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Caenis vanuatensis, a new species of mayflies (Ephemeroptera: Caenidae) from Vanuatu

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Abstract

The first species of Caenidae from Espiritu Santo, Vanuatu, is described based on the larva and the female imago. *Caenis vanuatensis* sp. n. is most likely a parthenogenetic species, as only females have been found so far out of numerous specimens collected. The phylogenetic relationships of the new species thus remain enigmatic, as the distribution of *Caenis* throughout the Australian region is largely unknown and the taxonomically important males are missing.

Keywords: Mayfly, new species, parthenogenesis, New Hebrides, Australis, Santo 2006

Introduction

Except for Australia, the Caenidae of the Australian region are insufficiently investigated, and only a few Pacific islands are known to have been colonised by this group of mayflies. Caenidae are definitely absent from New Zealand and New Caledonia (Kimmins 1953; Edmunds 1972), even though both islands are of continental origin (White 1990). Two species are reported from New Guinea (van Bruggen 1957), namely *C. nigropunctata* Klapálek, 1905, and *Tasmanocoenis novaeguineae* van Bruggen, 1957. The identity of the latter species is dubious (Kluge 2004). *C. nigropunctata* is widely distributed and also occurs in the Oriental region, namely in the Philippines and Indonesia (Ulmer 1939). It has also been accidentally introduced to Hawaii (Zimmerman 1957; Smith 2000). The Fijian caenid fauna is represented by a single undescribed species of *Caenis* (Flowers 1990; Evenhuis 2006). Likewise, there has been only a single species of Baetidae described from Vanuatu (*Cloeon erromangense* Kimmins, 1936), but no species of Caenidae has ever been reported from this group of Pacific islands (Kimmins 1936).

In this contribution we describe *Caenis vanuatensis* sp. n., based on material (larvae and adults) collected from several localities in the western and eastern parts of Espiritu Santo, Vanuatu (formerly known as New Hebrides), in 2006.

Material and methods

One of us (AHS) participated in the scientific expedition ''Santo 2006'' conducted by the Muséum national d'Histoire naturelle Paris to document the biodiversity of Espiritu Santo,

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the largest island of Vanuatu. During this expedition throughout November 2006, there were also numerous larvae and imagines of mayflies collected throughout the island in several streams close to the shore. Most of the material belongs to the species described herein.

It should be noted that there were only larval specimens collected by kick-sampling, although several efforts were undertaken to catch adult specimens by light-trapping at dusk. However, adult specimens could be reared from last instar larvae in floating rearing cages (see Edmunds et al. 1976) that were placed in the streams. All material is stored in 75% EtOH.

Specimens used for SEM were dehydrated through a stepwise immersion in ethanol and then dried by critical point drying. The mounted material was coated with a 20 nm Au/Pd layer, and examined with an ISI-SS40 scanning electron microscope at 10 kV. Digital SEM photographs were directly acquired by using DISS 5 (point electronic) and subsequently enhanced using Adobe Photoshop 7. Series of digital habitus photographs of imago and larva were taken through a Leica Macroscope, processed with Synchroscopy Automontage, and subsequently enhanced with Adobe Photoshop 7.

The types of the new species are deposited in the following entomological collections: holotype and paratypes are deposited in the Staatliches Museum für Naturkunde Stuttgart, Germany (SMNS); additional paratypes in the Muséum national d'Histoire naturelle Paris, France (MNHN); Biological Centre, Institute of Entomology, Academy of Sciences of the Czech Republic, České Budějovice, Czech Republic (IEAVCR); Florida A&M University Museum Collections of Aquatic Entomology, USA (FAMU); and Australian National Insect Collection, Canberra, Australia (ANIC).

Systematic account

Caenis vanuatensis sp. n.

Material investigated. Holotype ♀ imago reared from larva with associated larval exuvia: Tasmate, Mamasa River, S 15.21343° E 166.67004°, 39 m, 10.XI.2006 (type locality); paratype ♀ imago reared from larva with associated larval exuvia: Peavot, Piabouboko River, 96 m, S 14.99462° E 166.76741°, 20.XI.2006; additional paratypes Tasmate, Mamasa River, S 15.21343° E 166.67004°, 39 m, 10.XI.2006, 50 ♀ L.

