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-RESEARCH ARTICLE-

Morphological Anomalies Observed on *Vertebralina striata* d'Orbigny, 1826 Test in the Northern Coast of Karaburun Peninsula (Izmir-Turkey)

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Abstract

Morphological abnormalities have been observed on the test of recent foraminifer samples and locally different ecological conditions, such as, hypersalinity, presence of heavy metals and thermal springs are suggested to be the cause of this phenomenon. Abnormal test development, as well as twins and triplets are commonly observed in natural and artificial saltpans which form hypersaline environments. Submarine freshwater springs can cause extreme seasonal salinity variations on the coastal regions which affects the benthic foraminifer species and results in the abnormal test development. *Vertebralina striata* d'Orbigny individuals with abnormal aperture morphology have been found in samples collected around the thermal springs in Çeşme-Ilıca Bay. More surprisingly, specimens with similar aperture abnormality have also been observed in samples collected from other two stations on the Karaburun Peninsula. Five of the abnormal specimens had two apertures the others had three. A specimen collected from Ilıca Bay had two apertures, one of which is the typical *Vertebralina striata* d'Orbigny aperture, but the other was distantly located and rounded. *Vertebralina striata* d'Orbigny is widely distributed in world's seas, however such aperture abnormalities has not been reported elsewhere. Observation of similar morphological abnormalities in three distinct locations suggests a common cause. The submarine spring found in Ilıca Bay supports the idea that spring waters affect the chemical composition of the seawater locally, leading to this aperture abnormality.

Keywords:
Vertebralina striata, foraminifera, morphological abnormality, Karaburun, Turkey.

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Introduction

Hypersalinity, presence of heavy metals, thermal springs, chemicals carried by the coastal and submarine springs found in karstic regions and rapid change in ecological parameters are suggested to play a major role in changing the ecological conditions that leads to abnormal test morphology in foraminifers (Boltovskoy et al., 1991). Abnormal test development, as well as twins and triplets are commonly observed in natural and artificial saltpans which form hypersaline environments (Almogi-Labin et al., 1992; Stouff et al., 1999; Geslin et al., 2000; Debenay et al., 2001). Submarine freshwater springs can cause extreme seasonal salinity variations on the coastal regions which affect the benthic foraminifer species and result in the abnormal test development (Nigam et al., 2006; Meriç et al., 2008a). The high heavy metal concentrations, either natural or artificial, locally affect the benthic foraminifera. The heavy metals directly disposed from the industrial plants or carried by the water systems result in the change in environmental conditions and cause variations on test morphology in benthic foraminifers (Alve, 1991; Sharifi et al., 1991; Yanko et al., 1998 and 1999; Meriç et al., 2002b and 2005), as well as abnormal test development (Geslin et al., 2002; Meriç et al., 2003b; Elberling et al., 2003; Meriç et al., 2008e and 2009a).

The benthic foraminifer assemblages in thermal springs were investigated at shallow habitats in the Aegean Sea (Thierman et al., 1997; Varnavas et al., 1999). Similar studies were conducted around the thermal springs in Ilıca Bay - Çeşme (Izmir, western coast of Turkey), (Meriç, 1986; Avşar and Meriç, 2001). *Peneroplis* individuals with abnormal morphology are highly abundant around the submarine springs (Sözeri, 1966; Sellier de Civrieux, 1970).

Vertebralina striata d'Orbigny individuals with abnormal aperture morphology have been found in samples collected around the thermal springs in Ilıca Bay. More surprisingly, specimens with similar aperture abnormality have also been observed in samples collected from another station on west side of Karaburun Peninsula. Such aperture abnormality has not been reported elsewhere. Observation of similar morphological abnormalities in two distinct locations could suggest a common cause.

Material and Methods

Sediment samples were manually collected on 06.11.2008, around a submarine spring which is located in Çeşme-Ilıca Bay (Figure 1, Station 1), on the northwestern of Karaburun Peninsula (coordinates: 4240949N and 0444185E). The spring was taken as the center and three transects were set on A (210^{o}N), B (120^{o}N) and C (290^{o}N) directions (depth range 1-4 m). Sampling was done at each 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90 and 100 m distances according to the spring. But, because of a jetty, samples beyond 40 m could not be obtained on line A.

