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The new potential invader *Linopherus canariensis* (Polychaeta: Amphinomidae) in a Mediterranean coastal lake: Colonization dynamics and morphological remarks

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A B S T R A C T

The newly introduced polychaete *Linopherus canariensis* Langerhans, 1881 was found in the Lake of Faro (NE Sicily), during a study comparing the macrobenthos in artificial modules with a neighboring sandy bottom assemblage. Of a total of 4465 specimens, almost 6% showed morphological variation related to branchial turfs and mean body size. The sandy bottom exhibited an average density of 41.86 ind L^{-1} and a wet biomass of 30.35 mg L^{-1}, whereas the artificial substratum reached levels of 205.29 ind L^{-1} and 318.44 mg L^{-1}. The highest estimated immigration rate was 3.7 ind L^{-1} d^{-1} (5.8 mg L^{-1} d^{-1}). In the artificial microhabitat, 0.4% of the population showed mid-anterior fragmentation, with anterior- (2%), mid- (<1%) and posterior- (1%) regenerating lineages, which contributed significantly to the dispersion ability of this species. *L. canariensis* was a selective micro-deposit feeder, even under conditions of reduced sediments. *Linopherus* was found to be a new potential invader of stressed environments that is probably tied to the import of oysters.

1. Introduction

The latitudinal shift of areals for both aquatic and terrestrial taxa linked to global warming is demonstrated by the northward spread of warm-temperate and tropical species (Mooney and Hobbs, 2000; Streftaris et al., 2005; Rilov and Crooks, 2009). In marine environments, the spread of benthic organisms frequently occurs at the planktonic larval stage. These organisms may be transported northward by mass water incursions and scale-dependent hydrological changes due to climatic fluctuations (Galil, 2000, 2008; Bianchi and Morri, 2003). Newly established non-indigenous species that are introduced via ships' hulls or by aquaculture exhibit a diversity of disjoined areals (Zibrowius, 1992; Minchin, 2007; Wonham et al., 2001; Streftaris et al., 2005). Once they settle and become established through single or repeated immigration events, the physiological adaptability and reproductive potential of these allochthonous species can dramatically increase their population density, particularly when biotic control is lacking or weak. The negative direct or indirect effects produced by a non-native species on the indigenous biota represent biopollution (Holloway and Keough, 2002; Olenin et al., 2007). Opportunistic species draw benefits from the confined and organically enriched environments of transitional waters, where local competition is limited and abiotic variability is high, thus rendering harbors, coastal lakes, lagoons and estuaries critical environments in the primary and secondary dispersion of exotic species. Moreover, fish-farming and other human activities also facilitate the dispersion of these species (Afli and Chenier, 2002; Occhipinti-Ambrogi, 2000; Occhipinti-Ambrogi and Savini, 2003). The marine Lake of Faro in the central Mediterranean region is classified as both SCI and SPA (Council Directive 92/43/EEC; cod. ITA030008); it hosts at least one microendemism (Parenzan, 1979) and traditionally supports several small-scale family-run mollusk-farming facilities (mainly for the culture and trade of oysters, mussels and clams). This small coastal basin frequently hosts allochthonous macroinvertebrates, as has recently been demonstrated with regard to mollusks, crustaceans and polychaetes. Regular monitoring of these species has revealed the occurrence of the Amphinomid *Linopherus canariensis* Langerhans, 1881 (Cosentino et al., 2009).

L. canariensis (junior synonym: *Linopherus fauchaldi* San Martin, 1987) is a warm-temperate species known both from the eastern and western Atlantic. The Canary Islands are the site of the type locality and holotype description of this species (Núñez et al., 1991), although it also occurs in the shallow waters off Cuba, the Mexican Caribbean Sea (Salazar–Vallejo, 1996), Panama (Cubit and Williams, 1983) and probably as far south as the northern coast of Brazil (Barroso and Paiva, 2007; Paiva et al., 2007). In the Mediterranean Sea, the presence of *L. canariensis* in the Levantine and Aegean basins was recently reported by Çinar (2009), while no record of this species has been reported for the western Mediterranean and the Tyrrhenian basin. The species exhibits typical

Abbreviations: Anter., anterior body; Chaet., chaetigers; Freq., frequency; Le., left body side; Len., length; post, hint body; Ri, right body side; Wid., width.

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infaunal and cavitary behavior. It colonizes sandy bottoms enriched with organic deposits, sciaphilous algal mats containing calcareous debris and encrusted rocky bottoms, where it lives in detritus-filled interstices (Núñez et al., 1991).

In the Lake of Faro, the colonization dynamics of this warm-temperate Atlantic species were investigated on a small spatial and temporal scale, following the investigation of a new semi-artificial substratum, and a comparative analysis of the natural sediment and introduced substratum was undertaken. Morphological and ecological observations were also conducted with particular regard to feeding preferences to evaluate the role of this new invader with respect the resident biota and ecosystem functioning in general.