Additional material. Tasmate, Pélapa River, S 15.17822° E 166.65511°, 16 m, 10.XI.2006, 33 ♀ L; Tasmate, Paé River S 15.21751° E 166.68706°, 139 m, 11.XI.2006, 40 ♀ L; Penaoru, Penaoru River, S 14.96105° E 166.63316°, 90 m, 13.XI.2006, 2 ♀ L; Penaoru, Pétouva River, 68 m, 15.XI.2006, S 14.97245° E 166.62572°, 2 ♀ L; Penaoru, Pétouva River, 215 m, 15.XI.2006, S 14.97770° E 166.64525°, 4 ♀ L; Peavot, Piabouboko River, 96 m, S 14.99462° E 166.76741° 20.XI.2006, 33 ♀ L; Peavot, Piabouboko River, 78 m, S 14.99361° E 166.77527°, 21.XI.2006, 19 ♀ larvae; Peavot, Piapoura River, 8 m, S 14.98416° E 166.79428°, 20.XI.2006, 70 ♀ L. All specimens A. Staniczek leg.

Female imago (Figure 1)

Body length 2.5 – 2.7 mm; wing length 2.2 – 2.4 mm; length of caudal filaments ±1.0 mm.

Colouration of chitinous layers. Mesonotum, metanotum, pleura and femora yellow to yellowish-brown; abdomen white. Bases of caudal filaments, tibiae, and sutures generally light brown to dark brown.

Figure 1. *Caenis vanuatensis* sp. n., female imago in dorsal view.

Epidermal pigmentation. Head, pronotum and abdomen almost entirely covered with blackish pigments (intensity differing in different specimens), in contrast to the nearly unpigmented mesonotum. Prealar bridge and metanotum greyish to blackish, the latter with a black median spot. Base of scutellum, submentum, base of antenna, wing base and veins grey; subcosta strongly reddish-grey.

Pedicel two times as long as scape. Base of antennal flagellum slightly dilated. Lateral margins of pronotum rounded, converging anteriorly. Mesonotum short and broad. Wing vein $ICuA_1$ forked with CuA_2 immediately (or with short stalk) distad of CuA1-CuP cross vein. Whole hind margin of wing with short, hair-like setae. Second abdominal tergum without posteromedian finger-like process. Lateral filaments on abdominal segments IV – IX short. Subgenital plate inconspicuous; hind margin straight. Hind margin of subanal plate medially straight or slightly concave.

Female larva (Figures 2 – 22)

Body length of last instar. 3.3 – 3.8 mm. Length of cerci 2.2 – 2.4 mm, length of paracercus 2.6 – 2.8 mm.

Colouration of chitinous layers (Figure 2). Head, pro- and mesonotum yellowish brown, mesonotum with lighter areas at base of wing buds, thoracic sterna pale, abdominal terga I, II, and VII – X light yellowish brown; abdominal sterna pale, caudal filaments, legs, and antennae yellowish white.

