Rapid Communication

First report of the non-native freshwater polychaete *Namalycastis hawaiiensis* (Johnson, 1903) (Nereididae: Namanereidinae) in Israel

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Abstract

The subfamily Namanereidinae (Annelida: Nereididae), is one of the most successful polychaete groups to colonize brackish and freshwater environments worldwide. Among them *Namalycastis hawaiiensis* (Johnson, 1903) is one of the few that have been identified as invasive, including recent introduction to Japan and Australia via the aquarium trade. Here, we report for the first-time finding of an established population of *N. hawaiiensis* in a freshwater spring in Israel, well outside of its Indo-Pacific native distribution. We further report on the finding of specimens in a pet store and discuss its possible route of introduction via aquarium-trade.

Key words: Annelida, Middle-East, invasion, aquarium trade, freshwater ecosystem monitoring

Introduction

In the previous century, more than fourty species have been introduced into Israel's freshwater habitats (Goren and Ortal 1999; Golani and Mires 2000; Goren and Galil 2005; Roll et al. 2007b; Wizen et al. 2008; Gasith et al. 2011; Yanai et al. 2017), many of them established lasting populations, taking a toll on freshwater native fauna and flora (Roll et al. 2007a, b).

The subfamily Namanereidinae (Annelida: Nereididae), is one of the most successful polychaete groups to colonize brackish and freshwater environments including caves and even Arboreal waters (Glasby 1999; Glasby et al. 2014; Glasby and Timm 2008; Alves and Santos 2016). They are distributed worldwide (Glasby and Timm 2008) but no representative of this subfamily or any other freshwater polychaete was ever found in Israel.

During routine monitoring of streams in northern Israel some polychaete worms were discovered and identified as *Namalycastis hawaiiensis* (Johnson, 1903). This species is one of the few members of Namanereidinae that were identified as invasive. It was first described from a freshwater spring in Hawaii and has a tropical Indo-Pacific distribution ranging from Ryukyu Islands (Japan) in the north to Papua New Guinea in the south, and

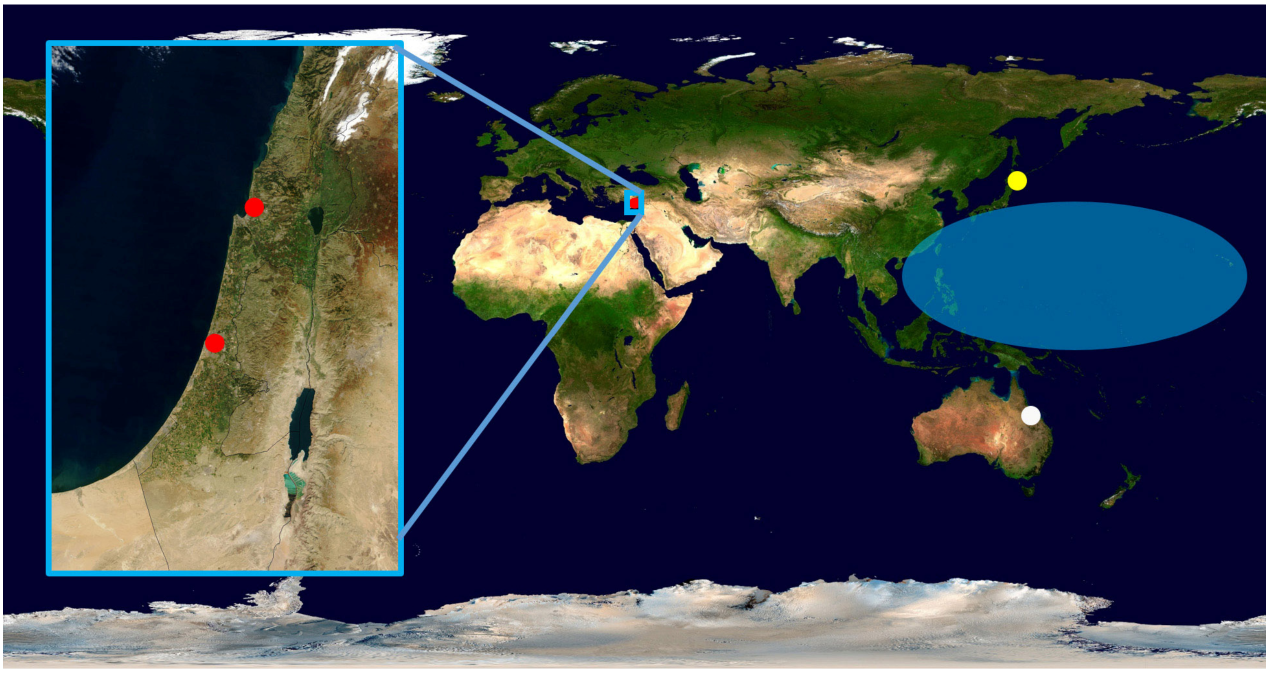

Figure 1. *Namlycastis hawaiiensis* distribution**:** blue – natural distribution; yellow and white – introduced location from Abe et al. 2017 and Glasby and Dane 2008, respectively; red – introduced location from this study. Image by NASA.

