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New alien foraminifer guests in the Eastern Aegean Sea (Turkey)

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Abstract

Four alien foraminifer species are found in the recent sediment samples collected from the Aegean coast of Turkey. *Nodobaculariella cristobalensis* McCulloch and *N. galapagosensis* McCulloch are observed in Güllük Bay (Muğla), Karşıyaka (İzmir) and Babakale (Balıkesir). These two species have not yet been recorded in the Mediterranean. Their absence in the Indian Ocean fauna suggests an introduction via ballast waters. Two individuals of Indo-Pacific originated foraminifer species, *Pseudonodosaria brevis* (d'Orbigny, 1846) are found in the recent sediment samples from Ildır Bay (İzmir) and Akköy (Aydın). This constitutes the first records of these species in the Mediterranean Sea. *Cornuspiroides striolata* (Brady) specimens are observed in grab samples collected from seven different stations in Ildır Bay. This is the second record of this species from the Turkish coastline and extends its range of distribution.

Keywords: *Cornuspiroides striolata*, *Nodobaculariella cristobalensis*, *Nodobaculariella galapagosensis*, *Pseudonodosaria brevis*, foraminifera, alien species, Aegean Sea, Turkey

Introduction

Eastern Mediterranean is invaded by many marine alien species, majority of which are Indo-Pacific originated (Zenetos et al. 2012). With more than 70 alien species, the Foraminifera constitute the 6th largest alien group in the Mediterranean (Zenetos et al. 2008; Zenetos et al. 2012; Meriç et al. 2012a, b). Since most of these alien foraminifers are Indo-Pacific species and are found in the Red Sea fauna, Suez Canal is considered the main vector for their introduction. However, some of the alien benthic foraminifers recorded in the Aegean Sea, such as, *Iridia diaphana* Heron-Allen and Earland (Meriç et al. 2008b; Okuş et al., 2004, 2006), *Euthymonacha polita* (Chapman) (Meriç et al. 2010), *Polymorphina fistulosa* (Cushman) (Meriç et al. 2012a),

Dentalina albatrossi (Cushman) (Meriç et al. 2004) were not yet recorded elsewhere in the Mediterranean, indicating that these species

might have been introduced not via Suez Canal, but by shipping.

During benthic surveys conducted in Ildır Bay (İzmir), Karşıyaka (İzmir), Akköy (Aydın), Güllük Bay (Muğla) and Babakale (Balıkesir) (eastern coast of Aegean Sea, Turkey), four alien foraminifer species were found in recent sediment samples. The findings of *Nodobaculariella cristobalensis* McCulloch, *N. galapagosensis* McCulloch and *Pseudonodosaria brevis* (d'Orbigny, 1846) have not yet been recorded elsewhere in the Mediterranean. The recent observation of *Cornuspiroides striolata* (Brady) constitutes the second record of this species in the Mediterranean and extends its range of distribution along the Turkish coastline.