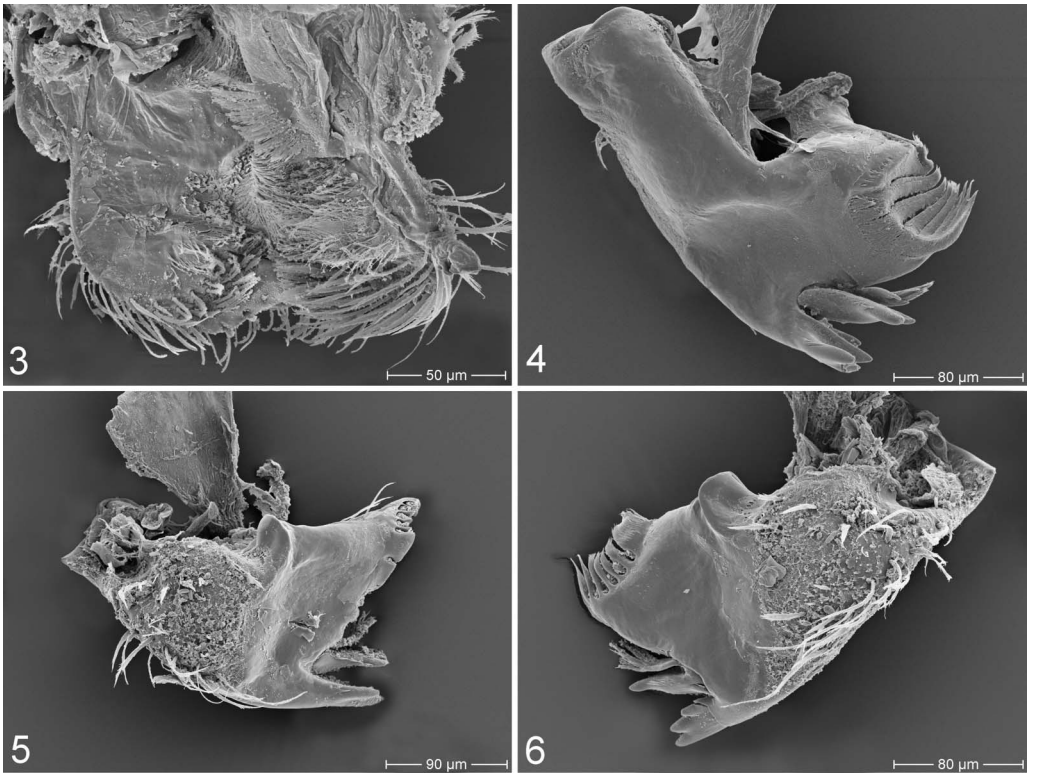
Epidermal pigmentation. Head with broad, blackish brown band between lateral ocelli; roundish to oblong brownish tinge medially of each antennal base, vertex pale with narrow, grey margin. Pronotum grey to blackish brown, with lighter margins and spots (one smaller, paramedian central spot and one larger, lateral spot in each half of pronotum). Mesonotum with weaker pigmentation compared to pronotum. Legs without pigmentation. Abdominal terga I and II with grey band on at least anterior half, terga VII – IX also with anterior grey

Figure 2. *Caenis vanuatensis* sp. n.: larva in dorsal view.

band, which is sometimes medially interrupted by a lighter dash. Gill cover with strongly scattered greyish pigmentation. Terminal filaments without pigmentation (Figure 2).

Head. Genae distinctly bulged. Numerous thick bristles between genae and compound eyes and also between bases of mandible and maxilla. Labrum with broadly notched anterior margin; dorsal surface with long, simple, setae. Right half of epipharynx (Figure 3) distally covered with a dense field of thick bristles directed medially, left half of epipharynx only with few of these bristles. Right half of epipharynx with another dense field of fine hairs proximally to the thick bristles. Left half of epipharynx only with very few fine hairs. Mandibles with lengthy field of conspicuously strong bristles ventrolaterally. Lateral part with field of small denticles. Apical incisivus of right mandible (Figure 5) with three denticles, subapical incisivus with two denticles. Apical incisivus of left mandible (Figures 4, 6) with four, subapical incisivus with three denticles, respectively. Maxilla (Figures 7, 8). Cardo dorsally with group of long, thick bristles. Stipes entirely fused with galeolacinia. Maxillary palp long and slender, first and third segment about the same length, second segment shorter. Labium (Figures 9 – 11). Aboral side of postmentum laterodorsally with numerous very stout setae (Figure 9). Aboral side of glossae and paraglossae, and lateral sides of labial palps with numerous stout setae (Figure 11). Paraglossae with stout setae also on oral side (Figure 10). Labial palp laterally also with numerous long, fine setae. Third segment of labial palp short, second segment 2 – 2.5 times as long as segment three.

