthema and mola. Maxillae (Fig. 40) with 4 long, slim teeth, none of them opposed to others; apex of galealacinia with one row of fine setae and one row of stout setae and two dentisetae; palp 3-segmented, bare, segment I approximately 0.7 x length of segment II and III combined, segment II 1.5 x length of segment III. Labium (Fig. 41) with glossae subequal to paraglossae; margin of glossae with short and stout setae, ventrally covered with medium and thin setae; paraglossae falcate with long and stout setae roughly arranged in rows; labial palp 3-segmented; segment I slender subrectangular, 0.8 x length of segment II and III combined; segment II enlarged apically, with a row of 5 pointed setae subparallel to distal margin of segment; segment III slightly broader than the second, apically tapered, distal margin with stout pointed setae, the apical ones longer. Thorax. Forelegs (Fig. 46). Femora dorsally with one row of about 15 small pointed setae, one row of about 15 small pointed setae subparallel to dorsal margin; dorsoapical setal patch of medium pointed setae; anterior and posterior margins bare; ventral margin with short, pointed setae. Tibiae dorsally with only thin setae, apically with one long pointed seta; ventral and anterior margins with pointed setae. Tarsi with only a few thin setae dorsally; ventral margin with one row of about 20 medium pointed and one row of about 10 short pointed setae; tarsal claws (Fig. 47) about 0.5 times length of tarsi, with 2 rows of 10 to 15 teeth the proximal ones extremely reduced and the apical ones well-developed; subapical setae absent. Abdomen. Tergites (Fig. 43) not shagreened with scale bases; posterior margin with spines alternating in a pattern of one short spine and one long pointed spine. Sternites with scale bases; posterior margin of sternites I to V smooth, posterior margin of segment VI to IX with small spines. Lateral margin (Fig. 44) of abdominal segment VIII with four to six spines; lateral margin of abdominal segment IX with six to eight spines; other lateral margins without spines. Gills I to VI with two lamellae (Fig. 42), gill VII single; lower lamella subrounded and well tracheated; upper lamella broad, similar in shape and tracheation to the lower but smaller in size. Paraproct (Fig. 45) with very few scale bases, margin with about 30 spines, broad and long distally, much smaller and thinner laterally; posterolateral extension without scale bases, margin with about 15 short spines. Cerci yellow with abundant thin setae on the inner margin in basal half, apical half extremely thin and without setae; median caudal filament similar to cerci except with setae on both margins.

Female imago: Length: Body 4.2-6.2 mm; forewings 4.8-5.1 mm; cerci 8.0-9.5 mm. Colouration of head and thorax yellowish (Plate 13). Thorax. Forewings (Plate 13) uniformly



Figs 42-47. Larval structures of *Cloeon arenorum* nov. spec. 42: Gill IV; 43: Distal margin of abdominal tergite IV; 44: Lateral margin of abdominal tergites VIII and IX; 45: Paraproct; 46: Foreleg; 47: Tarsal claw.

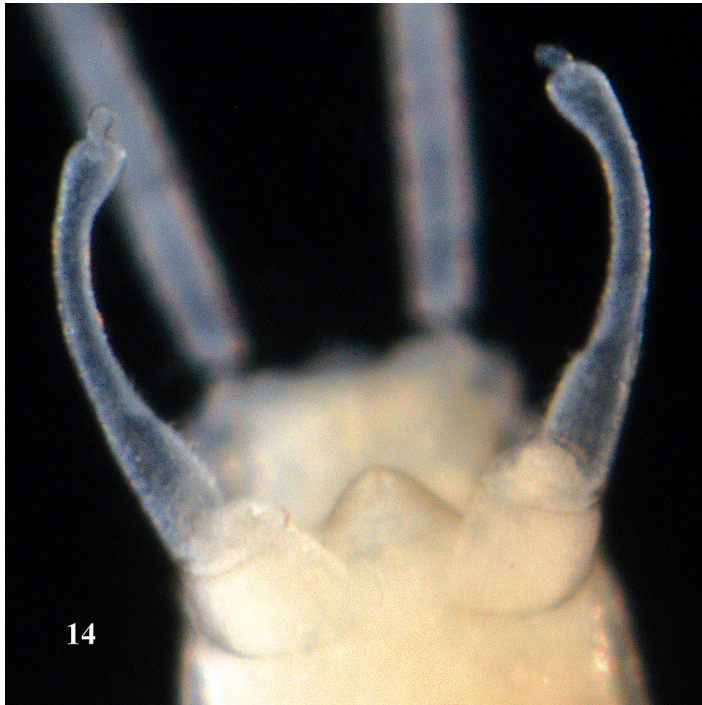
hyaline with costal and subcostal areas opaque; veins and cross veins not coloured; pterostigma with 4 to 5 cross-veins. Legs uniformly whitish. Abdominal tergites whitish without any pattern (Plate 13). Abdominal sternites uniformly yellowish.

Male Imago: Length: Body 4.8-5.7 mm; forewings 4.1-4.8 mm; cerci 10.0-12.0 mm. Head. Turbinate eyes honey brown, darker basally, apically divergent (Plate 15). Thorax. Forewings as female. Legs uniformly whitish. Abdominal tergites without any pattern, tergites I to VII whitish, tergites VIII to X light brown. Male genitalia (Plate 14) with first segment of gonopods completely fused to the second, first segment getting progressively thinner apically; second segment apically rounded and slightly expanded; third segment short and rounded. Well-developed genital plate triangular and highly sclerotised.

Remarks: With 3-segmented labial palp (Fig. 40), gills with broad upper lamella (Fig. 42), *Cloeon arenorum* shares characters with the *dipterum*-species group (sensu Sowa, 1975) but can be easily separated from other species of this group at the imaginal stage by the absence of the colouration of the costal and subcostal areas of the female forewing (Plate 13), absence of abdominal pattern (Plate 13) and at the larval stage by the less developed labial palp (Fig. 41).



Plates 12-13. Structures of *Cloeon arenorum* nov. spec. 12: ♀ larva (dorsal view). 13: ♀ imago (lateral view).



Plates 14-15. Structures of *Cloeon arenorum* nov. spec. 14: ♂ genitalia (ventral view); 15: ♂ imago in dorsal view.

