

Rapid Communication

First record of alien species *Eualetes tulipa* (Rousseau in Chenu, 1843) from the Royapuram fishing harbour at Chennai, India

Jebarathnam Prince Prakash Jebakumar*, Ganesan Nandhagopal, Shunmugavel Ragumaran, Bose Rajanbabu and Vijaya Ravichandran

Coastal Environmental Engineering Division, National Institute of Ocean Technology, Pallikaranai, Chennai -600100, India

*Corresponding author

E-mail: prince@niot.res.in

Received: 13 March 2015 / Accepted: 3 June 2015 / Published online: 23 June 2015

Handling editor: Demetrio Boltovskoy

Abstract

Eualetes tulipa (Rousseau in Chenu, 1843), a marine worm snail (family Vermetidae), was collected in the Royapuram fishing harbour, Chennai, coast of India. The identity of the species, initially based on morphology, was confirmed by molecular analysis (cytochrome oxidase I). Collected from submerged boulders of a breakwater at depths from 0.5 to 1.0 m, this represents the first record of the species from the coast of India. Its population density at the site was up to 55 individuals/m². Elsewhere, *Eualetes tulipa* has been recorded as an invasive species from the coasts of Hawaii and from Venezuela in the Caribbean Sea. The source of its introduction was likely fouling from the hull of a ship, although transport in ballast water is also possible.

Key words: epibiotic, marine worm snail, Vermetidae, alien, invasive

Introduction

Eualetes tulipa (Rousseau in Chenu, 1843), a sessile worm-like gastropod dwelling in tube-shaped shells, attaches to hard substrates in shallow waters. The species was originally described by Rousseau, in Chenu (1843), without reference to its type locality. *Eualetes tulipa* was later reported from several localities in Panama Bay, eastern Pacific Ocean (Keen 1971), including the boulder reef at Vera Cruz (Hughes 1985), as well as in Veraguas Province of Panama (Vega and González 2002). The species has also been observed in the Caribbean Sea at two locations in the Puerto Cabello area, Venezuela, since 1986. Specimens (reported as *Vermetus* sp.) were attached to concrete pilings at the El Palito oil refinery, and to metal remains of ship wreckage at Isla Larga (Miloslavich and Penchaszadeh 1992; Osman and Hirley 2007). In Hawaii, it has been reported since 1997 as a non-indigenous species at 32 localities, where individuals are mainly found attached to artificial substrates (concrete pilings,

walls, metal, and wood), but also in natural environments, such as reefs and on mangrove roots (Coles and Eldredge 2002; Coles et al. 2002; Schlucker 2003; Ray 2005).

During an assessment of epibiotic populations along breakwaters of the Royapuram fishing harbour by the National Institute of Ocean Technology in 2014, a gastropod thought to be the invasive *Eualetes tulipa* was discovered. Tentative identification of the species, based on morphology, was confirmed by molecular analysis. After its initial detection, surveys of the area confirmed the presence of the gastropod within a relatively small area of the fishing harbour. This paper documents the discovery of *E. tulipa* in India, and provides a morphological and molecular account of the species.

Methods

The Royapuram fishing harbour, also known as Chennai fishing harbour, is located near the port of Chennai on the southeast coast of India (Figure 1). The fishing harbour, immediately north

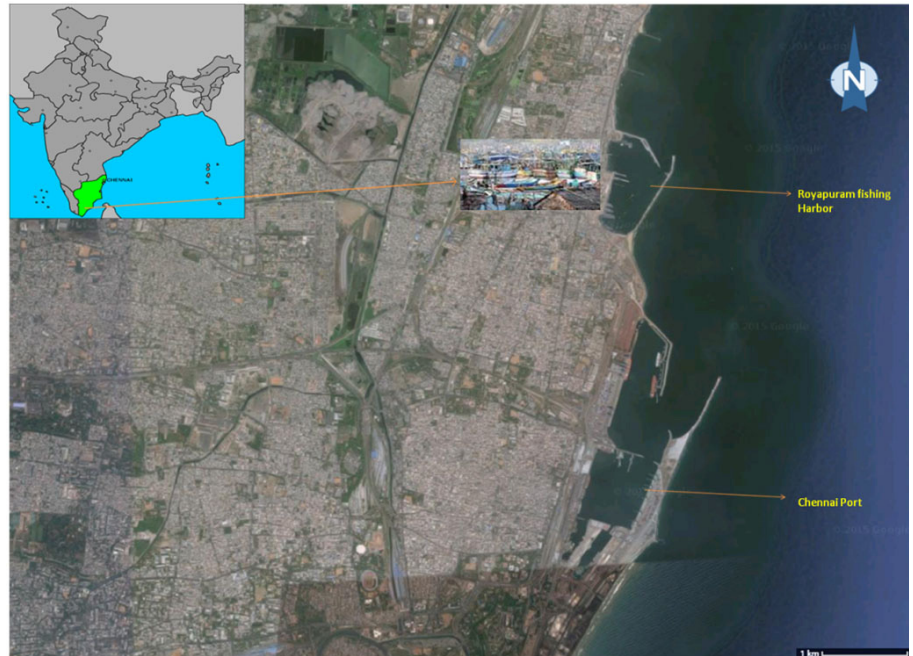


Figure 1. Study location.

of the port of Chennai, was originally designed to berth 575 fishing vessels but currently provides a home port for 1395 vessels. Its boulder breakwater, extending 300 m into the sea, provides habitat for recruitment of epibiotic communities.