Thorax. Sides of pronotum slightly convex, converging posteriorly (Figure 2). Lateral parts of pro- and mesonotum, dorsal side of femora (Figure 12), and also parts of coxae (Figure 14) with overlapping, strongly pointed epicuticular scales (Figure 13). Anterior medial protrusion of prosternum with several short, apically pinnate bristles. Few strong bristles surrounding coxal cavities. Legs (Figures 12 – 16). Coxal process of mid coxa broad, sickle-shaped; coxal process of hind coxa semicircular (Figure 14). Profemur dorsally with more or less straight, dense row of sturdy, pinnate bristles (Figure 13), which are also apically rounded and pseudobifid (bristles appear to be bifid under light microscopy, while under scanning electron microscopy it becomes obvious that the bristles are not bifid but medially fused). Mid and hind femur (Fig. 14) dorsally with numerous bristles of different length. Foretarsus in its apical half ventrally with inner row of 5 – 6 slightly unipinnate bristles. Mid tarsus in its apical half ventrally with inner row of 4 – 6 unipinnate bristles and outer row of 1 – 2 unipinnate bristles (Figure 15). Hind tarsus in its apical half ventrally with inner row of 5 – 8 unipinnate bristles and outer row of 4 – 5 unipinnate bristles (Figure 16). Pinnae of bristles always



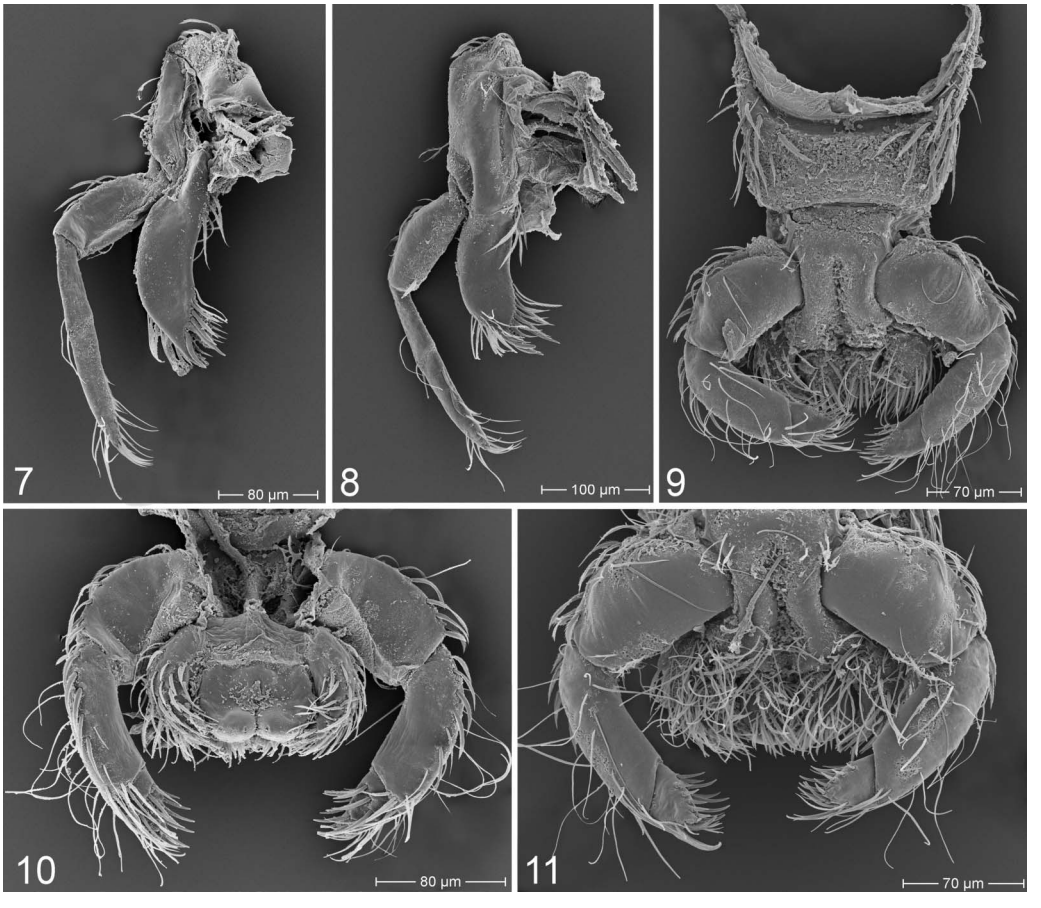
Figures 3–6. *Caenis vanuatensis* sp. n., larva: (3) epipharynx; (4) left mandible in posterior view; (5) right mandible in anterior view; (6) left mandible in anterior view.

directed medially (Figures 15, 16). Foreclaw with slender tip and without denticles. Mid claw more compact and also without denticles. Hind claw with curved tip and with single row of denticles (Figure 16).