from the Hawaiian Islands to Sumatra (Glasby et al. 2003; Abe et al. 2017). Recently, the polychaete has spread to mainland Japan via the aquarium trade (Abe et al. 2017), and in Australia it was intercepted as an exotic species in an aquarium (Glasby and Dane 2008). Here we report for the first time, on the finding of an established population of this polychaete in a freshwater spring in Israel. We further report on *N. hawaiiensis* specimens found in a local pet store and discuss its possible route of introduction via aquarium-trade.

Materials and methods

Five specimens of *Namalycastis hawaiiensis* were collected using a Surber net (0.4 mm mesh) in May 2017 and April 2018, at a site adjacent to the spring that feeds the Se'adya stream (32°47′20.0″N; 35°01′33.1″E) – a short (*ca.* 2 km) freshwater tributary of the Kishon River, at the foothill of Mount Carmel (Haifa bay, Israel; Figure 1). It is a slow flowing stream with shallow depth (mean 40 cm) and clear water. The bottom is muddy with lush emergent vegetation, dominated by Cyperaceae. Due to the proximity of the site to the spring, water temperatures and conductivity are seasonally stable: 21°C and 2280 µS cm^{-1} (less than 2 PSU), respectively.

Live material was preserved in the field (100% ethanol) to be further identified at the Israel Center for Aquatic Ecology (Steinhardt Museum of Natural History, Tel Aviv University). Five specimens of *N. hawaiiensis* were found, on the two separate dates, at the uppermost site adjacent to the spring that feeds the stream. In addition, one specimen of *N. hawaiiensis* was collected from the bottom gravel of an ornamental fish aquarium in a pet store in the town of Ness-Ziona (south-central Israel; 31°55′16.0″N; 34°47′32.8″E; April 2019; Figure 1), approximately 120 km south of Se'adya stream.

Morphological identification

Observations were made using an SZ60 (Olympus, Tokyo, Japan) and an M205-C (Leica, Wetzlar, Germany) strereoscopic microscopes, and an Axioskop 50 (Zeiss, Oberkochen, Germany) light microscope equipped with an Axiocam 105 (Zeiss, Oberkochen, Germany) color camera. Morphological inspection and identification were conducted following the keys of Fauchald (1979), Glasby (1999) and Abe et al. (2017). Plates were created using Adobe Photoshop® 6 and Adobe Illustrator® 6 softwares. Voucher specimens (VR.25322, VR.25323, VR.25324) were deposited in the SMNH, Tel-Aviv University, Israel.

Genetic identification

DNA from VR.25322 was extracted with Qiagen DNeasy (#69504), and the18S rDNA gene was amplified using the primer set 18S1/18S2 (Borchiellini et al. 2001). The barcoding region of the mitochondrial COI gene was amplified using the primers developed by Folmer et al. (1994). Sequences obtained were submitted to GenBank under accession numbers MN125541 and MN125542 for the 18S (1776 bp) and COI (658 bp), respectively. A BLASTN search was performed against the nucleotide collection in GenBank (Zhang et al. 2000).

Results

Taxonomy

Family Nereididae Lamarck, 1818
Subfamily Namanereidinae Hartman, 1959
Genus *Namalycastis* Hartman, 1959

***Namalycastis hawaiiensis* Johnson, 1903**

Material examined. Se'adya stream, Haifa, Israel, May, 2017, VR.25322 one individual; April 2018, VR.25323, four individuals; Ornamental fish aquarium, Ness Ziona, Israel, April 2019, VR.25324, one individual.

Description. The best preserved specimen was fragmented in two, no gametes in coelom. 142 setigers, 37 mm long, 1.5 mm wide at setiger 10.

Body. Uniform in width anteriorly, tapering gradually posteriorly. Dorsum convex. Venter flat. Color in alcohol yellow-brown or pale. Epidermal pigment absent (Figure 2A).

