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Checklist of free–living nematode species in the transitional environment of Lake Varano (Southern Italy)

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Abstract
Checklist of free–living nematode species in the transitional environment of Lake Varano (Southern Italy).— This study documents for the first time the taxonomic composition of the nematode community and the number of free–living nematode species in Lake Varano, Southern Adriatic Sea, Italy. The nematode community was mainly composed of species typical of fine sediments that usually prevail in transitional environments (TEs). An overall high number of nematode species was recorded (55), belonging to 36 genera in 17 families. These values are highly comparable to those reported for other Italian TEs, but appear lower than those recorded in other European brackish–water systems, probably in relation to the low salinity range of Lake Varano. Forty taxa were identified up to species level, thus increasing the number of the nematode marine species known for the Italian coasts from 443 to 463, for the Adriatic basin from 310 to 313, and for the Southern Adriatic sector from 37 to 77. Considering the importance of this phylum in the assessment of ecological quality and the great vulnerability of the Adriatic Sea ecosystems, an intensification of sampling efforts should be planned, especially in the Central–Southern part of the basin. Such a plan would provide new insights into the biogeography of one of the most important components of the benthic domain and potentially yield new information about the climate warming effects on the Adriatic Sea.

Data published through GBIF [Doi:10.15470/xktjni]

Key words: Free–living nematodes, Biodiversity, Transitional environments, Southern Adriatic Sea

Resumen
Lista patrón de especies de nematodos de vida libre en el ambiente de transición del lago Varano (sur de Italia).— Este estudio documenta por primera vez la composición taxonómica de la comunidad de nematodos y el número de especies de nematodos de vida libre presentes en el lago Varano, al sur del mar Adriático (Italia). La comunidad de nematodos estaba compuesta principalmente por especies típicas de los sedimentos finos predominantes en ambientes de transición (TE). En conjunto, se registró un elevado número de especies de nematodos (55) pertenecientes a 36 géneros de 17 familias. Estos valores son comparables en gran medida a los registrados en otros TE italianos, pero inferiores a los registrados en otros sistemas de aguas salobres europeos, probablemente en relación con el bajo nivel de salinidad del lago Varano.

Se identificaron cuarenta taxones a nivel de especie, lo que incrementa el número de especies conocidas de nematodos marinos en las costas italianas de 443 a 463, en la cuenca del Adriático de 310 a 313 y en el sur del mar Adriático de 37 a 77. Considerando la importancia de este fílum para la valoración de la calidad ecológica y la gran vulnerabilidad de los ecosistemas del mar Adriático, debería planificarse la intensificación de las acciones de muestreo, especialmente en la parte centro–meridional de la cuenca. Un plan de este tipo proporcionaría nuevos conocimientos de la biogeografía de uno de los componentes más importantes del bentos y podría aportar nueva información acerca de los efectos del calentamiento climático en el mar Adriático.

Datos publicados en GBIF [Doi:10.15470/xktjni]

Palabras clave: Nematodos de vida libre, Biodiversidad, Ambientes de transición, Sur del mar Adriático

Resum

Llista patró d'espècies de nematodes de vida lliure a l'ambient de transició del llac Varano (sud d'Itàlia).— Aquest estudi documenta per primera vegada la composició taxonòmica de la comunitat de nematodes i el nombre d'espècies de nematodes de vida lliure presents al llac Varano, al sud de la mar Adriàtica (Itàlia). La comunitat de nematodes estava composta principalment per espècies típiques dels sediments fins predominants en ambients de transició (TE). En conjunt, es va registrar un nombre elevat d'espècies de nematodes (56) pertanyents a 36 gèneres de 17 famílies. Aquests valors són comparables en gran mesura amb els registrats en altres TE italians, però inferiors als registrats en altres sistemes d'aigües salabroses europeus, probablement en relació amb el baix nivell de salinitat del llac Varano. Es van identificar quaranta taxons a nivell d'espècie, la qual cosa incrementa el nombre d'espècies conegudes de nematodes marins a les costes italianes de 443 a 463, a la conca de l'Adriàtica de 310 a 313 i al sud de la mar Adriàtica de 37 a 77. Atesa la importància d'aquest fílum per a la valoració de la qualitat ecològica i la gran vulnerabilitat dels ecosistemes de la mar Adriàtica, s'hauria de planificar la intensificació de les accions de mostreig, especialment a la part centre–meridional de la conca. Un pla així proporcionaria nous coneixements de la biogeografia d'un dels components més importants del bentos i podria aportar nova informació sobre els efectes de l'escalfament climàtic a la mar Adriàtica.

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Paraules clau: Nematodes de vida lliure, Biodiversitat, Ambients de transició, Sud de la mar Adriàtica

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Introduction

Transitional environments (TEs) are aquatic systems characterized by large fluctuations of physicochemical and geochemical variables that could greatly affect the benthos (Barnes et al., 2008; Frontalini & Coccioni, 2011). The Adriatic Sea coast, in particular, hosts a large amount of TEs, ranging from the largest and most studied Lagoon of Venice to wetlands, estuaries, embayments and ponds. All these habitats have been modified to meet human requirements for millennia and are currently under severe stress due to anthropogenic activities and climate change (Airoldi & Beck, 2007).