It can be also separate from other Afrotropical and Palearctic species by the following combination of characters: male gonopods (Plate 14) with the first and second segments almost completely fused and a well sclerotized triangular genital plate between the gonopods; the big size of the teeth of the tarsal claws (Fig. 47), the presence of 4 to 8 lateral spines on abdominal segments VIII and IX (Fig. 44). If the colouration and size are relatively stable among each population, important variations have been found between populations. We can especially notice that specimens from the pools of Wadi Hatta are 50% bigger than specimens of other populations, and the larvae collected in Wadi Wurayah are almost completely faded. However, there are no morphological characters to support the establishment of different species.

The easiest characters to separate the two species of *Cloeon* occurring in UAE are the size (bigger in *Cloeon vanharteni*), the shape of male gonopods (segment I and II separated in *Cloeon vanharteni* (Plate 10), fused in *Cloeon arenorum* (Plate 14)), the shape of the upper lamella of gills (reduced in *Cloeon vanharteni* (Fig. 31), well-developed in *Cloeon arenorum* (Fig. 42)), the size of teeth of the tarsal claws (reduced in *Cloeon vanharteni* (Fig. 35), well developed in *Cloeon arenorum* (Fig. 47)) and the abdominal pattern of the larvae (Plates 8 and 12).

Cloeon arenorum can be also easily separated from *Cloeon smaeleni* by the colouration of the female forewing (Plate 13) and at the larval stage by the degree of development of the maxillary palp (Fig. 41) (Gattolliat & Rabeantoandro, 2002). *Cloeon saharensense* is rather similar both at the imaginal stage and larval stage to *Cloeon arenorum*, but the two species can be separated at the imaginal stage by the shape of the gonopods (Plate 14), especially of the apex of the second segment, and at the larval stage by the number of segments of the maxillary palp (Fig. 40), the degree of development of the upper lamella of the gills (Fig. 42) and the presence/absence of lateral spines on abdominal segments VIII and IX (Fig. 44) (Soldán & Thomas, 1983).

Distribution and ecology: *Cloeon arenorum* is by far the most common and abundant species of mayflies in United Arab Emirates. This species has been found in every kind of still and standing waterbody. We collected numerous larvae in natural small ponds as well as in artificial reservoirs. It is less abundant but anyway present in still part of stream (pools and riparian vegetation) as well as tanks used to collect water for agriculture. As mentioned for *Cloeon vanharteni*, it is possible that part of the material collected in Oman and Saudi Arabia and not assigned to a species (Thomas & Sartori, 1989) may belong to *Cloeon arenorum*.

With regards to the number of localities and diversity of habitat colonized by *C. arenorum*, it would be surprising if this species is restricted to the United Arab Emirates. The females of *Cloeon arenorum* are ovoviviparous.

Etymology: The specific epithet is Latin and means “coming from the sand”.

Family Leptophlebiidae

***Choroterpes (Choroterpes) pacis* Sartori, 1991 nov. comb.** (Plates 16-17, 20-21, Figs 48-61)

Choroterpes (Euthraulus) pacis Sartori, 1991

Specimens examined: Wadi Wurayah (stream), 42♂ subim., 45♀ subim., 43 larvae, 26.xi.2006, leg. JLG; 11 larvae (pool at the end of the road), 26.xi.2006, leg. JLG; 44 larvae, 4.xii.2006, leg. JLG. Wadi Shawkah (pond), 2 larvae, 27.xi.2006, leg. JLG; 17♂ subim., 19♀ subim., 2 larvae (stream), 28.xi.2006, leg. JLG. Wadi Shis, 1 larva, 3.xii.2006, leg. JLG.

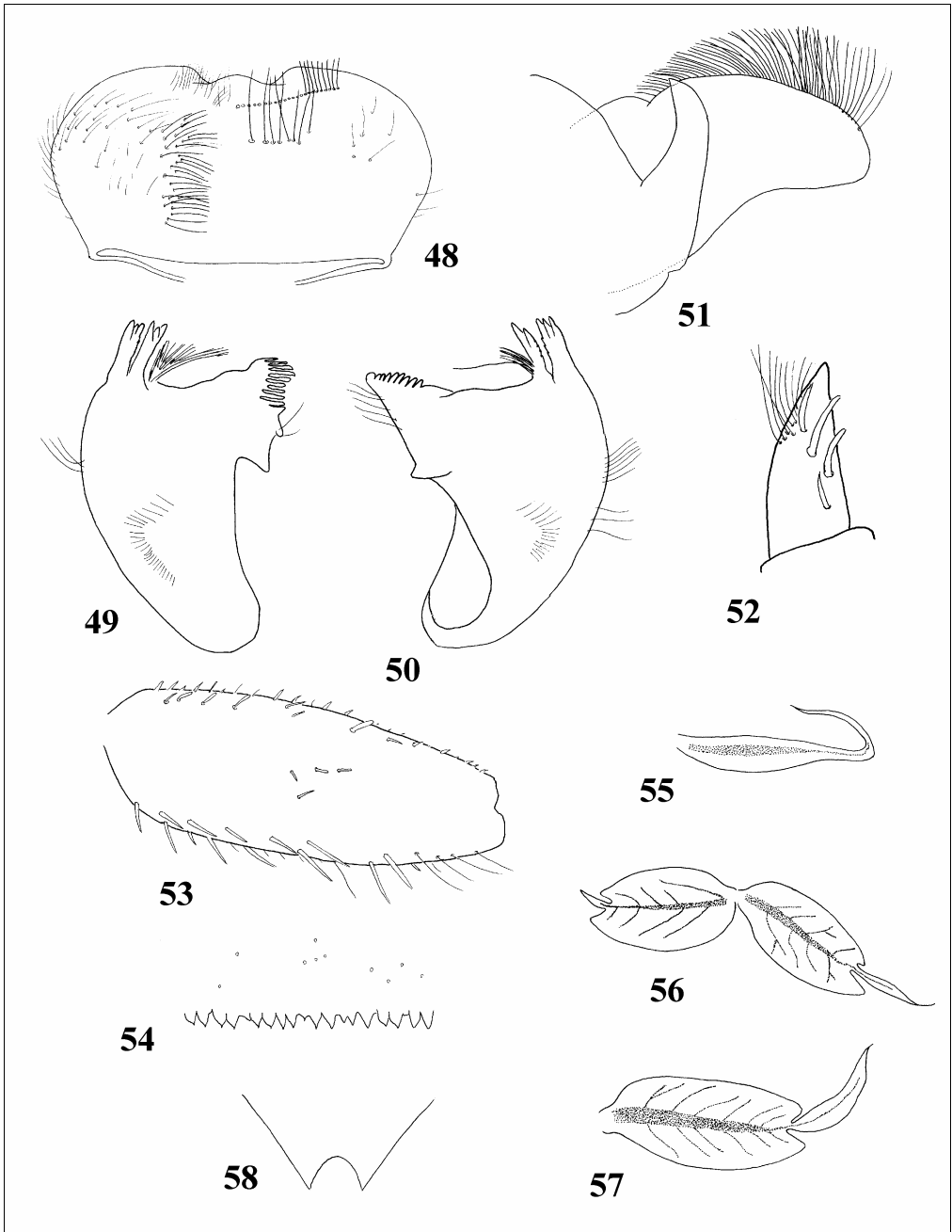
Description: Larva (Plate 16). Body length (without cerci) up to 4.8 and 5.3 mm in male and female larvae respectively. General colouration medium brown. Turbinate eyes in male larvae

