

Discovery of the flightless marine midge *Pontomyia* (Diptera: Chironomidae) at Christmas Island, Australia

Lanna Cheng^{1*} & Danwei Huang²

Abstract. We document the discovery of a unique flightless marine midge *Pontomyia* (Chironomidae) in the Indian Ocean, presenting descriptions and photographs of the insect and its environment at Christmas Island, Australia. The insect is identified as *P. natans*, with distinctive male genitalia and rudimentary claws on the hind legs. This species is widely distributed in the Pacific Ocean but the only previous record from the Indian Ocean was from the Maldives. It is highly likely that other populations are present along the continental coast of the latter ocean basin.

Key words. Chironominae, Christmas Island, Diptera, marine midge, Tanytarsini, tide pool

INTRODUCTION

Pontomyia Edwards, 1926, is a genus of tiny, exclusively marine midge (Chironomidae) with adults measuring about 1 mm in body length. It was thought to be the first totally submarine insect known when first discovered in a plankton tow at Samoa (Buxton, 1926). However, studies on the second species described from Japan six years later (Tokunaga, 1932) revealed that the adults are aerial and do not live underwater. They are highly dimorphic. Males have very long antennae that are presumably used for locating females. The middle legs are short and end in strong claws used for clasping females while mating. The long, thin front and hind legs are not employed for locomotion. Additionally, their fleshy, non-membranous wings are not used for flight but function like oars to propel them over the sea surface (Cheng & Hashimoto, 1978). Females are larviform, totally wingless and do not possess any functional legs for locomotion. Although males have well-developed eyes, those in the female are much reduced. Functional mouthparts are absent in adults of both sexes—they do not feed after emergence and die shortly after mating or egg laying (Tokunaga, 1932; Cheng & Hashimoto, 1978; Cheng & Collins, 1980; Neumann, 1986; Cheng, 2004).

Huang & Cheng (2011) have reviewed the literature, ecology, distribution and molecular phylogeny of the genus. Four *Pontomyia* species were previously described: *P. natans*, *P. pacifica*, *P. cottoni* and *P. oceana* (Cheng & Hashimoto, 1978). They are widely distributed around island shores

in the Indo-Pacific. A fifth species was collected from several locations in the Atlantic Ocean and the Caribbean but no adult males have been found to allow for specific identification (Schärer & Epler, 2007). However, based on a recent systematic study, *P. cottoni* was found to be a synonym of *P. natans* (Huang et al., 2014). Here, we document the discovery of *Pontomyia* in the Indian Ocean, the first record of this rare marine insect genus outside the Maldives and Western Australia.

MATERIAL AND METHODS

During a recent expedition to the Christmas Island (Fig. 1) by members of the Raffles Museum of Biodiversity Research (RMBR; currently known as the Lee Kong Chian Natural History Museum), National University of Singapore (NUS), a collecting trip was made to Waterfall Bay (10°27.54'S, 105°42.30'E) on 25 March 2011 (Fig. 2). Swarming organisms were observed under headlights directed at the water surface during dusk, between 1800 and 1900 hours. The animals were collected by sweeping a fine-mesh net over the sea surface, preserved in 95% ethanol and brought back to the RMBR for further studies.

RESULTS AND DISCUSSION

The animals were identified as *Pontomyia natans* Edwards, 1926 (Fig. 3), a flightless midge belonging to the family Chironomidae. Many males and tens of females were found in the samples. Our identification was based on the structure of the male hypopygium with the inner lobe being very slightly hooked at the disto-mesal margin (Fig. 3b), as opposed to being deeply hooked or reduced as in *P. pacifica* and *P. oceana*, respectively (Cheng & Hashimoto, 1978; Huang et al., 2014). Females are larviform (Fig. 3c), as in all *Pontomyia* species (Cheng & Hashimoto, 1978).

Pontomyia natans is the most widely distributed species in the genus, and is the only one known to exist in west-central

¹Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92093-0202, USA; Email: lcheng@ucsd.edu (*corresponding author)

²Department of Earth and Environmental Sciences, University of Iowa, Iowa City, IA 52242, USA; Department of Biological Sciences, National University of Singapore, 14 Science Drive 4, Singapore 117543; Email: huangdanwei@nus.edu.sg



Fig. 1. Known collection localities of *Pontomyia natans* in the Indo-Pacific. Star symbols represent sites prior to this study (filled star indicates type locality at Apia, Upolu Island, Samoa). Filled pentagon denotes Christmas Island, Australia.



Fig. 2. Low tide at Waterfall Bay, Christmas Island, Australia. Photo: Tan Heok Hui.