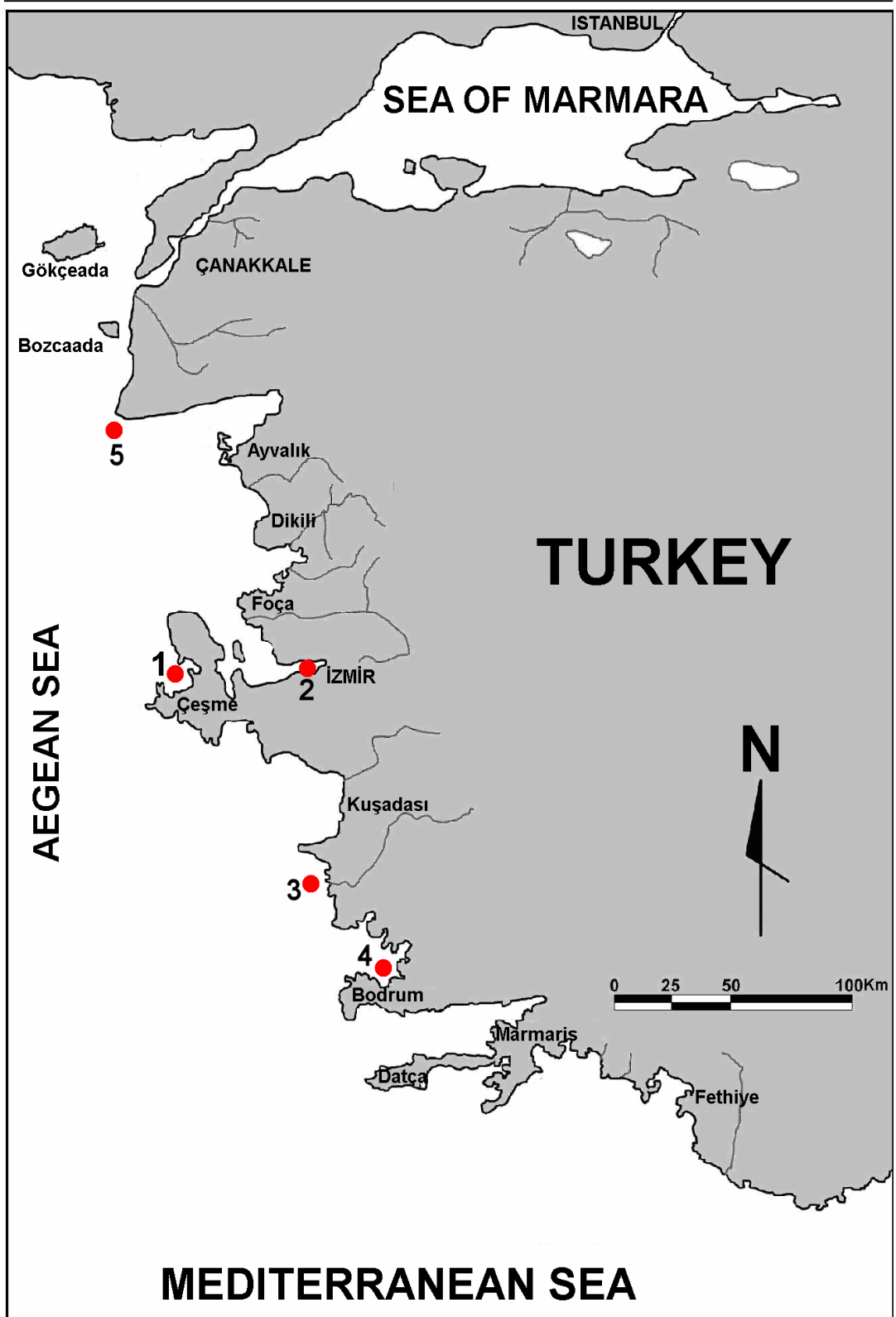


Fig. 1. Sampling locations: 1) Ildır, 2) Karşıyaka, 3) Akköy, 4) Güllük, 5) Babakale

Materials and Methods

In April 2014 a benthic survey was conducted by R/V Koca Piri Reis and recent sediment samples were collected via Van Veen and box core samplers in Ildır Bay (10 stations), Güllük (10 stations), Akköy (10 stations). Seven samples from the upper levels (14.00-16.60 m) of the SK-5 drill taken in Karşıyaka and one core sample in Babakale (50 cm) were also analyzed (Figure 1 and 2). Coordinates and some physical parameters of the stations are given in Table 1 and 2. 10 grams of wet sediment samples were weighed and treated with 10 % H₂O₂ for 24 hours. The samples were washed with pressurized water on 0.063 mm sieve and dried at 50 °C in the oven. The dried samples were further sieved with 2.00, 1.00, 0.500, 0.250, 0.125 mm mesh sizes. The foraminifer individuals were separated under a binocular microscope.

Systematics and Remarks

Loeblich and Tapan, 1988 was used for systematics.

Superfamily CORNUSPIRACEA Schultze, 1854

Family Cornuspiridae Schultze, 1854

Subfamily Cornuspiroidinae, Saidova, 1981

Genus Cornuspiroides Cushman, 1928

Cornuspiroides striolatus (Brady), 1928

Cornuspiroides striolata was first described by Brady (1882) as *Cornuspira striolata*. Cushman (1928) has named the Atlantic specimens as *Cornuspiroides striolata* (Brady) (p. 3, pl. 1). Loeblich and Tappan (1994) and Debenay (2012) also used *Cornuspiroides striolatus* (Brady).