The phylum Nematoda is the most diverse and numerically dominant component of the aquatic ecosystems (Balsamo et al., 2010; Appeltans et al., 2012). It is particularly important to study TEs due to its ability to survive during environmental changes that may reduce or eliminate macrobenthos (Hendelberg & Jensen, 1993). Furthermore, nematodes are well recognized as a useful tool for biomonitoring assessment of marine ecosystems (Balsamo et al., 2012; Semprucci et al., 2015). Many studies of meiofaunal communities have been carried out in Italian TEs, but they generally concern a higher taxonomic level of identification (Colangelo & Ceccherelli, 1994; Colangelo et al., 1996; Guerrini et al., 1998; Fiordelmondo et al., 2003; Gambi et al., 2003; Fabbrocini et al., 2005; Pusceddu et al., 2007; Cibic et al., 2012).

The species of marine nematodes known in the Italian seas are 443 and are distributed into 262 genera and 46 families (Semprucci et al., 2008). Since the total number of Italian species is a quarter of that of species recorded along European coasts, the overall level of knowledge for the Italian Seas can be considered good. However, these data were collected in the early the 20th century and should be updated (Semprucci, 2013). Furthermore, studies on nematode communities are scarce in southern Italy and have mainly been focused around genus level (De Zio, 1964, 1966; Grimaldi–De Zio, 1967, 1968a, 1968b; De Leonardis et al., 2008; Sandulli et al., 2010, 2011). This is also true for the only information available on the nematodes of the Lesina Lagoon, a southern Italian TE (Fabbrocini et al., 2005).

Lake Varano is a coastal lagoon located on the northern side of the Gargano National Park (Southern Adriatic Sea). It comprises an area of about 65 km^2 and its water depth is about 4 m (Spagnoli et al., 2002). The lake is fed by two artificial channels (Capoiale and Varano) connecting it with the Adriatic Sea and by two tributaries (Antonino and San Francesco Canals) bringing fresh waters from the catchment area. However, the range of salinity range in Lake Varano is generally low (from 23.0 to 31.9) (Frontalini et al., 2013).

In this paper, we list the species and their distribution both at a global and local scale. We also discuss the state of knowledge of Nematoda from the Adriatic basin and southern Italy along with the TE.

Material and methods

Sediment samples from 21 stations were collected on 22nd March 2012 using a modified model of Van Veen Grab (fig. 1). Samples were treated with a 7% $MgCl_2$ aqueous solution to narcotize the fauna, fixed in a 4% formaldehyde solution in buffered sea–water, and stained with Rose Bengal. In the laboratory, the samples were rinsed with a gentle jet of fresh water through a 0.5 mm sieve to remove the macrofaunal components. The residual sediment was then decanted, sieved 10 times through a 42 µm mesh and centrifuged three times with Ludox HS30 (specific density 1.18) (Pfannkuche & Thiel, 1988). One hundred nematodes were randomly picked from each sample and mounted on permanent slides for taxonomic study (Seinhorst, 1959). The specimens were observed under Nomarski Differential Interference Contrast illumination (Optiphot–2 Nikon, 100x oil immersion objective) and identified by means of the NeMys online identification key (Vanaverbeke et al., 2015). The list of nematode species reported below follows Hodda (2011) for the taxonomic status and the Nemys website for the relative geographical global distribution: in the cases for which updates of the latter were available specific references are cited in the Results section. The distribution of nematode species along the Italian coasts refers to Semprucci et al. (2008), while the recording localities in Adriatic Sea relate to Travizi & Vidaković (1997) and Semprucci (2013). All the nematode specimens studied are deposited in the collection of the Zoology Laboratory of the University of Urbino (Italy).

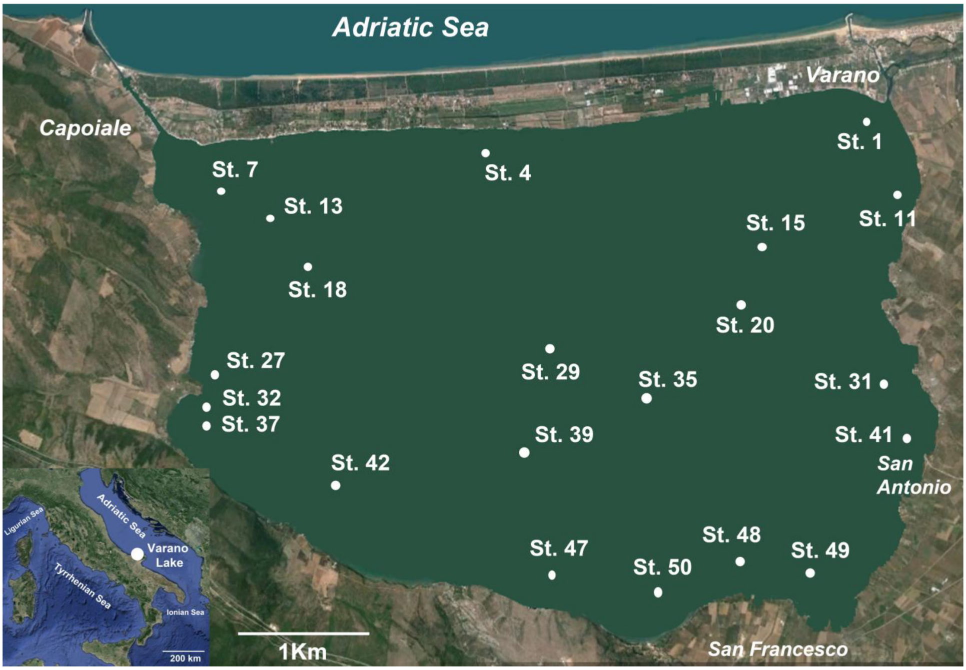

Fig. 1. Map of the study area with location of sampling stations.
Fig. 1. Mapa del área de estudio y localización de los emplazamientos de muestreo.