reddish brown. Legs whitish, anterior face of femora with distinct median dark spot; distal part of femora and proximal part of tibiae darker. Thoracic ganglia tinted with purple. Abdominal tergites medium brown, with a pair of submedian yellowish brown areas, increasing in size posteriorly. This pattern is variable; in some individuals, light areas are joined together (whereas these may be barely visible in others species). Abdominal sternites uniformly light brown. Cerci yellowish brown. Head. Labrum (Fig. 48) about 2 times broader than long; lateral margin regularly rounded; anterior margin with wide emargination bearing well developed median rounded process; dorsal face with double row of long setae; ventral face with scattered, long setae directed towards centre. Right mandible (Fig. 49) with outer incisor composed of three denticles and inner one of two denticles. Outer margin with few scattered long and thin setae. Left mandible (Fig. 50) with outer incisor with three denticles, ventral face bearing two teeth, inner incisor with three denticles. Outer margin with only 3-4 long and thin setae. Hypopharynx (Fig. 51) with superlinguae well developed laterally, broad, rounded at the apex, covered with long, thin setae on dorsal face, which do not reach apex of superlinguae. Maxillae typical of other *Choroterpes* Eaton, 1881 species. Segment III of the labial palp ca 2 times longer than wide at base, row of 4-5 stout setae on ventral side (Fig. 52). Legs slender; femora of all legs (Fig. 53) with row of long, pointed setae on dorsal margin and row of long, pointed submarginal setae. Ventral margin with short, stout, pointed setae, also with submarginal row of setae slightly longer. Anterior face of femora with very few stout, blunt setae. Tarsal claw with ca 12 teeth increasing in size towards apex. Abdominal tergites with very few setae; posterior margin of tergite VI with broad spines about 2 times as long as broad at base (Fig. 54). Gill I filliform and long (Fig. 55); gills II-VII similar to each other (Figs 56-57); upper lamella with well developed median process, much longer than in lower lamella. Sternite IX of female larva very characteristic, becoming regularly narrow and with short and rounded incision (Fig. 58). Cerci with a whorl of setae every two segments.

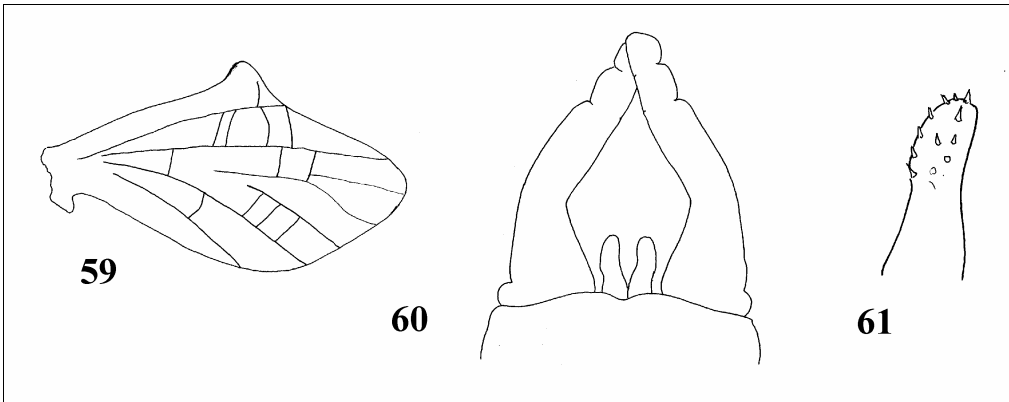
Subimagos: Female body length: 5.0-5.5 mm; forewing length: 5.0-5.3 mm. Male body length: 4.5-4.8 mm; forewing length: 4.5-5.0 mm. General patterns of colouration, especially markings on femora, thoracic ganglia and tergites, as in larva (Plate 17). Colouration more contrasted in male than in female. Fore- and hindwing (Fig. 59) venation same as in male imago. Subanal plate of the female deeply cleft in middle, as shown in female larva. Male genitalia (Fig. 60) similar to those of the imago, especially concave margin of styliger plate, basal reinforcement of segment I of gonopods, presence of numerous spines on outer margin as well as dorsal and ventral surfaces of the penis lobes (Fig. 61).

Eggs: Elongated shape, length ca 125 μm , width ca 70 μm . Polar cap absent, no extrachorionic structures (Plate 20). Chorion smooth, slightly granular in appearance. Micropyle simple, located near one pole (Plate 21).

Remarks: The shape of the gills (Figs 56-57) clearly indicates that *Ch. pacis* belongs to the subgenus *Choroterpes* s.s. and not to the subgenus *Euthraululus* Barnard, 1932 where it was originally placed. Different authors had pointed that the characters used to separate both subgenera at the winged stage, especially the shape of the costal process of the hindwing (Peters & Edmunds, 1964), were not stable enough for the circummediterranean species (Kluge, 1984; Vitte & Thomas, 1988; Sartori & Gillies, 1990; Sartori, 1991). More recently, Bauernfeind (1998) was the first to propose some other features (spines on the penis lobes, concave margin of the styliger plate) to distinguish adult stages of both subgenera. He also questioned the placing of *Ch. pacis* in the subgenus *Euthraululus* on the basis of these new characters, concluding that without the larval stage, the question will remain open. We hereby confirm Bauernfeind's hypothesis and remove *Ch. pacis* from the subgenus *Euthraululus*, placing it into the subgenus *Choroterpes* s.s.