It is known to be distributed in the Pacific Ocean, in New Caledonia and Timor Sea (Loeblich and Tappan, 1994; Debenay, 2012). This species has been previously recorded in southeastern Sea of Marmara (Sakıncı, 2008, Plate 2, Figure 10). Cimmerman and Langer (1991) have reported this species from Adriatic Sea, however the SEM photo they have given do not show the characteristics of the species, which suggests a misidentification (Plate 15, Figure 8). A total of 27 *Cornuspiroides striolata* (Brady) specimens, 6 of which are large and well preserved, are

found in Ildır (stations 2, 3, 4, 5, 8, 9 and 10, Table 1, Figure 3). The highest abundance is observed in station 2.

Superfamily CORNUSPIRACEA Schultze, 1854

Family Fischerinidae Millett, 1898

Subfamily Nodobaculiellinae Bogdanovich, 1981

Genus Nodobaculiella Cushman and Hanzawa, 1937

Nodobaculiella cristobalensis McCulloch (1977)

Nodobaculiella galapagosensis McCulloch (1977)

The genus *Nodobaculiella* was first described *Nodobaculiella japonica* Cushman and Hanzawa (1937). McCulloch (1977 and 1981) described *Nodobaculiella cristobalensis* and *Nodobaculiella galapagosensis* from Panama Canal zone and Galapagos Islands (p. 583, pl. 244, figs. 16-19 and p. 584, pl. 244, figs. 7-10).

Nodobaculiella cristobalensis McCulloch is abundantly observed in the sediment samples collected at 45.00 m of depth from two stations (Station 7 and 8) in Güllük Bay (Figure 2, 4 and 5). It is also found in the 0-25 and 25-50 cm levels of the core sample collected from Babakale (Balıkesir, Gulf of Edremit) at 9.00 m of depth (Figure 1).

Both *Nodobaculiella cristobalensis* McCulloch and *Nodobaculiella galapagosensis* McCulloch were observed in the core sample SK-5 collected from Karşıyaka (Gulf of İzmir) during a marina construction (Figure 2 and 5). 6 samples between 14.00-16.50 m levels of the core were investigated and *Nodobaculiella cristobalensis* McCulloch were found to be abundant, but only two individuals of *Nodobaculiella galapagosensis* McCulloch were found.

Superfamily NODOSARIACEA Ehrenberg, 1838

Family Nodosariidae Ehrenberg, 1838

Subfamily Nodosariinae Ehrenberg, 1838

Genus Pseudonodosaria Boomgaard, 1949

Pseudonodosaria brevis (d'Orbigny, 1846)

Table 1: Distribution of individuals among stations.

Location	Station	Latitude (N) (degree, minute)	Longitude (E) (degree, minute)	# <i>Cornuspiroides striolatus</i>	# <i>Nodobaculariella crystalensis</i>	# <i>Nodobaculariella galapagosensis</i>	# <i>Pseudonodosaria brevis</i>
Ildır	I-1	38 25.70	26 26.51				
	I-2	38 25.51	26 26.09	17			
	I-3	38 25.51	26 26.19	2			
	I-4	38 25.32	26 26.09	2			
	I-5	38 25.32	26 26.21	3			1
	I-6	38 25.19	26 25.95				
	I-7	38 25.17	26 25.80				
	I-8	38 25.00	26 25.54	1			
	I-9	38 24.28	26 24.51	1			
	I-10	38 23.53	26 23.47	1			
Akköy	A-8	37 ⁰ 27.99	27 ⁰ 7.14				1
Güllük	G-7	37 10.40	27 27.44		4		
	G-8	37 10.60	27 27.21		5		
Karşıyaka	SK-5	38 27.10	27 07.10		7	2	
Babakale	UD	39 28.47	26 03.99		6		

Table 2. Maximum and minimum values of some physical parameters observed in Ildır Bay, Güllük Bay and Akköy in April 2014.