Results

Fifty–five nematode species belonging to 36 genera and 17 families were found at Lake Varano (table 1). Data published through GBIF: Doi:10.15470/xktjni. The richness ranged from 4 (V29) to 27 (V7) species per station.

The richest families were Chromadoridae (10 species), Linhomoeidae (9) and Xyalidae (8), followed by Oncholaimidae (5), Comesomatidae (3), Cyatholaimidae (3), Microlaimidae (3), Axonolaimidae (2), Camacolaimidae (2), Desmodoridae (2), Leptolaimidae (2), Anoplostomatidae (1), Diplopeltidae (1), Monhysteridae (1), Oxystominidae (1), Selachinematidae (1) and Sphaerolaimidae (1).

Fifteen taxa were identified as putative species because the specimens collected were juveniles or females, which often lack the diagnostic features required for an accurate taxonomic identification. However, their records are shown in table 1 because they contribute to the few available data for the Southern Adriatic coasts.

The list of species identified is given below:

Table 1. List per station of the free–living nematode species found in Lake Varano (Southern Adriatic Sea, Italy). Data published through GBIF (http://www.gbif.es/ipt/resource?r=semprucci_nematode).
Tabla 1. Lista de nematodos de vida libre registrados en las distintas estaciones de muestreo del lago Varano (sur del mar Adriático, Italia). Datos publicados en GBIF (http://www.gbif.es/ipt/resource?r=semprucci_nematode).