Figs 48-58. Larval structures of *Choroterpes (Choroterpes) pacis* Sartori. 48: Labrum (left: ventral; right: dorsal); 49: Right mandible; 50: Left mandible; 51: Hypopharynx; 52: Labial palp segment III; 53: Femora; 54: Distal margin of abdominal tergite IV; 55: Gill I; 56: Gill VII; 57: Gill IV, upper lamella; 58: Sternite IX of female larva.



Figs 59-61. Imaginal structures of *Choroterpes (Choroterpes) pacis* Sartori. 59: Hindwing; 60: Subimaginal ♂ genitalia; 61: Penis lobe.

Choroterpes (Ch.) pacis is very different to other Palearctic species. The larva of *Ch. (Ch.) pacis* possesses unique characters found in no other known species, namely *Ch. (Ch.) picteti* (Eaton, 1871); *Ch. (Ch.) atlas* Soldán & Thomas, 1983, *Ch. (Ch.) borbonica* Belfiore, 1988, *Ch. (Ch.) prati* Puig & Gaino, 1996 or *Ch. (Ch.) salamannai* Gaino & Puig, 1996. These are: the median process in the emargination of the labrum (Fig. 48), the few setae on the outer margin of the mandibles (Figs 49-50), general setation of the femora, the shape of the spines on the posterior margin of the abdominal tergites (Fig. 54, much shorter than in other species), as well as the shape of the sternite IX in female larvae (Fig. 58). Adults of *Ch. (Ch.) pacis* are also very unusual, especially with the shape of the penis lobes being rounded (Figs 60-61, pointed in all other species, including in *Ch. (Ch.) volubilis* Thomas & Vitte, 1988, for which the larval stage is unknown). Finally, the egg structure (Plate 20) of *Ch. (Ch.) pacis* is very unusual, lacking the distinctive ridges that characterize most of *Choroterpes* species (sensu lato) (see for instance Sartori & Gillies, 1990; Gaino & Puig, 1996; Puig & Gaino, 1996). To our knowledge, a single other species presents the same chorionic structure: *Ch. (Euthraulius) assimilis* Gaino & Sowa, 1985 described from the island of Lesbos (Greece).

Outside the Palearctic Realm, the subgenus *Choroterpes* is known from South Africa, the Neotropics as well as from the Oriental region. None of the species described from there are related to *Ch. (Ch.) pacis*. Based on the available literature, we can even question the placement of these species in the genus *Choroterpes*, because they present important differences, both at the larval and adult stages, with the ground plan proposed by Bauernfeind (1998) and confirmed here. It is not the purpose of the present paper to deal in more details relationships among “*Choroterpes*” species throughout the world, but a careful revision is highly necessary.

Distribution: *Ch. (Ch.) pacis* is known from the United Arab Emirates and the Sultanate of Oman. The new findings of the species reported here are at a distance of only 400 kilometres from the type locality, and both belong to the same mountain range along the Gulf of Oman (mounts Hajar). Its presence in Iran is also credible.

Family Caenidae



Plates 16-17. *Choroterpes (Choroterpes) pacis* Sartori. 16: Larva, dorsal view; 17: ♂ subimago, dorsal view.

The material here studied comprises two species, of which one is quite abundant whereas the other seems restricted to a single wadi.

***Caenis malzacheri* Sartori & Gattolliat nov. spec.** (Plates 18, 22-23, Figs 62-67)

Specimens examined: Holotype: ♂ larva: United Arab Emirates, Wadi Wurayah (stream), [25°24'N 56°17'E, 165 m]. 26.xi.2006, leg. J.-L. Gattolliat. Paratypes: 1 ♂ larva, same data as holotype; 2 larvae (one mounted in Canada Balsam), same locality and collector but 4.xii.2006.

Description: Larva (Plate 18). Body length (without cerci): up to 3.1 mm in male larva (female larva unknown). Head and thorax dark brown, abdomen lighter. Abdominal sternites yellowish brown, with triangular dark markings near lateral margins, becoming thinner and more elongated backwards. Head. Labial palp with segment III ca half length of segment II; dorsal face with row of 4-5 stout, pointed bristles in middle (Fig. 62). Pronotum with lateral margins regularly rounded, convex, without antero-lateral expansions. Forefemora (Fig. 63) with incomplete row of long, feathered and sometimes bifid bristles; anterior margin with row of long, solid and pointed setae, mixed with few very thin and long setae. Anterior surface of femora, distally to row of bristles, with polygonal mesh-like pattern, with sclerotized and pointed structures at angles of each polygon (Plate 22). Tarsal claws with 4-5 teeth in proximal part; claw moderately bent, apex without teeth or microteeth (Fig. 64). Abdominal margin with posterolateral expansions weakly developed on segments I-VI, moderately developed on segments VII-IX. Operculate gills (Fig. 65) with incomplete Y shape on upper face; long branch with numerous, long, simple setae; incomplete branch naked; margin with long, simple setae. Dorsal side mesh-like with two different structures: above long branch, structures similar to those on femora, with sparse flower-like microtrichiae (Plate 23); under long branch, reticulated structure only. No row of microtrichiae visible on ventral side. Margin of sternite IX (Fig. 66) smoothly emarginated, with short and feathered setae on margin (Fig. 67).