2. Methods

2.1. Study site, sampling, and sample treatment

L. canariensis was first recorded during an experimental study on the colonization dynamics of a new semi-artificial, hard-type substratum introduced into the coastal Lake of Faro (Cape Peloro Lagoon, 38°16′07″N, 15°38′13″E NE Sicily, central Mediterranean) (Fig. 1a). It is a temperate deep marine lake (average temperature of shallow waters 20.4 °C) that extends over 0.26 km^2 and reaches a maximum depth of 29 m; the connection to the sea via two small channels is weak, and hydrodynamic exchanges, which are driven by the tidal regime of the Strait of Messina, are limited (average salinity 36.2 psu; data from 1990 to 2004). The water body and sediments are characterized by a prevalent condition of mesotrophy (Saccà et al., 2008), and they support a high level of microbial productivity (Maugeri et al., 2000; Leonardi et al., 2009). Despite the extensive urbanization of the surrounding countryside, low contamination levels have been recorded both in the water and sediment (Giacalone et al., 2004; Minutoli et al., 2008). The sediment composition was found to be broadly homogeneous throughout the experimental field and consisted of coarse sand mixed with bioclastic shell fragments (cobbles 11.96%, gravel 21.93%, coarse sand 52.88%, medium sand 11.16%, fine sand 2.03%, and silt/clay 0.04%); it was poorly to scarcely sorted (mean σ_{φ} 1.28) and weakly altered by a finest mud fraction (mean Sk_{φ} 0.02). The sediments were highly reduced, even in the first few centimeters (mean pH 7.76; mean Eh −315.49), in accordance with a significant amount of organic matter (TOC content ranged from 2.8% to 4.3%).

In May 2008, an experimental field of 7 x 2 m with an average water depth of 1.2 m was delimited to test the colonization dynamics of the benthic fauna toward an artificial granular substratum. Granules of expanded fire clay (6.4 mm average diameter) were loaded into 18 cylindrical modules (height 20 cm; Ø 15 cm; about 3.5 L) formed by 5 mm mesh plastic nets. The modules were buried 15/20 cm into the lake bottom (Fig. 1b) approximately 50 cm apart. Two different treatments were applied throughout the substratum area as follows: group P (heavy treatment) received 5% coarse granular fish-feed pellets (“Advance Marine, Hendrix–Skretting SpA”), and group Y (intermediate treatment) received 10% soluble cell-sized yeast. Additionally, during the 66 days of experimentation, both groups were supplied once a week with 10 g of fish feed pellets, which were dispersed over the top surface of each module. A third control group, C, did not receive any type of organic supplement. Twenty-six samples of comparable volume of both natural sediment (NS, four samples on days 0, 14, 31 and 66; two replicates) and artificial substratum (AS, nine samples randomly selected on days 14, 31 and 66; two replicates) were extracted from the bottom on May 16th and 30th as well as July 22nd. Measurements were carried out for the temperature (probe Temp 5 Eutech/Oakton Instruments, resolution 0.1 °C, accuracy ±0.2 °C), acidity and redox potential (pH/mV Pocket Meter 330i WTW-GmbH, resolution 0.01 and 1.0 mV, respectively; accu-

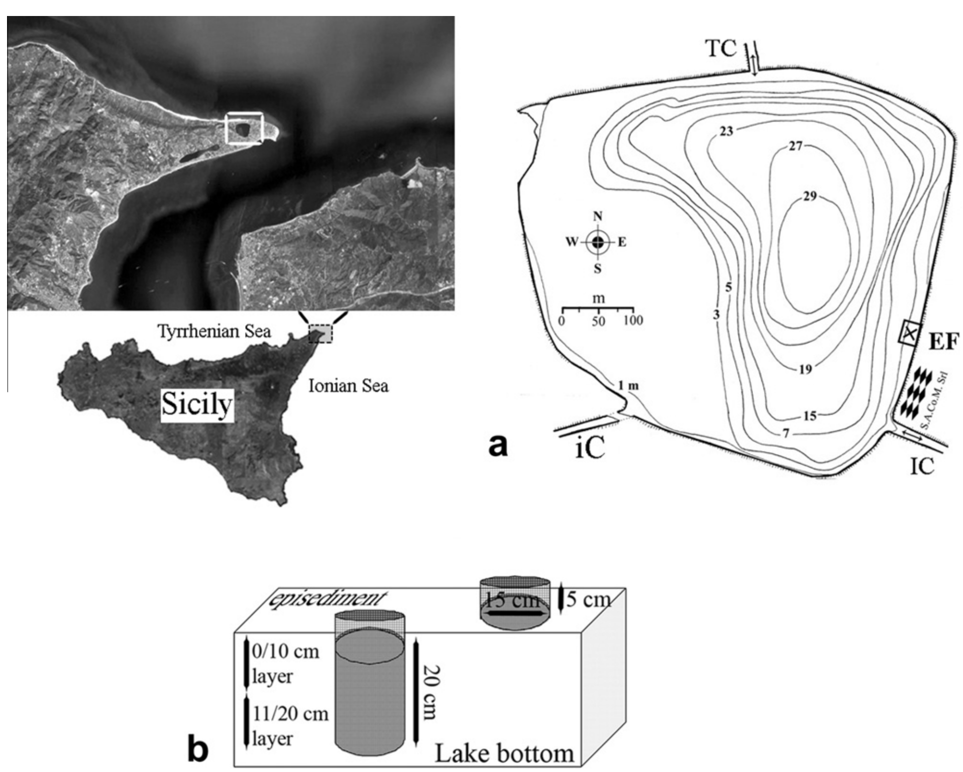

Fig. 1. (a) The coastal marine Lake of Faro (NE Sicily, Central Mediterranean Sea) and the location of the experimental field (EF). The adjacent mollusk-farming facility and connections to the Ionian Sea (IC), Tyrrhenian Sea (TC), and a third internal canal (iC) are shown. (b) The 3D scheme of the net cylinders and their position with respect to the sandy bottom.