	Stations																				
	V1	V4	V7	V11	V13	V15	V18	V20	V27	V29	V31	V32	V35	V37	V39	V41	V42	V47	V48	V49	V50
Latitude (N)	41.910	41.889	41.903	41.899	41.893	41.895	41.887	41.888	41.874	41.874	41.877	41.870	41.868	41.868	41.862	41.865	41.864	41.850	41.851	41.851	41.845
Longitude (E)	15.795	15.729	15.687	15.802	15.705	15.775	15.707	15.773	15.687	15.741	15.803	15.684	15.767	15.684	15.740	15.804	15.690	15.739	15.776	15.783	15.761
O. Enoplida Filipjev, 1929																					
F. Anoplostomatidae Gerlach & Riemann, 1974																					
Anoplostoma viviparum (Bastian, 1865) Bütschli, 1874	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	X
O. Oncholaimida Siddiqi, 1983																					
F. Oncholaimidae Filipjev, 1916																					
Oncholaimus brevisetosus Kreis, 1932	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–
Oncholaimus longicaudatus (Kreis, 1932) Rachor, 1969	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Oncholaimus sp. 1	X	–	–	–	–	–	–	–	X	–	–	X	–	–	–	–	–	–	–	–	–
Oncholaimellus mediterraneus Stekhoven, 1942	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Oncholaimellus sp. 1	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
O. Ironida Hodda, 2007																					
F. Oxystominidae Filipjev, 1918																					
Oxystomina sp. 1	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
O. Chromadorida Chitwood, 1933																					
F. Chromadoridae Filipjev, 1917																					
Chromadora yamadai Kito, 1978	X	–	X	–	–	–	X	–	–	–	–	–	–	–	–	–	X	–	–	–	–
Chromadorella macris (Gerlach, 1956) Lorenzen, 1972	–	X	–	–	–	X	X	–	–	–	X	X	–	–	–	–	–	–	–	–	–
Chromadorella salicaniensis Boucher, 1976	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chromadorina germanica (Bütschli, 1874) Wieser, 1954	–	–	–	X	X	–	–	–	–	X	–	X	X	X	–	–	X	–	X	–	–
Chromadorita sp. 1	–	–	X	–	–	–	–	X	–	–	–	X	–	X	X	–	–	–	X	X	X
Neochromadora papillosa Pastor de Ward, 1985	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	X	X
Neochromadora poecilosomoides (Filipjev, 1918) Wieser, 1954	X	X	X	–	–	–	–	–	–	–	X	–	X	X	–	–	–	–	–	X	X
Neochromadora sp. 4	–	–	–	–	–	–	–	–	–	–	–	X	–	X	X	–	X	–	X	–	–
Ptycholaimellus macrodentatus (Timm, 1961) Wieser & Hopper, 1967	X	–	X	–	X	–	–	–	–	–	X	X	–	–	–	X	–	–	X	–	–
Spilophorella euxina Filipjev, 1918	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
F. Cyatholaimidae Filipjev, 1918																					
Cyatholaimus gracilis (Eberth, 1863) Bastian, 1865	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Paracanthonchus longicaudatus Warwick, 1971	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–
Paracyatholaimus sp. 1	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
O. Selachinematida Hodda, 2011																					
F. Selachinematidae De Coninck, 1965																					
Synonchiella edax Aissa & Vitiello, 1977	X	X	–	–	X	X	X	X	–	–	–	–	X	–	X	–	X	–	–	–	–
O. Desmodorida De Coninck 1965																					
F. Desmodoridae Filipjev, 1922																					
Desmodora granulata Vincx & Gourbault, 1989	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Molgolaimus allgeni (Gerlach, 1950) Jensen, 1978	X	–	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
F. Microlaimidae De Coninck & Schuurmans Stekhoven, 1933																					
Aponema torosa (Lorenzen, 1973) Jensen, 1978	–	–	X	X	X	X	X	X	X	–	X	–	X	X	X	X	X	X	–	X	X
Microlaimus sp. 2	X	–	X	X	–	–	X	–	–	–	–	X	–	X	–	–	–	–	–	–	–
Microlaimus honestus De Man, 1922 (op. Kovalyev & Tchesunov, 2005)	X	–	X	X	–	X	X	X	–	X	X	X	X	–	–	X	X	X	X	–	X
O. Monhysterida Filipjev, 1929																					
F. Axonolaimidae De Coninck & Stekhoven, 1933																					
Axonolaimus caudostriatus Boucher, 1973	–	X	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Odontophora wieseri Luc & De Coninck, 1959	X	X	–	X	–	–	–	–	–	–	–	X	–	X	–	–	–	–	–	–	–
F. Diplopeltidae Filipjev, 1918																					
Southerniella sp. 1	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
F. Comesomatidae Filipjev, 1918																					
Paracomesoma dubium (Filipjev, 1918)	X	–	–	X	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sabatieria pulchra (Schneider, 1906)	–	–	X	X	–	X	–	X	X	–	X	–	–	X	X	X	–	X	X	X	X
Sabatieria pomarei (Boucher, 1973)	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
F. Linhomoeidae Filipjev, 1922																					
Metalinhomoeus biformis Juario, 1974	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–
Metalinhomoeus musaecauda Lorenzen, 1966	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	X	–	X	–	X
Metalinhomoeus sp. 4	X	–	X	–	X	–	X	–	–	–	–	X	X	X	X	–	X	–	–	–	X
Metalinhomoeus sp. 3	–	–	X	–	–	X	–	X	–	–	–	X	–	–	–	–	–	–	–	–	–
Paralinhomoeus sp. 1	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Terschellingia brevicauda Ott, 1972	X	–	X	X	–	–	X	–	–	–	–	–	–	–	–	–	X	–	–	–	X
Terschellingia communis De Man, 1888	–	–	–	–	–	–	–	X	–	–	–	–	X	–	–	–	–	–	X	X	–
Terschellingia longicaudata De Man, 1907	X	–	X	X	X	X	X	X	X	–	X	X	X	X	X	X	X	X	X	X	X
Terschellingia vestigia Gerlach, 1963	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
F. Monhysteridae De Man, 1876																					
Thalassomonhystera parva (Bastian, 1865) Jacobs, 1987	–	–	X	–	–	X	–	–	X	X	–	X	–	X	X	X	–	X	X	X	X
F. Sphaerolaimidae Filipjev, 1918																					
Sphaerolaimus gracilis De Man, 1876	–	–	X	X	–	–	–	–	–	–	X	–	–	–	–	X	–	–	X	–	X
F. Xyalidae Chitwood, 1951																					
Daptonema fistulatus (Wieser & Hopper, 1967) Lorenzen, 1977	–	–	X	X	X	X	X	–	X	–	–	–	–	X	–	–	X	–	–	–	X
Daptonema curticauda (Tchesunov, 1980) Tchesunov, 1990	–	–	–	X	X	X	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–
Daptonema normandicum (De Man, 1890) Lorenzen, 1977	X	–	–	X	X	X	–	X	–	–	X	–	X	–	X	X	X	–	X	X	X
Daptonema sp. 1	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–
Daptonema sp. 5	–	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Paramonhystera pellucida (Cobb, 1920) Wieser, 1956	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Theristus sp. 1	–	X	–	–	–	–	–	–	–	–	–	X	–	–	–	X	X	–	–	–	–
Steineria simplex Timm, 1963	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–
O. Plectida Malakhov, Ryzhikov & Sonin, 1982																					
F. Camacolaimidae De Coninck & Stekhoven, 1933																					
Diodontolaimus sabulosus Southern, 1914	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Procamacolaimus sp. 1	X	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
O. Leptolaimida Hodda, 2007																					
F. Leptolaimidae Oerley, 1880																					
Leptolaimus luridus Timm, 1963	X	–	X	X	X	X	X	X	–	–	X	X	X	X	X	X	X	X	X	X	X
Leptolaimus elegans (Stekhoven & De Coninck, 1933) Gerlach, 1958	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	X

Order Enoplida Filipjev, 1929

Family Anoplostomatidae Gerlach & Riemann, 1974

Anoplostoma viviparum (Bastian, 1865) Bütschli, 1874
Geographical distribution: North Sea, Baltic Sea, Black Sea, Gulf of Mexico, Mediterranean Sea, North Atlantic Ocean, Azov Sea. In Italy this species was originally reported for the Northern Adriatic Sea where it was known only in the Po Delta and the Venice Lagoon.