	Ildır Bay	Güllük Bay	Akköy
Temperature (°C)	17.50-17.98	17.80-18.25	17.29-17.94
Salinity (ppt)	38.97-39.00	39.09-39.18	39.18-39.19
pH	8.03-8.22	8.09-8.19	8.13-8.20
Diss. Oxygen (mg/l)	6.87-7.42	6.80-7.49	6.85-7.28
Depth (m)	66-67	44-53	67-68

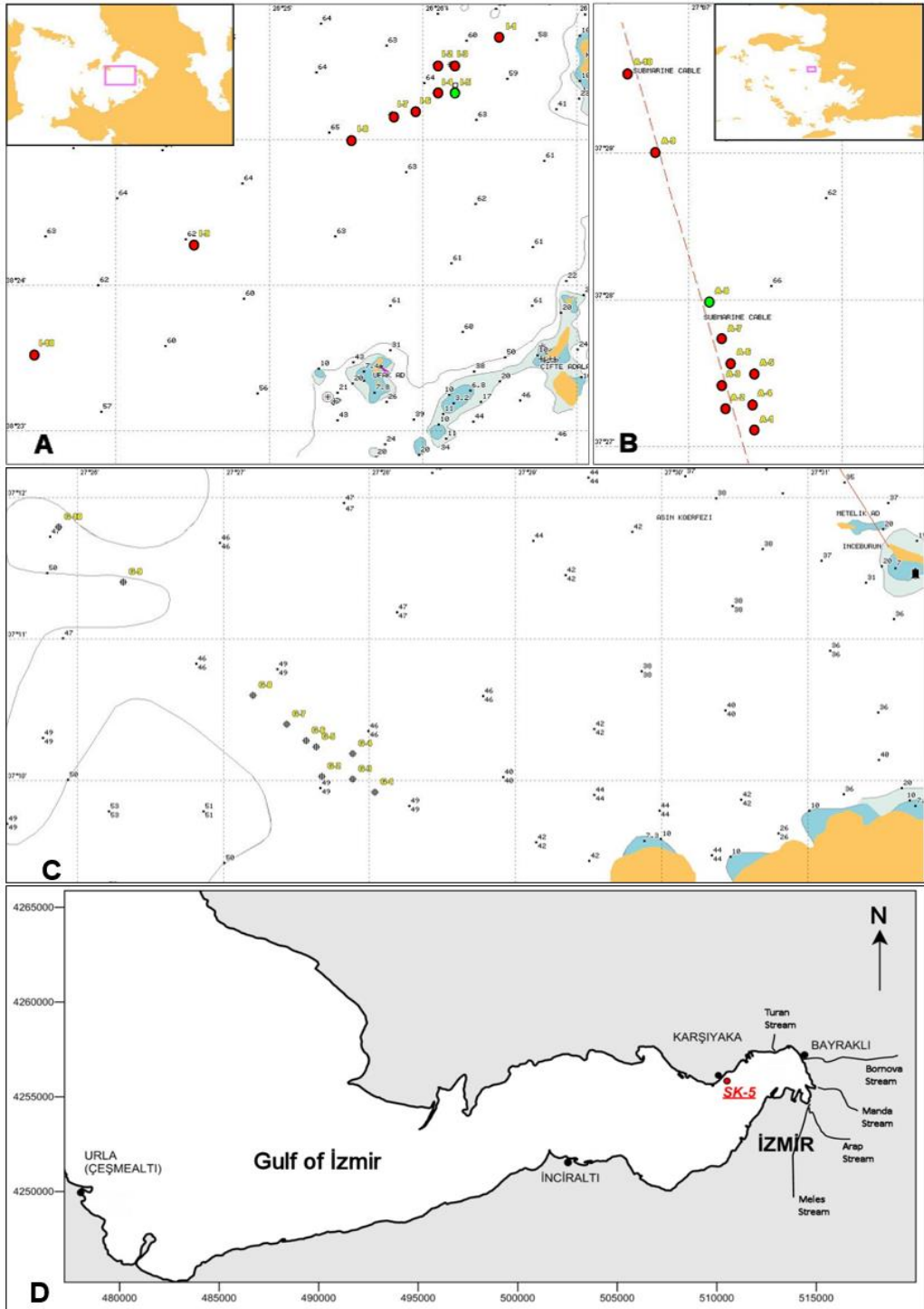


Fig. 2. Sampling stations and drill locations: A) Ildır; B) Akköy, C) Güllük; D) Gulf of Izmir.