Abdomen. Lateral lobes narrow, short, and little accentuated. Posteromedian processus of tergum II very flat and with rounded tip. Hind margins of terga VII–VIII (Figure 17) with long bristles, the longer ones filiform, the shorter ones apically slightly pinnate. Hind margins of terga IX and X without bristles, but with denticles. Hind margin of sternum IX (Figure 21) between lateral lobes densely covered with broad, apically slightly pinnate bristles (Figure 22). Inner side of sternum IX caudally with large, longish field of shagreen consisting of numerous rows of small tubercles. Ridges of operculate gill 2 shortened and merely basally developed, ridges medially not connected, caudally obliterated (Figures 17, 18). Operculate gill 2 dorsally with broad, pseudobifid, apical short pinnate bristles of various length, ventral row of microtrichia (Figure 20) originating at some distance from the gill base. Microtrichia in this basal area broad and flat, in the middle of the row with roundish, laminar, slightly pinnate microtrichia (hardly seen by light microscopy). Gills 3–6 with relatively small number of filaments (Figure 19).

Egg (Figures 23, 24)

Ovate (length/width = 1.5), average length about 100 μm, surface of chorion with numerous, very small pores, without granulation. Single very flat epithema (in Figure 23 figured with



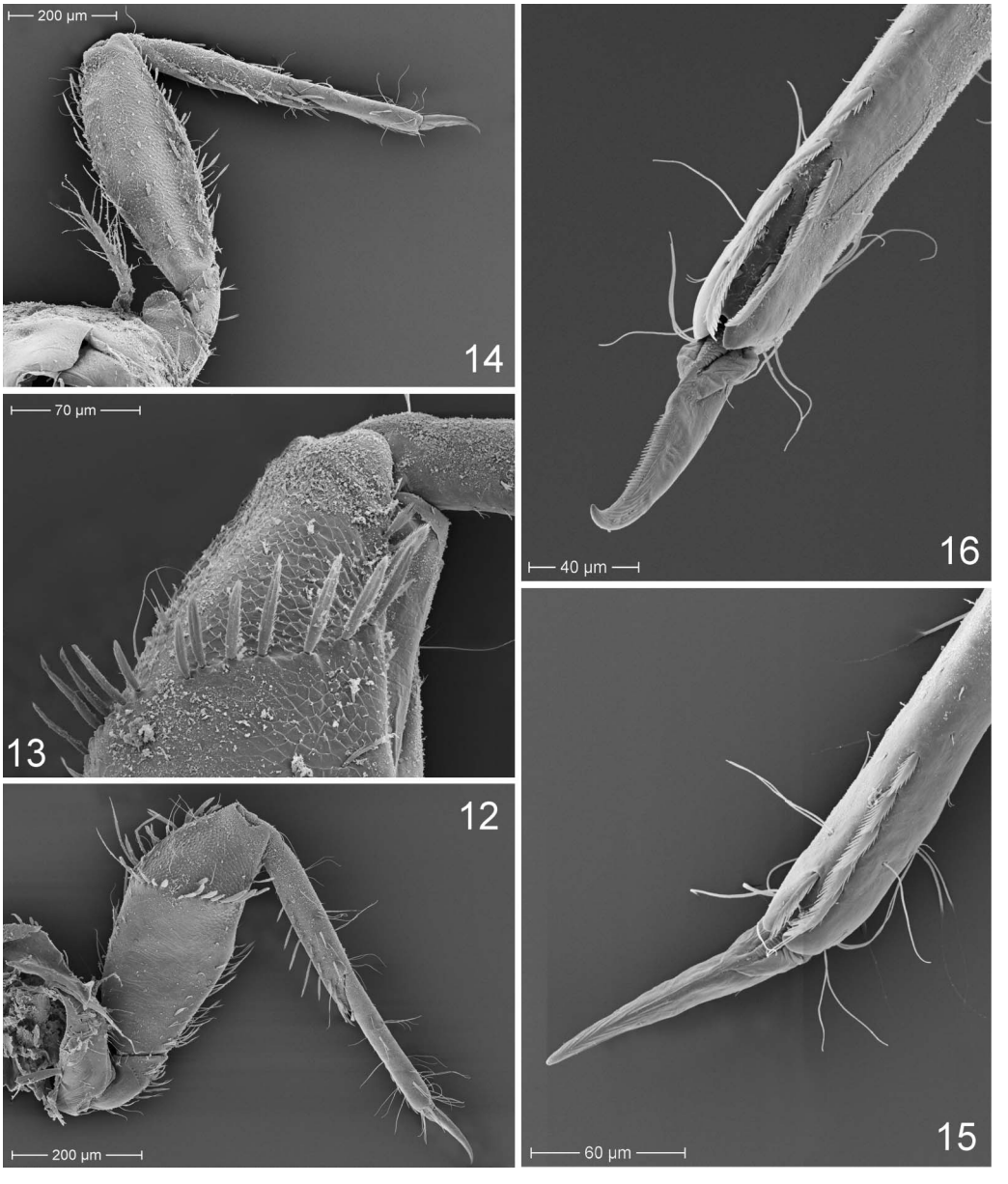
Figures 7–11. *Caenis vanuatensis* sp. n., larva: (7) right maxilla in anterior view; (8) left maxilla in posterior view; (9) labium in posterior view; (10) prementum in anterior view; (11) prementum in posterior view.