Ecological notes: the species was found in the southern part of the lake in sediments with a prevalent fraction of mud (mud: 66–68%; sand: 32–34%) and a level of organic matter ($CaCO_3$ content) ranging from 34 to 44%.

Order Oncholaimida Siddiqi, 1983

Family Oncholaimidae Filipjev, 1916

Oncholaimus brevisetosus Kreis, 1932
Geographical distribution: Indian Ocean (Indonesia). The species is the first record for Italy.

Ecological notes: the species was collected in a western station of the lake. The sediments were characterized by a prevalent amount of mud (58%) and the $CaCO_3$ content was high (81%).

Oncholaimus longicaudatus (Kreis, 1932) Rachor, 1969
Geographical distribution: Indian Ocean. This is the first record for Italy.

Ecological notes: it was found in front of the Capoiale Channel. The sediments were sandy deposits (sand: 63%; mud: 41%) characterized by 41% of $CaCO_3$.

Oncholaimellus mediterraneus Stekhoven, 1942
Geographical distribution: Mediterranean Sea, North Atlantic Ocean, North Sea. Sergeeva (1977) also reported this species from the Black Sea. In Italy, it was reported for the South Tyrrhenian Sea and the Northern Adriatic Sea: here it was recorded at Mirna Estuary, Rovinj area and Makarska harbour area (Croatia).

Ecological notes: it was collected only in the station in front of the Capoiale Channel. The substratum consisted of sandy sediments (sand: 63%; mud: 41%) with a 41% fraction of $CaCO_3$.

Order Chromadorida Chitwood, 1933

Family Chromadoridae Filipjev, 1917

Chromadora yamadai Kito, 1978
Geographical distribution: North Pacific Ocean. This is the first record for Italy.

Ecological notes: it was found especially in front of the Capoiale and Varano Channels and was associated with sediments with a prevalent fraction of sand (sand: 53–73%; mud: 27–47) and a generally rich amount of organic matter ($CaCO_3$: 28–63%).

Chromadorella macris (Gerlach, 1956) Lorenzen, 1972
Geographical distribution: South Atlantic Ocean. This is the first record for Italy.

Ecological notes: this species was scarce in the study area. It was mainly found in sandy sediments and only in one case in sediments with a dominance of mud (St. 31) (range of sand: 16–90%; mud: 10–84%). It was generally associated with relatively high levels of $CaCO_3$ (10–56%).

Chromadorella salicaniensis Boucher, 1976
Geographical distribution: North Sea and Adriatic Sea. It was found in the Venice Lagoon (Northern Adriatic Sea).

Ecological notes: it was not abundant in the study area and found only at two stations close to the baymouth bar. It was collected mainly from sandy sediments (sand: 73–90%; mud: 10–27%) characterized by a low level of $CaCO_3$ (10–28%).

Chromadorina germanica (Bütschli, 1874) Wieser, 1954
Geographical distribution: Mediterranean Sea, North Atlantic Ocean, North Sea. In particular, it was known in Italy only for the Ligurian and Northern Tyrrhenian coast.

Ecological notes: it was more frequent in the northern–central part of the lake. It was related to sediments characterized by a roughly equal fraction of sand and mud (39–68% and 32–61%, respectively). The amount of $CaCO_3$ was variable, ranging from 23 to 81%.

Neochromadora papillosa Pastor de Ward, 1985
Geographical distribution: West Atlantic. This is the first record for the Italian coasts.

Ecological notes: it was found in few stations, all in the eastern part of the lake, mainly in muddy sediments (sand: 32–65%; mud: 35–68%) with a generally high organic content ($CaCO_3$: 10–48%).

Neochromadora poecilosomoides (Filipjev, 1918) Micoletzky, 1924
Geographical distribution: Black Sea, Mediterranean Sea, North Atlantic Ocean, North Sea. The previous reports in the Italian coasts were from the Ligurian and Southern Tyrrhenian Seas, Strait of Messina, the south–eastern tip of Sicily and the northern part of the Adriatic sector (Rovinj area).

Ecological notes: it was found in several stations, but especially in the northern part of the lake and mainly in relation to the sand fraction (sand: 16–90%; mud: 10–84%). The amount of $CaCO_3$ varied from 9.5 to 80%.

Ptycholaimellus macrodentatus (Timm, 1961) Wieser & Hopper 1967
Geographical distribution: Bay of Bengal. It is the first record in Italy.

Ecological notes: it was mainly collected from the marginal zones of the lake, in sediments ranging in sand percentage from 16 to 73% and in mud from 27 to 84%. The $CaCO_3$ level varied from 10 to 81%.

Spilophorella euxina Filipjev, 1918
Geographical distribution: Black Sea, Mediterranean Sea, North Atlantic Ocean. The Adriatic sector was the only part of the Italian coasts reported to host this species (offshore area of the Rovinj —Po River mouth and Poreć— Venice transects, Lim Channel, Rovinj area and Raśa Bay, Croatia).

Ecological notes: it was collected only in front of the Varano Channel in association with sandy sediments (sand: 73%, mud: 27%) with a relatively poor organic content (28% of $CaCO_3$).