Pseudonodosaria brevis was first described as *Nodosaria brevis* by d'Orbigny (1846). Reuss (1850) described it as *Glandulina discreta* and it was changed to *Pseudonodosaria discreta* (Reuss) by Boomgaard (1951). *Pseudonodosaria discreta* (Reuss) was used in several later studies (Loeblich and Tappan 1955; Loeblich and Tappan 1994; Yassini and Jones 1995).

New Caledonia (Debenay 2013), Sahul Shelf and Timor Sea (Loeblich and Tapman, 1994). Two individuals of *Pseudonodosaria brevis* (d'Orbigny, 1846) were found in the sediment samples from Ildır Bay (İzmir) and Akköy (Aydın) which have been collected from depths of 66-68 m (Figure 2 and 6) This is the first record of this species from the Mediterranean.

Pseudonodosaria brevis has been known to inhabit New Zealand waters (Hayward 2015),

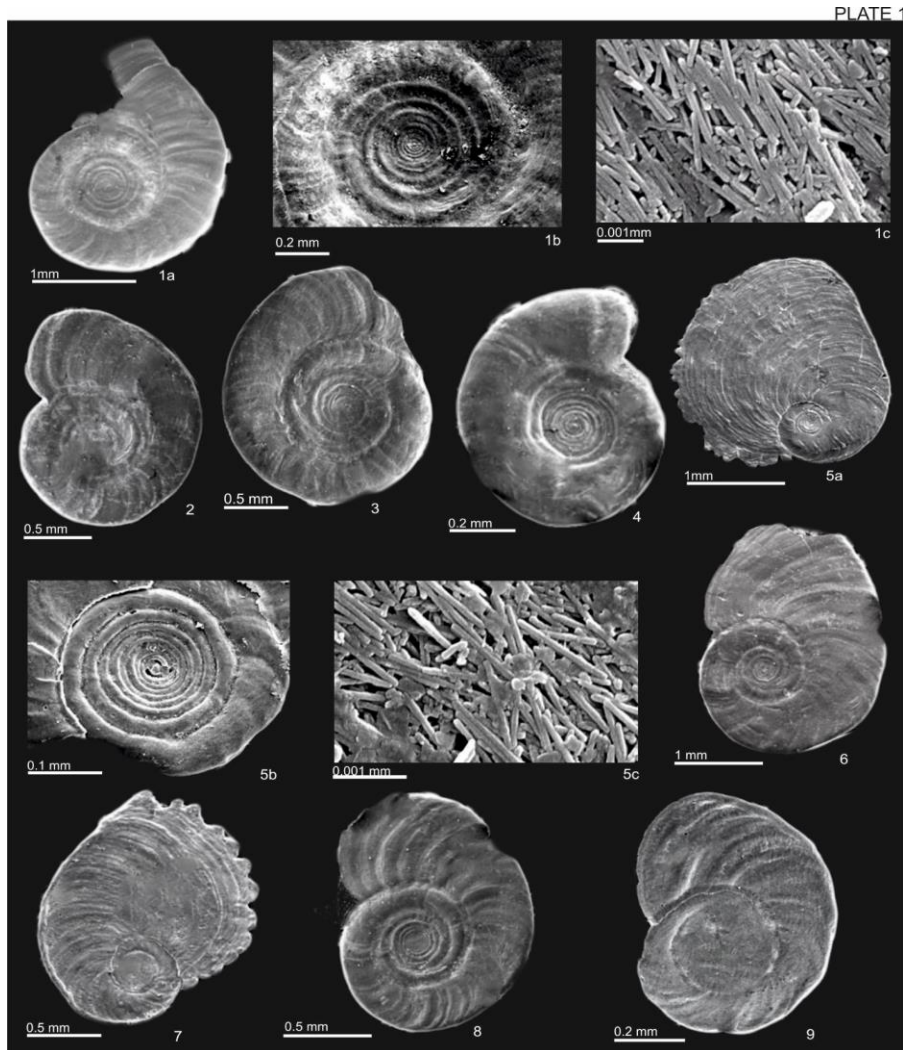