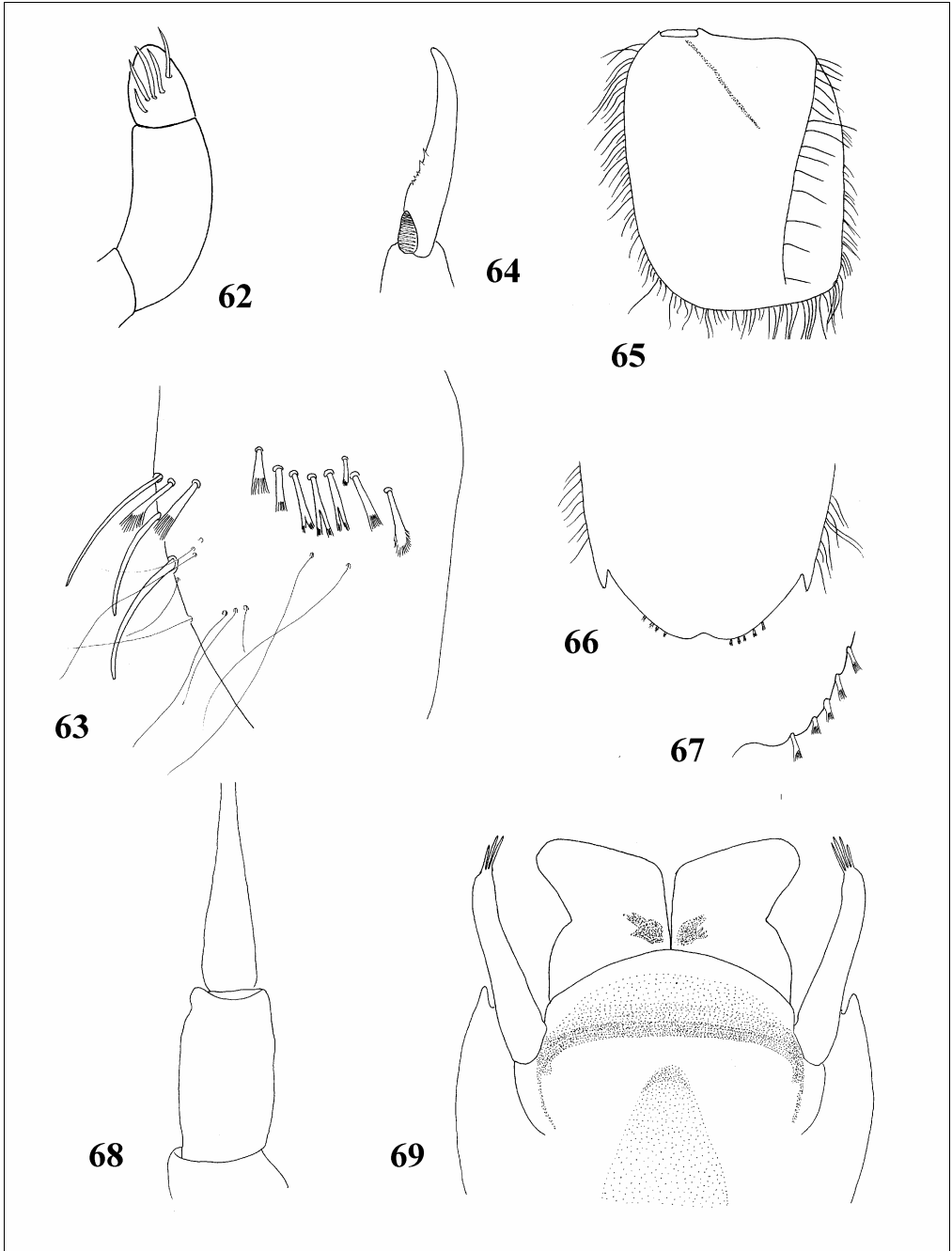
Imagos: Unknown.

Remarks: *C. malzacheri* is known only at the larval stage and is not assignable to any group of the West Palearctic species as defined by Malzacher (1984); it shares some affinities with the *macrura* group (Fig. 63, row of setae on the forefemora) and with the *pseudorivulorum* group (Fig. 66, emargination of the sternite IX). The absence of a row of microtrichiae on the lower surface of the operculate gills could be a unique apomorphy for *C. malzacheri*. Compared to *C. corana* Thomas & Sartori, 1989 described from Saudi Arabia, *C. malzacheri* presents important differences such as the length of the segment III of the labial part (Fig. 62, much shorter relatively to the segment II in *C. corana*), the absence of microteeth on the tarsal claw, the absence of setae on the incomplete branch of the operculate gills (Fig. 65), the shape of the sternite IX (Fig. 66, much pronounced emargination in *C. corana*).

Comparison with *Caenis* species from other areas is problematic since few species are known at the larval stage. From the Near East, it shares with *C. parabrevipes* Malzacher, 1992 the shape of the sternite IX, but the setae on the lateral margins of the abdomen are much longer in *C. malzacheri* (Malzacher, 1992). In the Afrotropics, it can be only compared to *C. occulta* Malzacher, 1990, from which it can be easily separated by the shape of the sternite IX (Malzacher, 1990).

Distribution: *Caenis malzacheri* is only known from the United Arab Emirates where it is restricted to a single wadi of the east coast.

Etymology: We are pleased to dedicate this new species to our colleague and friend Peter Malzacher (Ludwigsburg, Germany) in recognition to his outstanding contribution to our knowledge of the Caenidae worldwide.



Figs 62-69. Larval and imaginal structures of *Caenis malzacheri* nov. spec. (62-67) and *Caenis cf. luctuosa* (Burmeister) (68-69). 62: Labial palp; 63: Anterior face of fore femora; 64: Tarsal claw; 65: Operculate gill; 66: Margin of sternite IX; 67: Setae on the margin of sternite IX; 68: Pedicel of antenna; 69: ♂ genitalia (ventral view).