Family Cyatholaimidae Filipjev, 1918

Cyatholaimus gracilis (Eberth, 1863) Bastian, 1865
Geographical distribution: Black Sea, Mediterranean Sea, North Atlantic Ocean, North Sea. The presence of this species is well documented on the Italian coasts: Ligurian and Southern Tyrrhenian Seas, Strait of Messina, Northern Adriatic Sea (Po Delta, Rovinj area, Gulf of Trieste) and Central Adriatic Sea (Fiorenzuola and Brisighella).

Ecological notes: it was found only in front of the baymouth bar, in sandy sediments (sand: 90% and mud: 10%) with a very low organic content (10% of $CaCO_3$).

Paracanthonchus longicaudatus Warwick, 1971
Geographical distribution: Barents Sea, North Atlantic Ocean, North Sea. It is the first record for Italy.

Ecological notes: it was found in only two stations, associated with sandy sediments (sand: 53–90%, mud :10–47%). The level of $CaCO_3$ varied from 10 to 63%.

Order Selachinematida Hodda, 2011

Family Selachinematidae De Coninck, 1965

Synonchiella edax Aissa & Vitiello, 1977
Geographical distribution: Mediterranean Sea. It is a new record for the Italian coasts.

Ecological notes: it was located especially in the northern and central part of the lake. The sediments were mainly characterized by a dominant sandy component (from 39 to 90%) with a medium–low organic content ($CaCO_3$ from 10 to 63%).

Order Desmodorida De Coninck, 1965

Family Desmodoridae Filipjev, 1922

Desmodora granulata Vincx & Gourbault, 1989
Geographical distribution: France (Morlaix, Brittany). This is a new record for Italy.

Ecological notes: it was found only in front of Capoiale Channel in sandy sediments (sand: 63%, mud: 41%), with 41% of $CaCO_3$.

Molgolaimus allgeni (Gerlach, 1950) Jensen, 1978
Geographical distribution: North Atlantic Ocean, North Sea and Adriatic Sea (Rovinj —Po River mouths and Venice).

Ecological notes: it was detected in almost all the stations of the study area and was one of the most abundant species. It was mainly associated with the fine sediment fraction (sand: 32–73%; mud: 27–84%) and organic enrichment ($CaCO_3$: 10–81%).

Family Microlaimidae De Coninck & Stekhoven, 1933

Aponema torosa (Lorenzen, 1973) Jensen, 1978
Geographical distribution: North Atlantic Ocean, North Sea. In the Adriatic Sea, it was reported for the Northern sector (Lim Channel and Raśa Bay, Croatia).

Ecological notes: it was one of the most widespread species in the lake, but it was especially abundant in front of the two channels) and in the central parts of the lake. Sediments were muddy (mud fraction from 37 to 84%; sand fraction from 16–65%) and usually contained a high level of organic matter ($CaCO_3$ from 10 to 81%).

Microlaimus honestus De Man, 1922 (op. Kovalyev & Tchesunov, 2005)
Geographical distribution: Argentina (Fuegian Archipelago), Baltic Sea, English Channel, Mediterranean Sea, North Atlantic Ocean, North Sea, South Atlantic Ocean, Southern Ocean (Antarctic Ocean, Graham Island, King George Island, South Weddell Sea), Uruguay, East Pacific.

In Italy it was reported only for the Tyrrhenian coasts. The present finding is a new record for the Adriatic basin.

Ecological notes: this species was found in almost all stations, but especially in front of two channels and in the central part of the lake. Sediments were mainly muddy (mud: 27–84%; sand: 16–73%) and salinity levels ranged from 23 to 30‰.

Order Monhysterida Filipjev, 1929

Family Axonolaimidae De Coninck & Stekhoven, 1933

Axonolaimus caudostriatus Boucher, 1973
Geographical distribution: Pacific Ocean (Polynesian islands). It is a new record for the Italian coasts.

Ecological notes: the species was found only in the area close to the baymouth bar and mainly in sandy sediments (sand: 43–90%; mud: 10–57%) with a $CaCO_3$ level from 10 to 27%.

Odontophora wieseri Luc & De Coninck, 1959
Geographical distribution: North Atlantic Ocean. In Italy, it was previously known only in the Central Adriatic Sea.

Ecological notes: it was collected in few stations, mainly located in the northern part of the lake. It was strongly associated with the sandy fraction of the sediment (sand: 42–90%; mud: 10–58%) and a low organic content ($CaCO_3$: 10–81%).

Family Comesomatidae Filipjev, 1918

Paracomesoma dubium (Filipjev, 1918) Stekhoven, 1950
Geographical distribution: Mediterranean Sea, North Atlantic Ocean. In Italy, it was only known in the Northern Adriatic Sea (in the Venice Lagoon) and Bakar Bay, Croatia.

Ecological notes: it was collected from the northern part of the lake, and in particular in sandy sediments (sand: 43–73%; mud: 27–57%) with a medium level of organic matter content ($CaCO_3$: 27–28%).

Sabatieria pulchra (Schneider, 1906) Riemann 1970
Geographical distribution: Baltic Sea, Black Sea, Mediterranean Sea, North Atlantic Ocean, North Sea. In the Northern Adriatic Sea it was reported for: Po Delta, Venice Lagoon (Italy) Mirna Estuary, Raśa Bay and Makarska harbour area (Croatia).