Gastropods found in northern breakwater samples were initially identified on the basis of the morphology of their long, tube-like shells (Figure 2; Figure 3), which differ from those of indigenous gastropod species. Morphological observations, including shell length, colour, texture of the inner shell, colour and length of the soft body, were made as described by Keen (1971) and Miloslavich and Penchaszadeh (1992). Population densities were estimated by the belt quadrat method along submerged portions of the boulders (13°08.001'N; 080°18.031'E) using SCUBA and snorkelling during low tide periods. Voucher specimens were submitted to the Zoological Survey of India for reference purposes (accession number M-1689).

Molecular taxonomy

Five specimens of *Eualetes tulipa* were sequenced for molecular analysis, targeting the region COI used for identification by Folmer et al. (1994). The universal primers (COI-FP-GGTC AACAAATCATAAAGATATTGG and COI-RP-TAAACCTTCAGGGTGACCAAAAAATCA) were used

for PCR analysis. Sequences of *E. tulipa*, downloaded from the Genbank record of Rawling et al. (2010), were aligned with our data.

Results

Notwithstanding its occurrence as an invasive in Hawaii and the Caribbean coast of Venezuela (Coles et al. 2002; Miloslavich et al. 2010), surprisingly few morphological descriptions and illustrations exist of *Eualetes tulipa*. The taxonomy of the family Vermetidae, to which the species belongs, is complicated (Keen 1961; Bieler 1996) and few genera are defined by valid autapomorphic characters (Gould 1994). In India, live specimens of *E. tulipa* were observed only along the northern arm of the Royapuram fishing harbour breakwater, facing the Bay of Bengal, on boulders at depths of 0.5 to 1.0 m. Previous studies of the fauna of this region (Venkataraman and Wafar 2005; Gautam and Gautam 2012) had not reported this species. We found densities of 45 to 55 individuals/m² in aggregations. Golden-yellow egg capsules were observed during July and August, although elsewhere the species is reported to reproduce throughout the year (Miloslavich and Penchaszadeh 1992). Empty shells were observed above the high tide line and in among live specimens (Figure 2; Figure 3).



Figure 2. Live *Eualetes tulipa* with the shells attached to a boulder. Photograph by Ganesan Nandhagopal.



Figure 3. Empty shells of *Eualetes tulipa* on boulders at the fishing harbour. Photograph by Ganesan Nandhagopal.



Figure 4. *Eualetes tulipa* removed from the shell. Photograph by Ganesan Nandhagopal.

Morphology

Specimens of *Eualetes tulipa* from the Royapuram fishing harbour were attached to the substrate by tightly coiled whorls, while the lax distal part of the shell, referred to as the feeding tube, grows quite large (Schiaparelli and Cattaneo-Viatti 1999). The lengths of the shell varied from 5 to 9 cm, 1 to 1.5 cm in width. Shell colours varied from ivory white to light brown and dark grey. The inner surface of the shell is smooth, with light brown coloration. The elongated and worm-shaped soft body, of a pale red-wine colour (Figure 4), measured from 5.0 to 7.2 cm (maximum recorded length reported elsewhere: 14.1 cm; Miloslavich and Penchaszadeh 1992). The brown concave operculum, marked with several whorls, measures around 0.5 cm in diameter.

Molecular taxonomy

Molecular analysis was undertaken on five specimens. The identity of the species was confirmed from a nucleotide BLAST assigned by Rawlings et al. (2010), GenBank accession number: KP241014.

Discussion

Eualetes tulipa reported from Venezuela at depths from 0 to 5 m (Miloslavich and Penchaszadeh 1992), attached to submerged artificial substrates, inhabit similar water temperatures and salinities to those along the Chennai coast (26–30°C, salinity 34–36; Hughes 1985; Miloslavich and Penchaszadeh 1992). In the Caribbean, the shells attain a maximum length of 7 cm and a width of 4.4 cm, which is slightly larger than those of specimens recorded from the Indian coast. Although adults are considered solitary, in Venezuela they dwell in clusters of up to 100 individuals/m² (Miloslavich et al. 2010). High population densities were reported from channel walls of the sea water intake at a thermal power plant in Puerto Cabello, Venezuela (Miloslavich and Penchaszadeh 1992). The high tolerance of *Eualetes tulipa* to adverse conditions, such as lack of food, clean water (Schiaparelli and Cattaneo-Viatti 1999; Strathmann and Strathmann 2006), extended (several days) exposure to fresh water (Miloslavich and Penchaszadeh 1992), its ability to attach to different artificial substrata (Miloslavich and Penchaszadeh 1992; Schiaparelli et al. 2002), and its feeding larvae that allow them to spend large periods adrift (Strathmann and Strathmann 2006), suggest that the invasive capabilities of

this species are high. These attributes ensure survival during extended natural advection by currents or transport or by ships. Notably, the species was discovered on the breakwater of Royapuram fishing harbour in close proximity to a major port. Considering the vessel traffic of the Royapuram fishing harbour, the gastropod may spread rapidly along the east coast of India.