Prostomium. Shallowly cleft anteriorly, with narrow longitudinal groove extending from tip to mid-posterior prostomium. Prostomium shape roughly trapezoidal, 2.02 × wider than long (1.7–2.25). Antennae smooth,

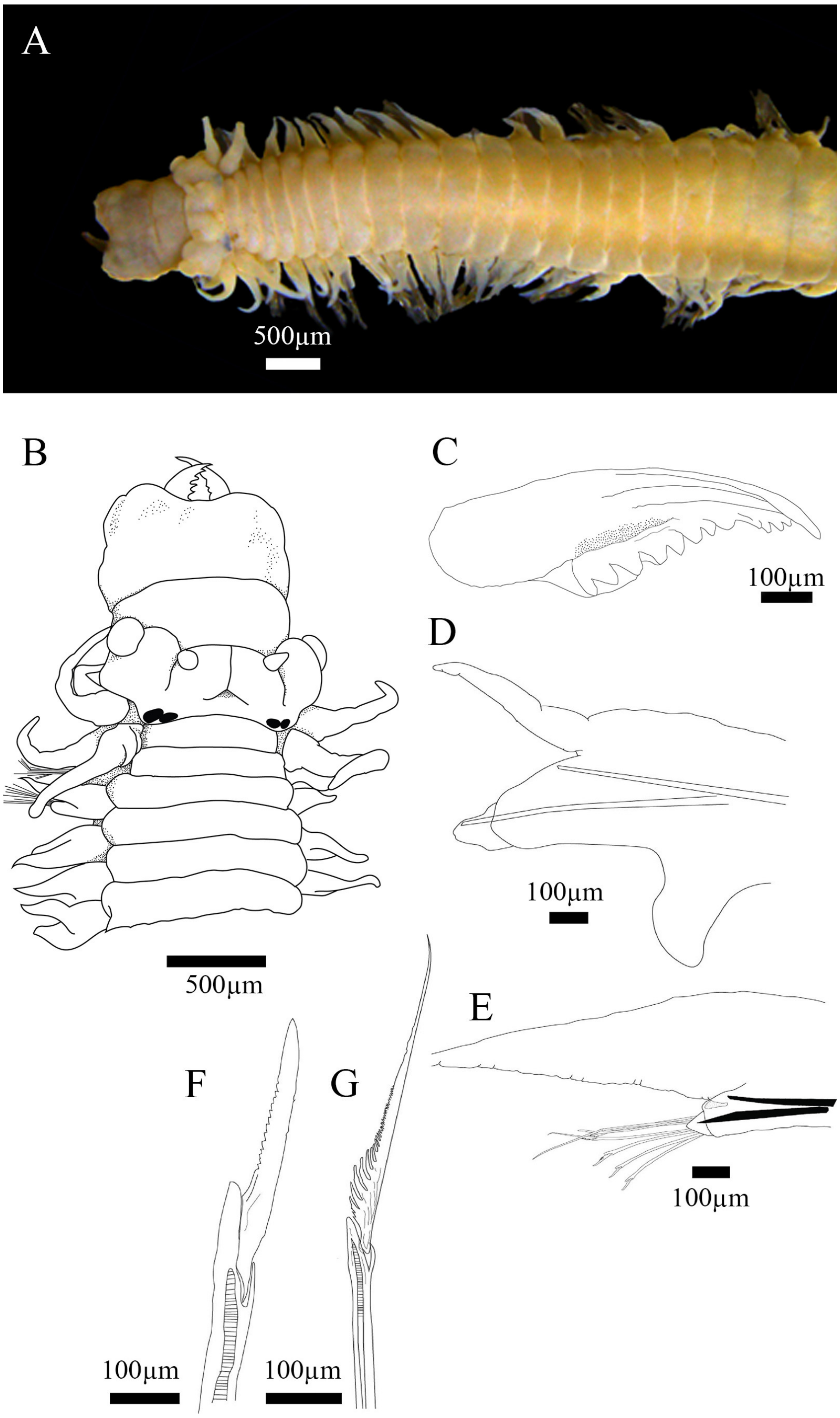

Figure 2. *Namalycastis hawaiiensis* (Johnson, 1903) collected from Se'adya stream, Israel: A, general view; B, dorsal view of anterior; C, jaw; D, parapodium from 10th chaetiger with notopodial supra-acicular sesquigomph spiniger; E, parapodium from posterior segment; F, subneuroacicular falcigers in 10th chaetiger with finely serrated blades; G, sub-neuroacicular spinigers with coarsely serrated blades from posterior chaetiger. Photograph by Liron Goren.

extending short of tip of palpophore. Eyes 2 pairs, black, arranged transversely, both pair roughly the same size (Figure 2B).

Peristomium. Four tentacular cirri with cirrophores distinct; cirrostyles smooth. Tentacular cirri unequal in length; postero-dorsal ones longest, extending posteriorly to setiger 5 (Figure 2B). Jaws with single robust terminal tooth, 7 subterminal teeth, 4 teeth ensheathed, brown (Figure 2C).