expanded threads). One micropyle lying in subequatorial plane, mouth of micropylar canal barely broadened, chorionic sperm guide roundish (Figure 24).

Diagnosis. The larvae of *C. vanuatensis* can be distinguished from all other species of Caenidae by the combination of the following characters: (1) without ocellar tubercles, (2) maxillary palps with three segments, (3) operculate gill 2 ventrally with single row of microtrichia, (4) dorsal ridges of operculate gill 2 medially not connected and caudally obliterated, (5) hind margin of sternum IX with broad, apically slightly pinnate bristles, (6) tarsi ventrally with one or two rows of unipinnate bristles.

Etymology. The new species is named in allusion to Vanuatu.

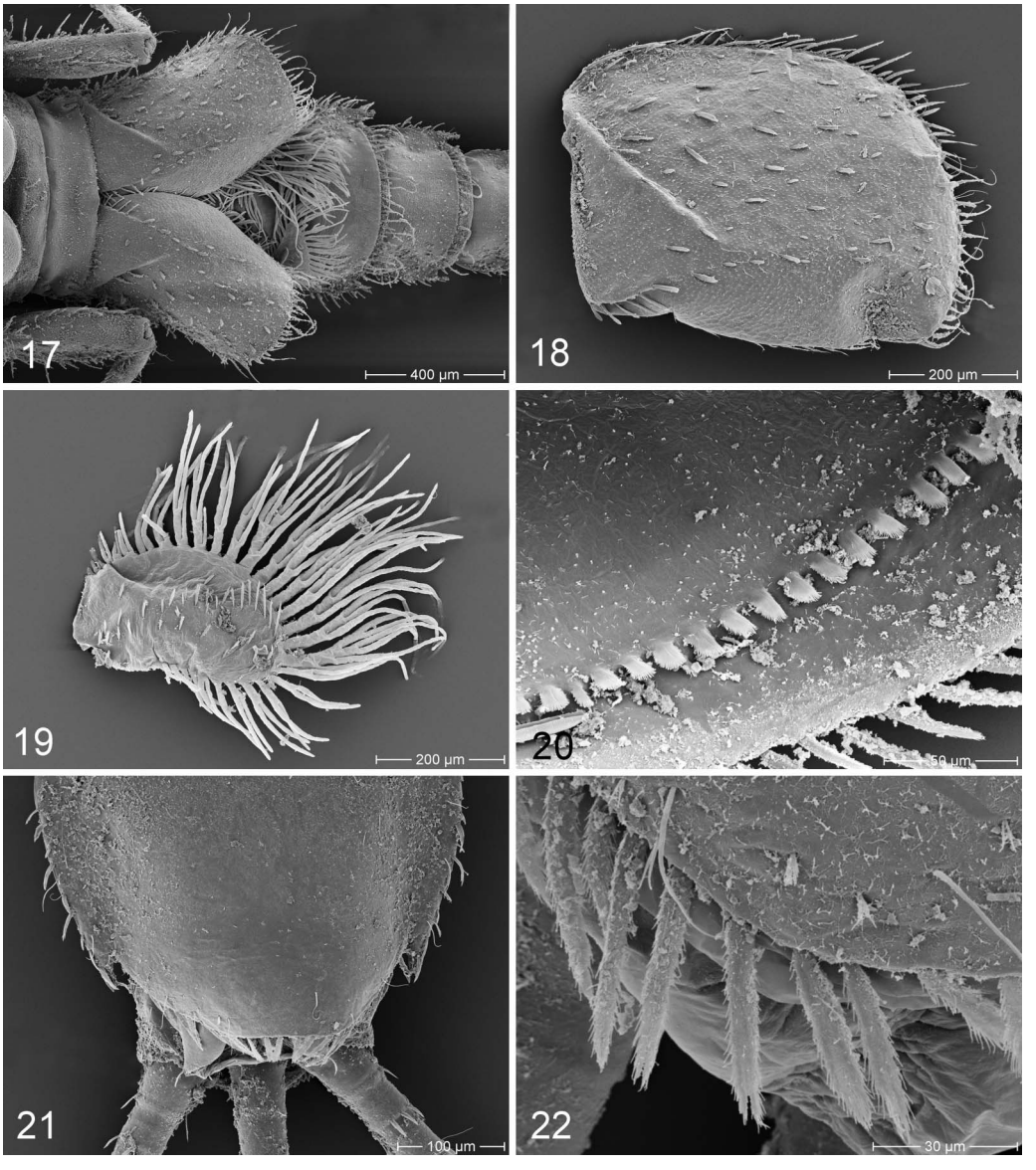
Distribution. The species is abundant in many of the streams of Cumberland Peninsula that have been investigated (type locality see Figure 25). It is possible that the species is distributed throughout Espiritu Santo.