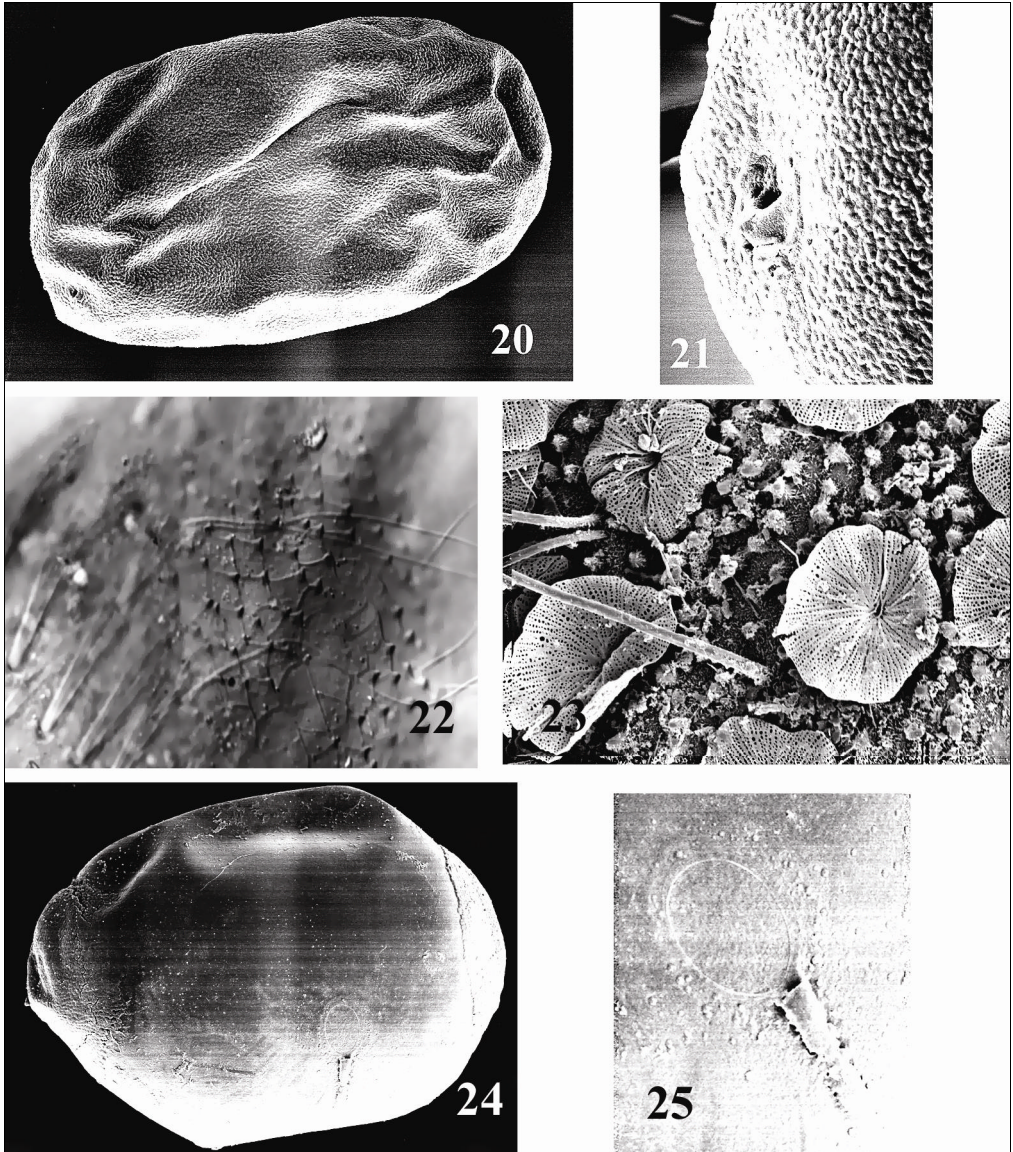


18



19

Plates 18-19. *Caenis* spp. 18: *Caenis malzacheri* nov. spec., larva, dorsal view. 19: *Caenis cf. luctuosa* (Burmeister), ♂ imago, dorsal view.



Plates 20-25. Microscopic pictures. 20: *Choroterpes (Choroterpes) pacis* Sartori, egg (SEM); 21: *Choroterpes (Choroterpes) pacis*, micropyle area (SEM); 22: *Caenis malzacheri* nov. spec., details of the cuticle on the fore femora (OMPC); 23: *Caenis malzacheri*, detail of the operculate gill (SEM); 24: *Caenis cf. luctuosa* (Burmeister), egg (SEM); 25: *Caenis cf. luctuosa*, micropyle area (SEM). SEM = Scanning Electronic Microscope; OMPC = Optic Microscope with Phase Contrast.

Caenis spec. cf. *Caenis luctuosa* (Burmeister, 1835) (Plates 19, 24-25, Figs 68-69)

Specimens examined: Bithnah, 2♂ im., 31.xii.2005-2.ii.2006, LT. SSW of ad-Dhaid, 1♂ im., 29.xii.2005-7.i.2006, LT. Hatta, 1♀ im., 08-26.iv.2006, LT. Sharjah x Khor Kalba, near tunnel, 1♂ im., 16-31.i.2006, LT; 1♂ im., 7-22.iii.2006, LT. Wadi Madaq, 155♂ im., 52♀ im., 5-15.xii.2005, LT; 54♂ im., 6♀ im., 27.xi-22.xii.2005, LT; 4♂ im., 1 im., 22.xii.2005-2.ii.2006, LT. Wadi Shawkah, 1♂ subim., 31.x-27.xi.2006, WT.

Description: Male imago. Body length: 2.8-3.2 mm; wing length: 2.2-2.5 mm. Colouration of chitinous layers: head and pronotum greyish brown; Mesonotum middle brown, pleurites paler; abdomen light brown (Plate 19). Epidermal colouration: pronotum with two submedian elongated markings; abdominal tergites I-II intensely coloured in purple brown, with two blackish elongated dots in middle; following tergites lighter except along lateral margins; tergite X with three brownish markings at base of cerci and terminal filament. Pedicel of antenna (Fig. 68) ca 1.8-1.9 longer than broad; base of antennal bristle moderately dilated. Prosternal triangle narrow and slightly tapered at apex. Lateral filaments of abdominal segments short. No filament on tergite II. Penis lobes boot-like, more or less squat at apex. Outer margin perpendicular or slightly turned inwards to body axis. Styliiger sclerites with short apophyses. Central sclerites rounded, bomb-shaped, and elongated. Forceps relatively straight, with bunch of 3-5 long spines; forceps covered with long stout setae (Fig. 69).

Female imago. Body length: 3.6-4.2 mm; wing length: 2.9-3.3 mm. Chitinous and epidermal colourations as in male, except head lighter, pronotum without markings, colouration on tergites I-II more contrasted and tergite X uniform.

Eggs. Rhomboid in shape (Plate 24), length ca 140 µm, width ca 100µm. Two polar caps present. Chorionic surface smooth, micropyle large in subequatorial position, with well marked sperm guide (Plate 25).