Fig. 3. *Cornuspiroides striolatus* (Brady) specimens. 1) a, side view and b, central part of the test, c, detailed view of the test, Ildır Bay, sample 2, 66.00 m. 2) Side view, Ildır Bay, sample 5, 67.00 m. 3) Side view, Ildır Bay, sample 5, 67.00 m. 4) Side view, Ildır Bay, sample 10, 66.00 m. 5). a, side view, b, central part of the test, c, detailed view of the test, Ildır Bay, sample 2, 66.00 m. 6) Side view, Ildır Bay, sample 2, 66.00 m. 7) Side view, Ildır Bay, sample 2, 66.00 m. 8) Side view, Ildır Bay, sample 2, 66.00 m. 9) Side view, Ildır Bay, sample 2, 66.00 m.

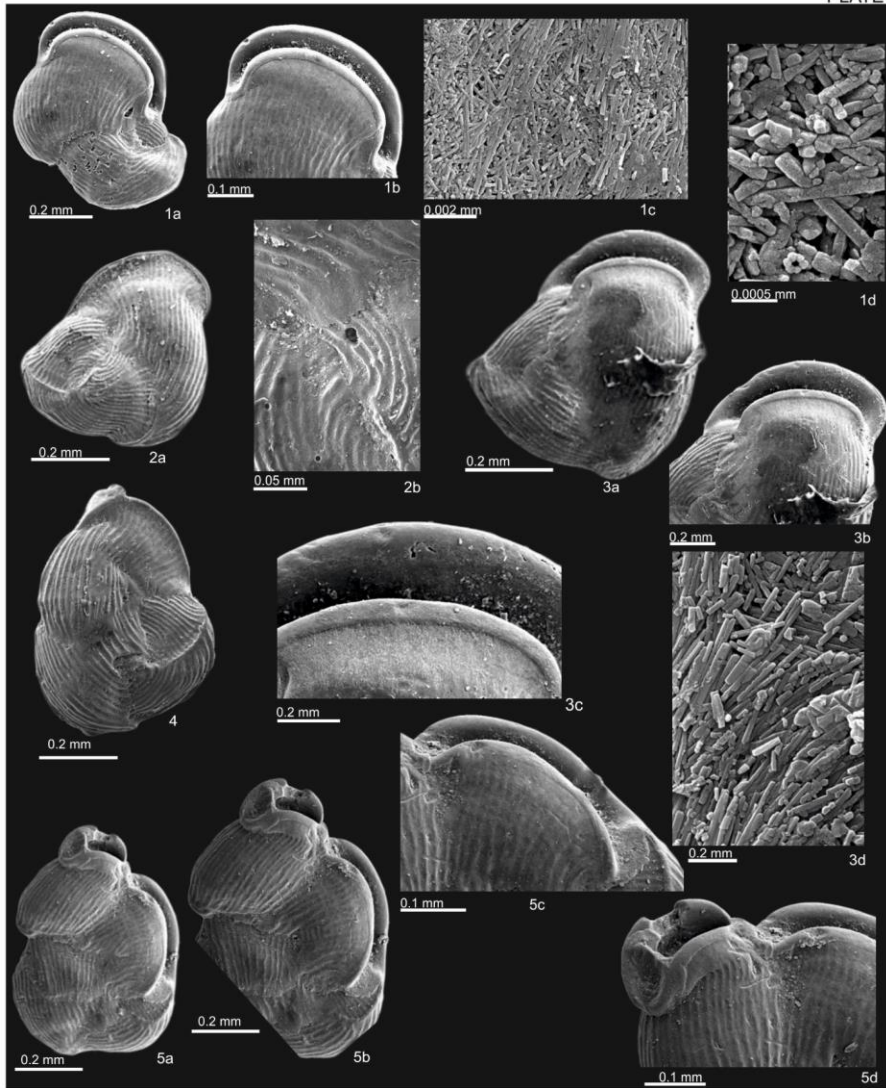


Fig. 4. *Nodobaculariella cristobalensis* McCulloch specimens. 1) a, side view; b, aperture; c and d. detailed view of the test, Güllük Bay, sample 8, 45.00 m. 2) a, side view, b, details of the side view, Güllük Bay, sample 8, 45.00 m. 3) a, side view, b, aperture, c, detailed view of aperture, d, detailed view of the test, Güllük Bay, sample 8, 45.00 m. 4) Side view, Güllük Bay, sample 8, 45.00 m. 5) a, side view, b, two aperture, c and d, detailed view of apertures, Güllük Bay, sample 8, 45.00 m.