Ecological notes: species abundant and widespread in the area. It was mainly related to fine sediments (mud: 35–84%; sand: 16–65%) in conjunction with levels of salinity from 23 to 30‰.

Sabatieria pomarei (Boucher, 1973) Jensen, 1979
Geographical distribution: South Pacific Ocean (Polynesia). This is a new record for the Italian coasts.

Ecological notes: It was found only in the station in front of the Capoiale Channel, in sandy sediment (sand: 63%, mud: 41%) characterized by 41% of $CaCO_3$.

Family Linhomoeidae Filipjev, 1922

Metalinhomoeus biformis Juario, 1974
Geographical distribution: Adriatic Sea (Po River mouth and Venice Lagoon in Venice, Rovinj, Mirna Estuary, Lim Channel, Rovinj area and Makarska harbour in Croatia).

Ecological notes: it was found in only one station at the western part of the lake, with 57% of sand and 43% of mud, and 54% of $CaCO_3$.

Metalinhomoeus musaecauda Lorenzen, 1966
Geographical distribution: North Atlantic Ocean and North Sea. It is the first record in Italy.

Ecological notes: it was found in a few stations, mainly located in the Southern part of the lake and in front of the Capoiale Channel. It was collected from sediments characterized by a prevalent mud component (from 47 to 68%), while the sand fraction was generally lower (32–53%). The level of $CaCO_3$ ranged from 34 to 63%.

Terschellingia brevicauda Ott, 1972
Geographical distribution: North Atlantic Ocean (North Carolina). It is the first record in Italy.
Ecological notes: it was found mainly in the northern and western part of the lake in sediments characterized by a prevalent sandy component (sand: 32–73%; mud: 27–68%) and a medium–high level of organic content (27–63%).

Terschellingia communis De Man, 1888
Geographical distribution: Mediterranean Sea, North Atlantic Ocean and North Sea. In the Adriatic Sea, it was recorded at the offshore area of the Rovinj —Po River mouths and Poreć— Venice transects, Po Delta, Venice Lagoon, Mirna Estuary, Lim Channel, Rovinj area, Raśa Bay and Makarska harbour area
Ecological notes: it was found only in the central and eastern part of the lake. It was mainly associated with sediments, with a sand percentage from 44 to 65% and mud from 35 to 56%. The level of organic matter content ranged from 21 to 48%.

Terschellingia longicaudata De Man, 1907
Geographical distribution: Baltic Sea, Barents Sea, Gulf of Mexico, Mediterranean Sea, North Atlantic Ocean, North Sea and New Zealand zone. Ürkmez et al. (2011) also reported its presence in the Black Sea. In the Adriatic Sea, it was reported in the offshore area of the Rovinj —Po River mouth and Poreć— Venice transects, Po Delta, Venice Lagoon, Mirna Estuary, Lim Channel, Rovinj area, Raśa Bay, Makarska harbour area and South Adriatic (eastern coasts).
Ecological notes: it was abundant and frequent in all the stations of the lake. It was found in sediments with ranges of sand from 16 to 63% and mud from 27 to 84%. The range of $CaCO_3$ was 10 to 81%.

Terschellingia vestigia Gerlach, 1963
Geographical distribution: Indian Ocean (Maldives). It is the first record from Italy.
Ecological notes: it was recorded in a single station in the central part of the lake, with sandy sediments (sand: 60% and mud: 40%) and a medium level of organic matter (25% of $CaCO_3$).

Family Monhysteridae De Man, 1876

Thalassomonhystera parva (Bastian, 1865) Jacobs, 1987
Geographical distribution: North Atlantic Ocean, North Sea. It is the first record in Italy.
Ecological notes: it was well distributed in the lake, but more abundant in the eastern part. It was associated with sediments mainly represented by mud (32–68%) and sand (32–68%). The organic content varied from 10 to 81% and the species was related to salinity levels ranging from 23 to 29‰.

Family Sphaerolaimidae Filipjev, 1918

Sphaerolaimus gracilis De Man, 1876
Geographical distribution: Black Sea, Mediterranean Sea, North Atlantic Ocean and North Sea. In the Northern Adriatic sector, it was reported in the offshore area of the Rovinj —Po River mouth and Poreć— Venice transects and Rovinj area.
Ecological notes: it was collected from the stations close to Capoiale and Varano Channels and in the south–eastern part (see San Antonio Canal). It was found in sediments with a generally high level of mud (range from 37 to 84%) and low level of sand (16 to 63%) and an organic content that ranged from 10 to 44% of $CaCO_3$.

Family Xyalidae Chitwood, 1951

Daptonema curticauda (Tchesunov, 1980) Tchesunov, 1990
Geographical distribution: Caspian Sea. It is a new record for the Italian coasts.

Ecological notes: it was found in a few stations, mainly located in the northern part of the lake (Varano Channel) and at one station on the western coast. The species was associated with a prevalent mud component (mud range: 43–61%; sand range: 39–57%) and a generally high amount of organic matter ($CaCO_3$: 31–56%).

Daptonema fistulatus (Wieser & Hopper, 1967) Lorenzen, 1977
Geographical distribution: Gulf of Mexico, North Atlantic Ocean and North Sea. Its presence is documented in the shallow sublittoral of the central Adriatic coast (Fiorenzuola and Brisighella).