Remarks: The identification of these specimens, based only of adult stages, is tentative. They show clear affinities with *Caenis luctuosa*, such as the enlarged antennal pedicel (Fig. 68), the shape of the styliiger and central sclerites (Fig. 69), as well as the shape of the eggs (Plate 24). They slightly differ anyway in the shape of the penis lobes, and the length of the postero-lateral spines on abdominal segments VIII-IX. The possibility that *Caenis* cf. *luctuosa* adults constitute in fact the alate stage of *C. malzacheri* is unlikely, based on cuticular pigmentation and the fact that we have an incomplete larva similar to *C. luctuosa* from a locality where adults of *C. cf. luctuosa* were found. Further material, including larvae, is necessary to clear its status.

Distribution: *Caenis luctuosa* is a widespread Palaearctic species, found throughout Europe and North Africa. It has already been mentioned from the Arabian Peninsula by Thomas & Sartori (1989).

ACKNOWLEDGEMENTS

We want to express our gratitude to Antonius van Harten for involving us in his project, making the material he collected available to us and especially for his kind hospitality during the stay of the first author in UAE. We also thank Khalid Mahmood for his help during the fieldtrips and the collecting of insects. Our gratitude to Helen M. James (Albany Museum, Grahamstown, South Africa) for providing a critical review of the manuscript. The SEM photographs were realized at the Electronic Microscopy Center of Lausanne University by Geneviève L'Eplattenier, thanks for her technical assistance.

REFERENCES

- Abdu, R.M. & N.F. Shaumar (1985): A preliminary list of the insect fauna of Qatar. *Qatar University Science Bulletin*, 5: 215-232.
- Barber-James, H.M., J.-L. Gattolliat, M. Sartori, & M.D. Hubbard (in press): A global assessment of animal diversity in continental waters: Ephemeroptera. *Hydrobiologia*.
- Bauernfeind, E. (1998): Taxonomie und Verbreitung von *Choroterpes* Eaton in der Palaearktis (Insecta: Ephemeroptera: Leptophlebiidae). *Stapfia*, 55: 629-640.
- Fujitani, T., T. Hirowatari & K. Tanida (2003): Nymphs of *Nigrobaetis*, *Alainites*, *Labiobaetis*, *Tenuibaetis* and *Baetis* from Japan (Ephemeroptera: Baetidae): Diagnoses and keys for genera and species. *Research Update on Ephemeroptera and Plecoptera* (E. Gaino, ed.), pp. 127-133. University of Perugia, Italy, Perugia.
- Gaino, E. & M.A. Puig (1996): *Choroterpes (Choroterpes) salamannai*, a new species of mayfly from Central and South West Spain (Ephemeroptera, Leptophlebiidae). *Bollettino della Societa entomologica italiana*, 128: 99-104.
- Gattolliat, J.-L. (2004): First reports of the genus *Nigrobaetis* Novikova & Kluge (Ephemeroptera: Baetidae) from Madagascar and La Réunion with observations on Afrotropical biogeography. *Revue Suisse de Zoologie*, 111: 657-669.
- Gattolliat, J.-L. & S.Z. Rabeantoandro (2002): The genus *Cloeon* (Ephemeroptera, Baetidae) in Madagascar. *Mitteilungen der Schweizerischen Entomologischen Gesellschaft*, 74: 195-209 (2001).
- Gattolliat, J.-L., M.T. Monaghan, M. Sartori, J.M. Elouard, H. James, P. Derleth, O. Glaizot, F. de Moor & A.P. Vogler (in press): Preliminary results from a molecular analysis of the Afrotropical Baetidae: genetic insights regarding phylogeny. *International Advances in the Ecology, Zoogeography and Systematics of Mayflies and Stoneflies* (F.R. Hauer, J.A. Stanford & R.L. Newell, eds). University of California Press, Berkeley, California, USA.
- Gillies, M.T. (1985): A preliminary account of the East African species of *Cloeon* Leach and *Rhithrocloeon* gen. n. (Ephemeroptera). *Aquatic Insects*, 7: 1-17.
- Gillies, M.T. (1998): The mayflies (Ephemeroptera) of the upper River Sigi, North-East Tanzania. *Freshwater Forum*, 10: 49-57.
- Gillies, M.T. (2001): New species of Baetidae (Ephemeroptera) from the Upper River Sigi, Usambara, Tanzania. *Journal of Natural History*, 35: 23-32.
- Gillett, M. & B. Howarth (2004): The insects of Jebel Hafit. Pp. 94-143 in: S. Aspinall & P. Hellyer (eds): *Jebel Hafit, a Natural History*, Emirates Natural History Group, Abu Dhabi.
- Jacob, U. (2003): *Baetis* Leach 1815, sensu stricto oder sensu lato. Ein Beitrag zum Gattungskonzept auf der Grundlage von Artengruppen mit Bestimmungsschlüsseln. *Lauterbornia*, 47: 59-129.
- Kang, S.C., H.C. Chang & C.T. Yang (1994): A revision of the genus *Baetis* in Taiwan (Ephemeroptera, Baetidae). *Journal of Taiwan Museum*, 47: 9-44.
- Kluge, N.J. (1983): [New and little-known mayflies of the family Baetidae (Ephemeroptera) from Primorye Territory.] (in Russian). *Revue d'Entomologie de l'URSS*, 61: 65-79.
- Kluge, N.J. (1984): [Mayflies of the subgenus *Euthraulius* Barn. (Ephemeroptera, Leptophlebiidae, genus *Choroterpes*) of the fauna of the USSR.] (in Russian). *Entomologiceskoe Obozrenie*, 63: 722-728.