Figures 12 – 16. *Caenis vanuatensis* sp. n., larva: (12) left foreleg in dorsal view; (13) distal half of left foreleg in dorsal view; (14) left hind leg in dorsal view; (15) distal half of mid tarsus and claw in ventral view; (16) distal half of hind tarsus and claw in ventral view.

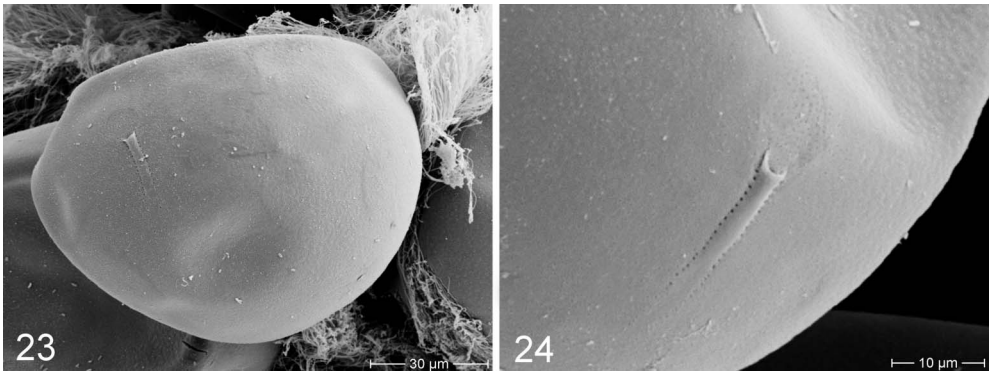
Discussion

Insufficient data on the distribution of Caenidae in the Australian region make it difficult to assess the biogeographic origin of *C. vanuatensis*. The geology of Vanuatu however indicates that these islands are largely of volcanic origin and date back to the early Miocene (Quantin 1975) indicating that colonisation occurred within the last 20 million years. This geologically



Figures 17 – 22. *Caenis vanuatensis* sp. n., larva: (17) tracheal gills and abdominal segments in dorsal view; (18) right operculate gill in dorsal view; (19) right gill 3 in dorsal view; (20) row of microtrichia from ventral side of operculate gill; (21) sternum IX; (22) lateral hind margin of sternum IX with bristles.