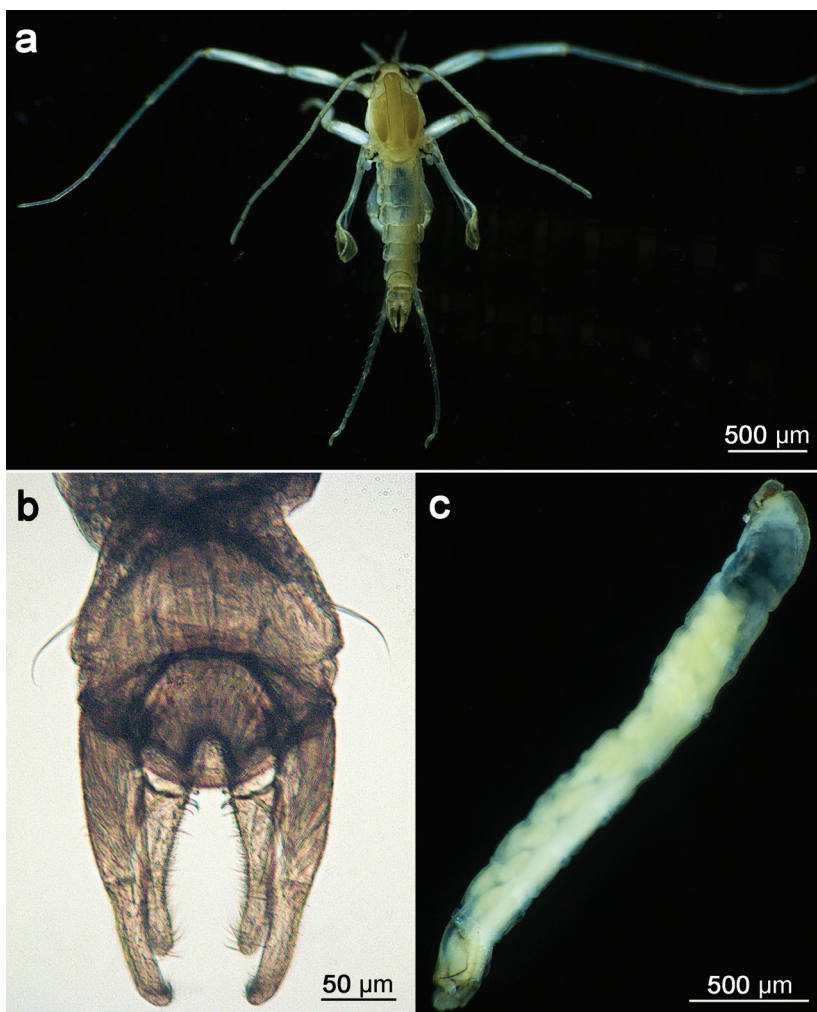


Fig. 3. *Pontomyia natans*: a, dorsal view of whole male; b, male hypopygium; c, lateral view of larviform female, head end at top right.

Indian Ocean. It was first described from Samoa (Edwards, 1926), and has subsequently been collected from Fiji, Japan, Malaysia, Marshall Islands, New Caledonia, Taiwan and the Queensland coast of Australia in the Pacific Ocean (Fig. 1). The Maldives was the only previously known location for this species in the Indian Ocean (Cheng, 2004). How such a tiny, flightless midge could achieve such a wide, transoceanic distribution remains a mystery. Even more remarkable is the presence of cryptic diversity within the Maldives, with high molecular divergences unaccompanied by morphological differentiation between males collected on different days at about the same location (Huang & Cheng, 2011).

In addition to being flightless, *Pontomyia* is also known to have one of the shortest adult lives (generally <3 hours) among the Insecta (Cheng, 2004). Males die shortly after mating and females die soon after egg laying. Eggs are laid in coils and sink to the bottom of the bay or rock pool (Cheng & Collins, 1980). The larvae, upon hatching, feed on algae or marine plants. Adults emerge at the sea surface and emergence is controlled by various environmental cues that are still under investigation (Soong et al., 2011). Two species, *P. natans* and *P. oceana*, are known to co-occur in southern Taiwan, but emerge at different times of the day with only the latter species following the lunar cycle (Soong

et al., 1999). It is thus likely that they respond differently to environmental cues (Neumann, 1986; Soong et al., 2006).

Almost all the previous collections of *Pontomyia natans* were made after dusk either around periods of full moon or new moon (Cheng, pers. obs.). The Christmas Island population was collected during the last quarter of the lunar period. The midges were attracted to light at around low tide (1759 hours; 0.33 m) shortly after sunset (1805 hours) in the thousands, with the sea being relatively calm. It is reasonable to assume that calm waters would facilitate mate-finding and successful mating for such tiny flightless midges. Low tide would ensure that egg coils sink more rapidly to the bottom of the bay or rock pool where larvae, upon hatching, would be able to find food and shelter.