- Lugo-Ortiz, C.R. & F.C. de Moor (2000): *Nigrobaetis* Novikova & Kluge (Ephemeroptera: Baetidae): first record and new species from southern Africa, with reassignment of one northern African species. *African Entomology*, 8: 69-73.
- Lugo-Ortiz, C.R. & W.P. McCafferty (1997a): Contribution to the systematics of the genus *Cheleocloeon* (Ephemeroptera: Baetidae). *Entomological News*, 108: 283-289.
- Lugo-Ortiz, C.R. & W.P. McCafferty (1997b): New species and first reports of the genera *Cheleocloeon*, *Dabulamanzia*, and *Mutelocloeon* (Insecta: Ephemeroptera: Baetidae) from Madagascar. *Bulletin de la Société d'Histoire Naturelle de Toulouse*, 133: 47-53.
- Lugo-Ortiz, C.R. & W.P. McCafferty (1998): *Cheleocloeon falcatum* (Crass), a new combination for a southern African species previously assigned to *Afroptilum* Gillies (Ephemeroptera: Baetidae). *African Entomology*, 6: 379-380.
- Malzacher, P. (1982): Eistrukturen europäischer Caenidae (Insecta, Ephemeroptera). *Stuttgarter Beiträge zur Naturkunde, Serie A (Biologie)*, 356: 1-15.
- Malzacher, P. (1984): Die europäischen Arten der Gattung *Caenis* Stephens (Insecta: Ephemeroptera). *Stuttgarter Beiträge zur Naturkunde, Serie A (Biologie)*, 373: 1-48.
- Malzacher, P. (1990): Caenidae der äthiopischen Region (Insecta: Ephemeroptera). Teil 1. Beschreibung neuer Arten. *Stuttgarter Beiträge zur Naturkunde, Serie A (Biologie)*, 454: 1-28.
- Malzacher, P. (1992): Mayflies from Israel (Insecta, Ephemeroptera) II. Caenidae. *Mitteilungen der Schweizerischen Entomologischen Gesellschaft*, 65: 385-394.
- Malzacher, P. (1993): Caenidae der äthiopischen Region (Insecta: Ephemeroptera). Teil 2. Systematische Zusammenstellung aller bisher bekannten Arten. *Mitteilungen der Schweizerischen Entomologischen Gesellschaft*, 66: 379-416.
- Malzacher, P. (1995): Caenidae from Madagascar (Insecta, Ephemeroptera). *Stuttgarter Beiträge zur Naturkunde, Serie A (Biologie)*, 530: 1-12.
- McCafferty, W.P. (2001): New Baetidae (Insecta: Ephemeroptera) from Lake Malawi. *Bulletin de la Société d'Histoire Naturelle de Toulouse*, 136: 65-72 (2000).
- Monaghan, M.T., J.-L. Gattolliat, M. Sartori, J.M. Elouard, H. James, P. Derleth, O. Glaizot, F. de Moor, & A.P. Vogler (2005): Trans-oceanic and endemic origins of the small minnow mayflies (Ephemeroptera, Baetidae) of Madagascar. *Proceedings of the Royal Society, B-Biological Sciences*, 272: 1829-1836.
- Müller-Liebenau, I. (1969): Revision der europäischen Arten der Gattung *Baetis* Leach, 1815 (Insecta, Ephemeroptera). *Gewässer und Abwässer*, 48/49: 1-214.
- Müller-Liebenau, I. (1984): New genera and species of the family Baetidae from West-Malaysia (River Gombak) (Insecta: Ephemeroptera). *Spixiana*, 7: 253-284.
- Peters, W.L. & G.F. Edmunds (1964): A revision of the generic classification of the Ethiopian Leptophlebiidae (Ephemeroptera). *Transactions of the Royal Entomological Society of London*, 116: 225-253.
- Puig, M.A. & E. Gaino (1996): *Choroerpes (Choroerpes) prati* n. sp., a new species of mayfly from North-East of Spain (Ephemeroptera: Leptophlebiidae). *Annales de Limnologie*, 32: 229-233.
- Sartori, M. (1991): The Mayfly fauna (Insecta; Ephemeroptera) of the Arabian Peninsula (Part 3). *Fauna of Saudi Arabia*, 12: 242-245.
- Sartori, M. & M.T. Gillies (1990): Further Records of Mayflies (Insecta: Ephemeroptera) from the Arabian Peninsula. Leptophlebiidae and Baetidae. *Fauna of Saudi Arabia*, 11: 10-17.

- Soldán, T. (1977): Three new species of mayflies (Ephemeroptera) from the mist oasis of Erkwit, Sudan. *Acta Entomologica Bohemoslovaca*, 74: 289-294.
- Soldán, T. & A.G.B. Thomas (1983): New and little-known species of mayflies (Ephemeroptera) from Algeria. *Acta entomologica bohemoslovaca*, 80: 356-376.
- Soldán, T. & A.G.B. Thomas (1985): *Centroptilum dimorphicum* sp. n., a new species of mayfly (Ephemeroptera, Baetidae) from Algeria. *Acta entomologica bohemoslovaca*, 82: 180-186.
- Sowa, R. (1975): What is *Cloeon dipterum* (Linnaeus, 1761)? - The nomenclatural and morphological analysis of a group of the European species of *Cloeon* Leach (Ephemera: Baetidae). *Entomologica Scandinavica*, 6: 215-223.
- Sowa, R. (1980): Taxonomy and ecology of European species of the *Cloeon simile* Eaton group (Ephemeroptera: Baetidae). *Entomologica Scandinavica*, 11: 249-258.
- Thomas, A.G.B. & M. Sartori (1989): Mayflies (Insecta, Ephemeroptera) of Saudi Arabia. *Fauna of Saudi Arabia*, 10: 87-94.
- Vitte, B. & A.G.B. Thomas (1988): Complément et corrections à la faune des Ephéméroptères d'Afrique du Nord. 2. Le genre *Choroerpes* Eaton, sous-genre *Euthraululus* Barnard (Ephemeroptera). *Annales de Limnologie*, 24: 160-165.
- Waltz, R.D., W.P. McCafferty & A. Thomas (1994): Systematics of *Alainites* n. gen., *Dipheter*, *Indobaetis*, *Nigrobaetis* n. stat., and *Takobia* n. stat. (Ephemeroptera, Baetidae). *Bulletin de la Société d'Histoire Naturelle de Toulouse*, 130: 33-36.
- Wuillot, J. & M.T. Gillies (1993): *Cheleocloeon*, a new genus of Baetidae (Ephemeroptera) from West Africa. *Revue d'Hydrobiologie tropicale*, 26: 213-217.

Authors' addresses:

Dr. J.-L. Gattolliat, Musée cantonal de zoologie, Palais de Rumine, Place de la Riponne 6, CH-1014 Lausanne, Switzerland; e-mail: jean-luc.gattolliat@vd.ch

Dr. M. Sartori, Musée cantonal de zoologie, Palais de Rumine, Place de la Riponne 6, CH-1014 Lausanne, Switzerland; e-mail: Michel.Sartori@vd.ch