Conclusion

Foraminiferal assemblages of the Aegean and Levantine coasts of Turkey have been extensively studied (Meriç et al. 2004; Meriç et al. 2008a, b; Meriç et al. 2010; Meriç et al. 2011; Meriç et al. 2012a, b). Recent findings of these species indicate new introductions to the region. Our findings suggest that these alien foraminifers might have been introduced to the Aegean Sea via ballast waters. It was reported

that nearly 70% of the marine alien species introduced by ships in the Aegean Sea were recorded in Gulf of Izmir (Çınar et al. 2005). Some of these records are quite historical, being the first records of alien species from the Mediterranean (Quatrefages, 1865). The nearby İzmir harbor has a heavy maritime traffic; thus it may be the main cause of these introductions. The finding of *Nodobaculariella galapagosensis* McCulloch and *Nodobaculariella cristobalensis*

McCulloch in the 14.00-16.50 m levels of the core sample from Karşıyaka suggests that these species might have been introduced to the antique harbor not in the very near past, and buried because of the high sedimentation rate due to five streams in the gulf (Figure 2D).

Eastern Aegean coasts which might have been used the same way of introduction, such as, *Iridia diaphana* Heron-Allen and Earland, *Euthymonacha polita* (Chapman), *Coscinospira acicularis* (Batsch) and *Polymorphina fistulosa* (Cushman) (Meriç et al., 2008b; 2010; 2011 and 2012a).