short time span, the relatively isolated geographical position and the limited dispersal powers of mayflies (Monaghan et al. 2005) may account for the comparatively low diversity of the mayfly fauna of Espiritu Santo: apart from *C. vanuatensis* there were only two other species of mayflies found (Baetidae: *Cloeon* sp., *Pseudocloeon* sp.) during our field trip in Cumberland. As Caenidae neither occur in New Zealand nor in New Caledonia, colonisation from these islands is unlikely. Several genera of Caenidae do however occur in Australia (Suter 1999). The female, larva and egg of *C. vanuatensis* have few characters that may elucidate its closer affinities. A characteristic feature of the larva is the significantly reduced and shortened dorsal



Figures 23–24. *Caenis vanuatensis* sp. n., egg: (23) total view; (24) micropyle with sperm guide.

Figure 25. Type locality of *Caenis vanuatensis* sp. n.: Mamasa River near Tasmate village, Cumberland Peninsula, Espiritu Santo, Vanuatu.

ridge of the operculate gill. To a certain extent such a shortened dorsal ridge is also present at least in some species of the Australian *Tasmanocoenis* (Alba-Tercedor & Suter 1990), namely in *T. tillyardi*, and to a certain extent also in *T. arcuata*. It cannot be excluded that there is a closer affinity between *Tasmanocoenis* and *C. vanuatensis*. Suter (1984) gives a generic diagnosis of the larvae of *Tasmanocoenis*, but to our knowledge all of these characters are present in some species of *Caenis*. *Tasmanocoenis* is defined by the distinctive structure of the male gonopods together with the associated musculature and lateral sclerites. In the absence of males, the generic attribution of *Caenis vanuatensis* is thus provisional.

The present distribution of *Tasmanocoenis* is restricted to Australia. The genitalia of one species *T. novaeguineae* described from New Guinea and figured by van Bruggen (1957) suggest that this species should be placed within *Caenis*.

According to the few data available, *C. vanuatensis* does not seem to be closely related to *C. nigropunctata*: the dorsal ridge of the opercular gill in *C. nigropunctata* is not shortened as in *C. vanuatensis*, the gill itself is darkly pigmented, and its posterolateral margins are equipped with short, bifid bristles surrounded by simple, long bristles (Ulmer 1939). The larval pronotum strongly diverges anteriorly, its anterior lateral margins protruding into broadly rounded tips.

More undescribed Caenidae are reported from Indonesia (Sartori et al. 2003), Papua New Guinea (Dudgeon 1999), and Fiji (Flowers 1990; Evenhuis 2006). It cannot be decided with certainty if the origin of *C. vanuatensis* can be traced back to Australia, New Guinea, or even to the Oriental region, as the taxonomically important males are lacking in *C. vanuatensis*, and DNA comparisons are not available at present.

In total there were 255 specimens collected, all of which were female. This makes it likely that *C. vanuatensis* is a parthenogenetic species. It has often been assumed that parthenogenesis is more likely to occur on islands (Tomlinson 1966; Sherratt & Beatty 2005). Parthenogenesis is also known from other species of Caenidae, namely from *C. cuniana* (Froehlich 1960) and *C. knowlesi* (Gillies & Knowles 1990). In the latter species it was shown that first instar larvae even may hatch within dead females after a longer period of time (Gillies & Knowles 1990), so in Caenidae a colonisation by wind drifted females (even if already dead) may be more likely than previously thought, even if some species like *C. nigropunctata* have only a brief imaginal life span (Ulmer 1939).

Ecology

C. vanuatensis is probably widespread throughout Espiritu Santo. It has been found in great numbers in the lower course of many investigated streams. As mainly lower streams have been investigated, there are no data on the altitudinal distribution of this species. The species however seems to be well adapted to warm tropical streams with low oxygen content (see Figure 25). The larvae were present in creeks with low water current and measured water temperatures of up to 28°C. All of the collected larvae are of similar size which also points to a similar stage of development. This may indicate a synchronised life cycle of *C. vanuatensis* which is however rather unusual for tropical mayflies.

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