In a laboratory population studied in Queensland, Australia, the midges were found to emerge within 30 min after dark, with males emerging 20 min or so before females (Cheng & Collins, 1980). Adult emergence within a population is often synchronised and the entire process completed within a short period of time. Thus, timing is vital if one wants to capture these midges, as illustrated by a previous field study carried out at Carp Island, Palau. On a calm night with quarter moon in July 1995, a storm lantern was placed at the

end of a wooden pier ~40 m from shore at 1830 hours, just before sunset. A 10-cm diameter plastic scoop with 0.5-mm mesh was used to sweep over the sea surface under the light at 10-min intervals. No midges were caught between 1830 and 1850 hours. The first midges were observed at 1900 hours and less than 10 males were caught per scoop. Peak emergence occurred at 1910 hours with over 900 caught per scoop. Insect numbers decreased rapidly thereafter so that by 1930 hours only a few dozen were caught and none were seen after 2000 hours.

Although little known by marine biologists and hardly ever seen by most entomologists, the tiny flightless *Pontomyia* is likely to be much more widely distributed than previously suspected. It is not known why adults are attracted to light though this is the easiest means of finding and capturing these rather elusive midges (Satoh & Cheng, 2009). The discovery of *P. natans* outside the Maldives suggest that other populations are likely to be found along the continental coast of the eastern Indian Ocean. Several studies on the life history and ecology of *Pontomyia* spp. have been carried out since its discovery, but it remains an oddity in nature. Much of its origin, evolution and adaptations await further study.

ACKNOWLEDGEMENTS

We are grateful to Tan Heok Hui for collecting these fascinating midges and Tan Kai-xin for providing information on its habitat. The illustrated map was supplied by Online Map Creation (now planiglobe; <http://www.planiglobe.com>).

LITERATURE CITED

- Buxton PA (1926) The colonization of the sea by insects: with an account of habits of *Pontomyia*, the only known submarine insects. Proceedings of the Zoological Society of London, 96: 807–814.
- Cheng L (2004) The flightless marine midge *Pontomyia* (Diptera: Chironomidae) with a first record from the Republic of the Maldives, Indian Ocean. In: Gujar GT (ed.) Contemporary Trends in Insect Science. Campus Books International, New Delhi, pp. 52–59. (N.B. This paper was not proofread by the author prior to publication and contained many errors. Contact author <lcheng@ucsd.edu> for errata)
- Cheng L & Hashimoto H (1978) The marine midge *Pontomyia* (Chironomidae) with a description of females of *P. oceana* Tokunaga. Systematic Entomology, 3: 189–196.
- Cheng L & Collins JD (1980) Observations on behaviour, emergence and reproduction of the marine midge *Pontomyia* (Diptera: Chironomidae). Marine Biology, 58: 1–5.
- Edwards FW (1926) On marine Chironomidae (Diptera); with descriptions of a new genus and four new species from Samoa. Proceedings of the Zoological Society of London, 96: 779–806.
- Huang D & Cheng L (2011) The flightless marine midge *Pontomyia* (Diptera: Chironomidae): ecology, distribution, and molecular phylogeny. Zoological Journal of the Linnean Society, 162: 443–456.
- Huang D, Cranston PS & Cheng L (2014) A complete species phylogeny of the marine midge *Pontomyia* (Diptera: Chironomidae) reveals a cosmopolitan species and a new synonym. Invertebrate Systematics, 28: 277–286.
- Neumann D (1986) Diel eclosion rhythm of a sublittoral population of the marine insect *Pontomyia pacifica*. Marine Biology, 90: 461–465.
- Satoh A & Cheng L (2009) A new record of *Pontomyia pacifica* (Diptera, Chironomidae) from Okinawa, Japan. Biological Magazine of Okinawa, 47: 47–48.
- Schärer M & Epler JH (2007) Long-range dispersal possibilities via sea turtle—a case for *Clunio* and *Pontomyia* (Diptera: Chironomidae) in Puerto Rico. Entomological News, 118: 273–277.
- Soong K, Chen GF & Cao JR (1999) Life history studies of the flightless marine midges *Pontomyia* spp. (Diptera: Chironomidae). Zoological Studies, 38: 466–473.
- Soong K, Chen J & Tsao CJ (2006) Adaptation for accuracy or for precision? Diel emergence timing of the intertidal insect *Pontomyia oceana* (Chironomidae). Marine Biology, 150: 173–181.
- Soong K, Lee Y-J & Chang I-H (2011) Short-lived intertidal midge *Pontomyia oceana* have semilunar eclosion rhythm entrained by night light. Marine Ecology-Progress Series, 433: 121–130.
- Tokunaga M (1932) Morphological and biological studies on a new marine chironomid fly, *Pontomyia pacifica*, from Japan. Part I. Morphology and taxonomy. Memoirs of the College of Agriculture, Kyoto Imperial University, 19: 1–56.