Parapodia. Notopodial lobe absent. Acicular neuropodial ligule bilobed (Figure 2D). Superior lobe papilliform. Inferior lobe globular. Dorsal cirri increasing in length posteriorly (Figure 2E).

Setae. One notopodial sesquigomph spinigers in each setiger from setiger 2, though absent in some podia. Supra-neuroacicular setae include sesquigomph spinigers in postacicular fascicles and heterogomph falcigers in preacicular fascicles. Sub-neuroacicular setae include heterogomph spinigers and heterogomph falcigers in postacicular fascicles (variation of type C; Conde-Villa 2017). Supra-neuroacicular sesquigomph spinigers in setiger 10 with boss 1.6 × length of collar. Heterogomph setae with boss not prolonged. Supra-neuroacicular falcigers in setiger 10 with blades 6.05 × longer than width of shaft head, moderately serrated, 15–16 teeth, 0.44–0.51 × total blade length, teeth about uniform in length (Figure 2F). Sub-neuroacicular falcigers in setiger 10 with blades moderately serrated; dorsal-most 7.5–8 × longer than width of shaft head, 14 teeth; ventral-most 6.8 × longer than width of shaft head, 6 teeth. Sub-neuroacicular falcigers in mid-posterior region with blades moderately serrated. Sub-neuroacicular spinigers in anterior region with blades finely serrated; posteriorly, from setiger 120, blades having coarse serrations proximally (Figure 2G). Setae brown. Acicula in brown-black.

Pygidium. Pygidium with multi-incised rim. Anus dorsoterminal.

Remarks

Morphological identification

The individuals examined were consistent with the description of *N. hawaiiensis* found in a home aquarium in Japan (Abe et al. 2017). It differs to some extant from the neotype described by Glasby (1999) in the presence of notochaetae, which are considered rare in this species (Glasby 1999) and the length of the tentacular cirri. The presence of notochaeta in this species was reported by other authors as well (Horst 1909: *Lycastis hawaiiensis*; Augener 1933: *Lycastis ranauënsis* [sic]; Feuerborn 1931). This morphological variation within the species have led Abe et al. (2017) and Sato (2017) to raise the possibility it represents cryptic speciation in *N. hawaiiensis* and that in fact *L. ranauensis*, which is now regarded as a junior synonym of *N. hawaiiensis* (Glasby 1999), is a valid species. Future taxonomic studies are required to solve this problem.

Molecular identification

The nuclear 18S (Accession MN125541) and mitochondrial COI (Accession MN125542) sequences of VR.25322 were both 100% identical to *Namalycastis hawaiiensis* sequences from Japan, available at the GenBank (LC213729 and LC213726, respectively, Abe et al. 2017).

Discussion

Namalycastis hawaiiensis represents the first species of Namanereidinae recorded from Israel, which is a considerable distance from the native distribution of the species i.e. East Asia and Pacific islands. The possibility of translocation of *N. hawaiiensis* via the aquarium trade has been previously highlighted in other studies on the species in Palau (Glasby et al. 2003), Australia (Glasby and Dane 2008) and Japan (Abe et al. 2017). The finding of this species in an ornamental fish aquarium in a pet store in Israel, and several reports of an unidentified polychaete from freshwater aquaria in Israeli public internet forums (in Hebrew; https://www.fishy.co.il/post.php?postid=10143; https://www.fishy.co.il/post.php?postid=470696; http://www.aqua.org.il/forums/showthread.php?t=171475) suggests introduction via aquaria trade as the main path of distribution. As it is often the case with aquatic organisms, it is likely that this species have reached the local environment when aquaria and tanks were disposed of or cleaned in nearby open bodies of water (Duggan 2010; Marr et al. 2010). By this method of introduction, many species (such as the snails *Mieniplotia scabra* and *Physella acuta* and the goldfish *Carassius auratus*) were introduced to natural freshwater habitats in Israel (Roll et al. 2007a; Yanai et al. 2017), some of which have established lasting populations (Heller et al. 2014). Although the complete life history of this species is unknown, it has been reported that a southern Sumatran population of this species (as *Lycastis ranauensis*) is hermaphroditic (Feuerborn 1931; Glasby et al. 2003) which may enable it to be a more successful invader. The implications of this introduction on the food web and ecosystem of the local environment is yet unknown. However, its presence in two consecutive years and the presence of eggs in the body of one of the specimens may indicate a stable self-sustaining population.

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Authors' Contribution

L.G. – Research conceptualization, sample design and methodology, investigation and data collection, data analysis and interpretation, writing – original draft. T.F – Investigation and data collection, data analysis and interpretation, writing – review and editing. Y.H – Research conceptualization, investigation and data collection, funding provision, writing – review and editing.

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