Ecological notes: it was frequently found in the northern and south–western part of the lake. It appeared associated with muddy sediments (mud: 37–61%; sand: 42–63%) with organic detritus ($CaCO_3$: 27–81%).

Daptonema normandicum (De Man, 1890) Lorenzen, 1977
Geographical distribution: France (Wimereux), Mediterranean Sea, North Atlantic Ocean, North Sea. In Italy its presence was documented by Guerrini et al. (1998) in the 'Valli di Comacchio' complex (Northern Adriatic Sea).

Ecological notes: it was frequent and abundant in the Varano Lake and was particularly abundant in the stations close to the San Francesco output and in the central area. It was present in sediments characterised by 27–84% of mud and 16–73% of sand, and appeared more abundant in sites with a low salinity level.

Paramonhystera pellucida (Cobb, 1920) Wieser 1956
Geographical distribution: North Pacific Ocean (California), Arabian Sea. This is the first record in Italy.

Ecological notes: it was collected only near the baymouth bar in relation to sandy sediments (sand: 90%; mud: 10%) with a poor organic content ($CaCO_3$: 10%).

Steineria simplex Timm, 1963
Geographical distribution: Arabian Sea. This is the first record in Italy.

Ecological notes: it was collected only at one station located on the eastern edge of the lake, in sandy sediments (sand: 65%; mud: 35%) with a high organic content (48%).

Order Plectida Malakhov, Ryzhikov & Sonin, 1982

Family Camacolaimidae De Coninck & Stekhoven 1933

Diodontolaimus sabulosus Southern, 1914
Geographical distribution: North Atlantic Ocean. This is the first record for Italy.

Ecological notes: this species was found only in the area close to the baymouth bar and in particular in sandy sediments (sand: 63%; mud: 41%) with 41% of $CaCO_3$.

Order Leptolaimida Hodda, 2007

Family Leptolaimidae Oerley, 1880

Leptolaimus luridus Timm, 1963
Geographical distribution: North Atlantic Ocean. This is a first record for the Italian coasts.

Ecological notes: it was one of the most abundant and widespread species in the lake, closely associated to muddy sediments (mud: 27–84%; sand: 16–73%) rich in organic detritus ($CaCO_3$: 10–81%).

Leptolaimus elegans (Stekhoven & De Coninck, 1933) Gerlach, 1958
Geographical distribution: North Atlantic Ocean, North Sea. In Italy, it was reported for the Southern Tyrrhenian coasts.

Ecological notes: it was found in a few stations on the eastern side of the lake, in muddy sediments (mud: 68–84%; sand: 16–32%). $CaCO_3$ ranged from 18 to 44%.

Discussion

Given its particular physico–chemical features, the Adriatic Sea is strongly influenced by meteorological conditions and river discharges, and it is particularly sensitive to human impact and climatic changes (Occhipinti–Ambrogi et al., 2005; Balsamo et al., 2010; Frontalini et al., 2011).

However, the biodiversity of the Adriatic macrofauna does not appear to have suffered a substantial decrease during the last years, mainly because alien species have masked the overall species loss, but the trophic web and the functioning of marine ecosystems have been affected (*e.g.,* Occhipinti–Ambrogi, 2002, 2007; Giani et al., 2012).

If it is relatively easy to document the changes in macrofaunal communities over time, it is not possible to do the same for meiofaunal organisms since their spatial distribution is frequently understudied in many geographical regions (Balsamo et al., 2010). Even when data are available, they are often outdated, making it difficult to determine biogeographic patterns or to support possible hypotheses of 'tropicalization' of the Adriatic Sea (Artois et al., 2011; Semprucci, 2013). The significance of the present study is that it provides a detailed list of nematode species from a littoral area of the Southern Adriatic Sea and updates knowledge on the Mediterranean regions.

Of the 55 species identified in the present study, 20 are new records for the Italian coasts, three are new records for the Adriatic basin, and 40 are reported for the first time for the Southern Adriatic sector (Semprucci et al., 2008). These data greatly increase our faunistic knowledge about the distribution of marine Nematoda along the Italian coasts, and especially in the TE systems that are still poorly known environments.

The nematode community of Lake Varano mainly comprised species representative of fine sediments (Heip et al., 1985; Travizi & Vidakovic, 1997) or TEs (Villano & Warwick, 1995; Pallo et al., 1998; Fabbrocini et al., 2005; Barnes et al., 2008). The richness values were overall highly comparable to those reported for other Italian TEs (Guerrini et al., 1998; Fabbrocini et al., 2005), but were generally lower than those found in the European brackish water systems (*e.g.,* Hendelberg & Jensen, 1993; Barnes et al., 2008; Ferrero et al., 2008). This might be because the low range of salinity levels of Varano Lake (Frontalini et al., 2013) does not host typical freshwater fauna as in European brackish systems.

The lagoon has been intensively exploited, mainly for mussel aquaculture (Beneduce et al., 2010), but agricultural activities have also been noted to have some impact in the surrounding areas (Specchiulli et al., 2008). However, a significant anthropogenic impact on the meiobenthic communities of the Lake Varano was not detected despite the economic development of the surrounding area (Frontalini et al., 2014). This suggests that the composition of the nematode community reported in this study represents a poorly disturbed environment and could be a valuable baseline for future monitoring programs (Moreno et al., 2011).

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