There are few other examples of alien foraminifer introductions observed in the

PLATE 2

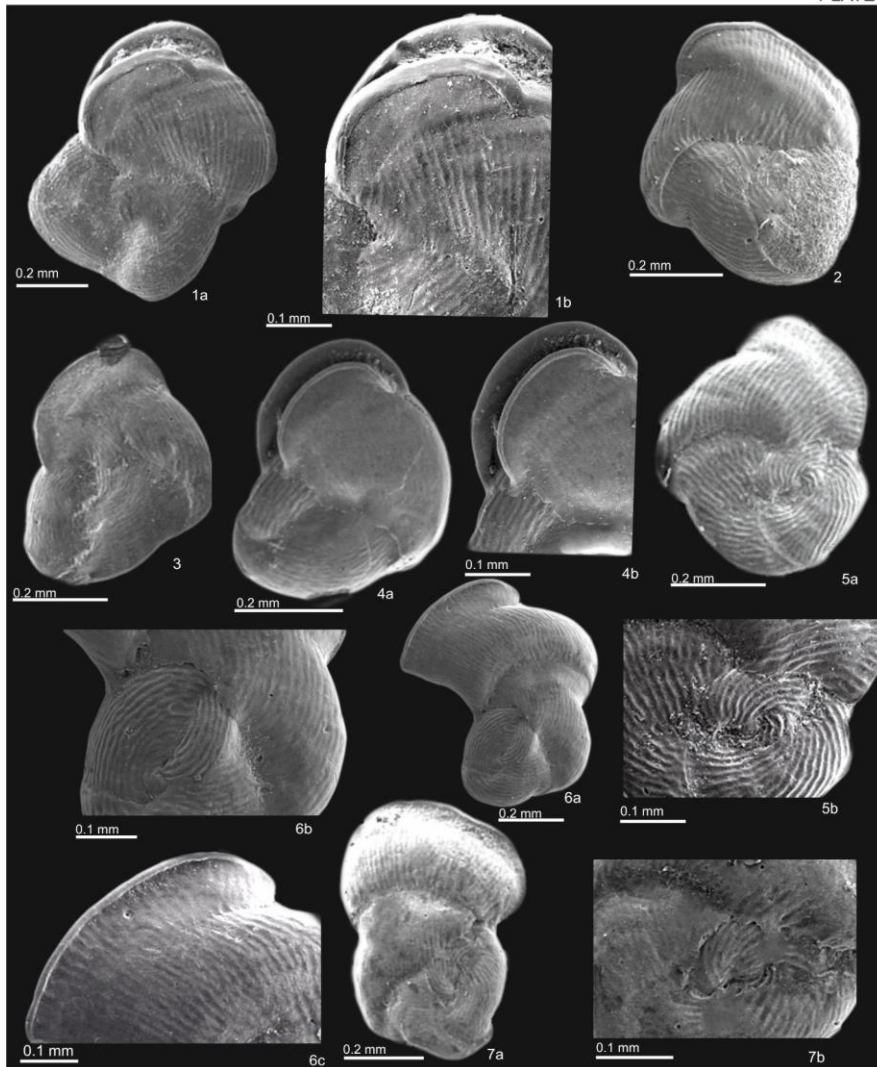


Fig 5. *Nodobaculariella cristobalensis* McCulloch (1-5) and *Nodobaculariella galapagosensis* McCulloch (6-7) specimens. 1) a, Side view and b, aperture, Güllük Bay, sample 7, 45.00 m. 2) Side view, Güllük Bay sample 7, 45.00 m. 3) Side view, Güllük Bay sample 7, 45.00 m. 4) a, Side view and b, aperture, Gulf of İzmir, Karşıyaka drill-hole, SK-5, 14.00-14.05 m. 5) a, Side view and b, details of the side view, Gulf of İzmir, Karşıyaka drill-hole SK-5, 14.20-14.25 m. 6) a, side view and b, details of the side view, c, aperture, Gulf of İzmir, Karşıyaka drill-hole SK-5, 16.00-16.05 m. 7) a, side view and b, details of the side view, Gulf of İzmir, Karşıyaka drill-hole SK-5, 16.40-16.45 m.

Cornuspiroides striolatus (Brady) and *Nodobaculariella cristobalensis* McCulloch are found to be locally restricted but abundant (Table 1). Only two individuals of *Pseudonodosaria brevis* (d'Orbigny) were yet found, however 100 Km distance between the two stations indicates the presence of a rare but established population. It has been shown that thermophilic alien foraminifer species form dense populations around submarine springs located on the eastern Aegean (Meriç et al. 2010; Meriç et al. 2011). There are numerous hot waters springs located on the active fault lines on the Eastern Aegean coastline. Presence of *Peneroplis pertusus* (Forsk.) and *P. planatus*

(Fichtel and Moll) in Babakale and Asos (Gulf of Edremit) indicates suitable thermal conditions for these thermophilic species to establish stable populations. Meriç et al. (2003) reports *Peneroplis* spp. from two different locations in the Gulf of Edremit, and the presence of warm springs along the coastline supports the idea of submarine springs. Thus, the thermophilic species reported in this study might have found suitable conditions to form established populations around the warm submarine springs located around these fault lines and they might have found enough time to adapt and spread along the Eastern Aegean by the local currents.

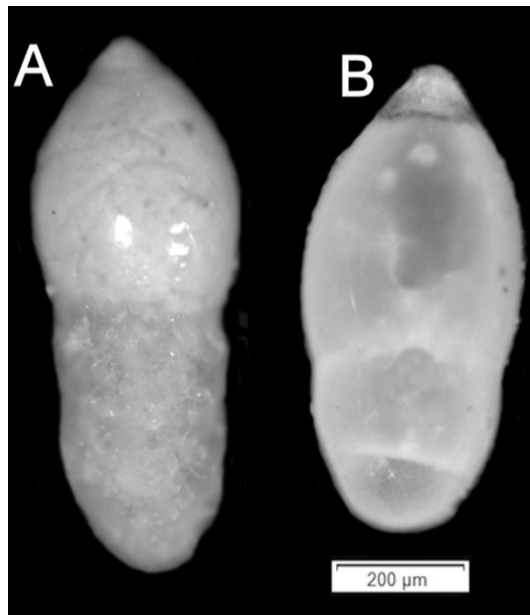


Fig 6. Stereo microscope photos of the *Pseudonodosaria brevis* (d'Orbigny) specimens collected from A) Ildır Bay; B) Akköy.

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