Acknowledgements

This preliminary study was carried out under the 'Sustainable Shoreline Management' program of the National Institute of Ocean Technology (NIOT), funded by the Ministry of Earth Sciences, Government of India.

References

- Bieler R (1996) Mörch's worm-snail taxa (Caenogastropoda: Vermetidae, Siliquariidae, Turritellidae). *American Malacological Bulletin* 13: 23–35
- Coles SL, DeFelice RC, Eldredge LG (2002) Nonindigenous marine species at Waikiki and Hawaii Kai, Oahu, Hawaii. Final Report prepared for the David and Lucile Packard Foundation and the State of Hawaii Department of Land and Natural Resources, Division of Aquatic Resources, Honolulu. Bishop Museum Technical Report, 244 pp
- Coles SL, Eldredge LG (2002) Nonindigenous species introductions on coral reefs: A need for information. *Pacific Science* 56: 191–209, <http://dx.doi.org/10.1353/psc.2002.0010>
- Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R (1994) DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology* 3(5): 294–299
- Gould SJ (1994) *Petalocochus sculpturatus alaminatus*, a new Pliocene subspecies of vermetid gastropods lacking its defining generic character, with comments on vermetid systematics in general. *Journal of Paleontology* 68(5): 1025–1036
- Hughes RN (1985) Feeding behavior of the sessile gastropod *Tripsyca tulipa* (Vermetidae). *Journal of Molluscan Studies* 51: 326–330
- Keen AM (1961) A proposed reclassification of the gastropod family Vermetidae. *Bulletin of the British Museum of Natural History Series D7*: 183–213
- Keen AM (1971) Sea shells of tropical west America. California. Stanford University Press, XIV + 1064 pp
- Miloslavich P, Penchaszadeh PE (1992) Reproductive biology of *Vermetus* sp. and *Dendropoma corrodens* (Orbigny, 1842): two vermetid gastropods from the southern Caribbean. *The Veliger* 35(1): 78–88
- Miloslavich P, Klein E, Penchaszadeh P (2010) Gametogenic cycle of the tropical vermetids *Eualetes tulipa* and *Dendropoma corrodens* (Mollusca: Caenogastropoda: Vermetidae). *Journal of Marine Biological Association of United Kingdom* 90(03): 509–518, <http://dx.doi.org/10.1017/S0025315409991287>
- Gautam N, Gautam VK (2012) New strategies to conserve marine biodiversity and coastal ecosystems of India. Proceedings of National seminar on Biodiversity and conservation of coastal and marine ecosystems of India, 115 pp
- Osman R, Shirley T (2007) Proceedings and final report of the Gulf of Mexico and Caribbean Marine Invasive Species Workshop, Harte Research Institute for Gulf of Mexico Studies, Texas A&M University-Corpus Christi, Corpus Christi, Texas, 26-27 February 2007. Harte Research Institute for Gulf of Mexico Studies and Smithsonian Environmental Research Center, 47 pp
- Ray GL (2005) Invasive marine and estuarine animals of Hawaii and other Pacific Islands. *Aquatic Nuisance Species Research Program ERDC/TN ANSRP-05-3*, 19 pp
- Rawlings TA, MacInnis MJ, Bieler R, Boore JL, Collins TM (2010) Sessile snails, dynamic genomes: gene rearrangements within the mitochondrial genome of a family of caenogastropod mollusks. *BMC Genomics* 11: 440, <http://www.biomedcentral.com/1471-2164/11/440>
- Schlucker A (2003) State of Hawaii aquatic invasive species management plan. The Department of Land and Natural Resources, Division of Aquatic Resources, The Nature Conservancy of Hawaii, 205 pp
- Schiaparelli S, Cattaneo-Vietti R (1999) Functional morphology of vermetid feeding-tubes. *Lethaia* 32: 41–46, <http://dx.doi.org/10.1111/j.1502-3931.1999.tb00579.x>
- Schiaparelli S, Guidetti P, Cattaneo-Vietti R (2002) Can mineralogical features affect the distribution patterns of sessile gastropods? The Vermetidae case in the Mediterranean Sea. *Journal of the Marine Biological Association of the United Kingdom* 83: 43–52
- Strathmann MF, Strathmann RR (2006) A vermetid with complex intracapsular cannibalism of nurse eggs and sibling larvae and a high potential for invasion. *Pacific Science* 60(1): 97–108, <http://dx.doi.org/10.1353/psc.2005.0062>
- Vega AJ, González A (2002) Moluscos del Pacífico Veraguense. *Tecnociencia* 4: 1–45
- Venkataraman K, Wafar M (2005) Coastal and Marine biodiversity of India. *Indian Journal of Marine Sciences* 34: 57–75