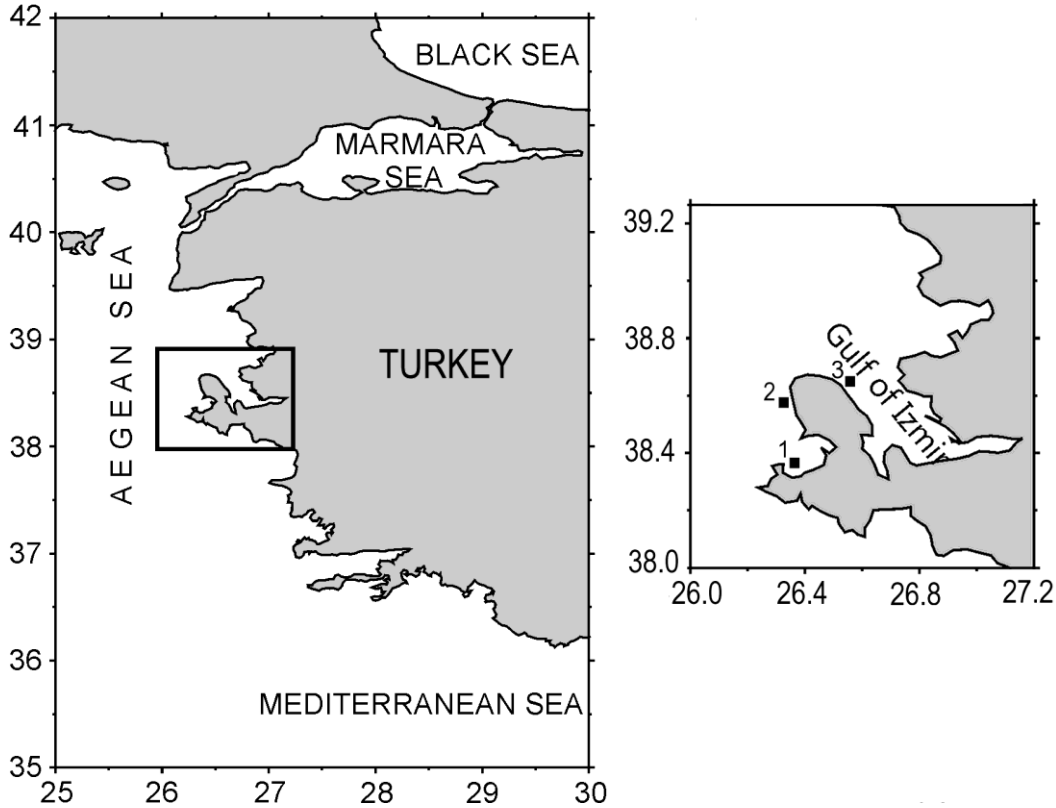

Figure 1. Map of the study area and locations of the stations. Station 1, Çeşme- Ilıca Bay; Station 2, west side of Karaburun Peninsula; Station 3, northeast side of Karaburun Peninsula.

45 surface sediment samples were collected from west of Karaburun Peninsula on 07.11.2018, at a depth of 1.00-19.30 m (Figure 1, Station 2). Starting from the center (coordinates: 4261268N, 0448465E), three transects were set in A (210º), B (125º) and C (290º) directions. Sampling was done at each 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90 and 100 m distances according to the center.

45 surface sediment samples were also collected from northeast of Karaburun Peninsula on 07.11.2018, at a depth of 1.00-5.70 m (Figure 1, Station 3). Starting from the center (coordinates of the center: 4276724N, 0458535E), three transects were set in A (80º), B (10º) and C (160º) directions. Sampling was done at each 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90 and 100 m. distances according to the center.

For each sample five grams of wet sediment were weighed and treated with 10 % H_2O_2 for 24 hours. The samples were washed with pressurized water on 0.063 sieve and dried at 50ºC 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 binocular microscope.

SEM microphotographs were taken in T.P.A.O. Research Center (Ankara) with Jeol. JSM-6490 LV microphotography instrument.

SYSTEMATICS
Superfamily Nubecularioidea Jones, 1875
Fischerinidae Millet, 1898
Subfamily Nodobacullariellinae Bogdanovich, 1981
Genus *Vertebralina* d'Orbigny, 1826
(Figures 2 and 3)

Description of *V. striata* (from Loeblich and Tappan, 1988)

Test is flattened, broad, and somewhat elongated, early chambers are slightly trochospiral and involute, final chamber is uncoiled and rectilinear; wall is calcareous, imperforate, porcellaneous, with numerous closely spaced longitudinal costae on the surface; aperture is terminal, lip is a narrow elongate slit with smooth and thickened bordering, which is slightly turned toward the side with the umbilical view of the coil. The species is known from Holocene with a distribution range in Atlantic, Pacific and Mediterranean.

Remarks

The benthic foraminifera *V. striata* has a global distribution in tropical and subtropical seas. It has been recorded from Indian Ocean (Azazi, 1992; Hottinger et al., 1993; Parker and Gischler, 2011; Langer et al., 2013; Montaggioni, 1981), from Pacific (Millet, 1898; Cushman, 1917 and 1932; Graham and Militante, 1959; McCulloch, 1977; Cheng and Zheng, 1978; Baccaert, 1987; Haig, 1988; Loeblich and Tappan, 1988; Hatta and Ujiie, 1992; Loeblich and Tappan, 1994; Yassini and Jones, 1995; Cann et al., 2000; Richardson and Clayshuttle, 2003; Debeney, 2003; Makled and Langer, 2011) and also from Atlantic (Williamson, 1858; Cushman, 1929).

In the Mediterranean, it has been recorded from Adriatic (Wiesner, 1923; Daniels, 1970; Cimerman and Langer, 1991); Gulf of Naples (Sgrrella and Moncharmont-Zei, 1993); Mallorca (Milker and Schmiedl, 2012). *V. striata* is also commonly found along the Turkish coastline, on the eastern Aegean coast, it has been frequently observed in Gulf of Saros, Dardanelles, Gökçeada, Bozcaada, Lesvos Island, Gulf of Edremit, Ayvalık, Dikili, Çandarlı, Gulf of İzmir, Karaburun Peninsula, Kuşadası, Gulf of Güllük, Gulf of Gökova, Datça and Marmaris (Meriç and Avşar, 2001; Meriç et al., 2002a and b, 2003a and b, 2004; 2008a, and b; 2009a, b and c). It has also been recorded from all along the Mediterranean coast of Turkey, from Kalkan, Kaş, Kekova, Antalya Bay to Gulf of Iskenderun (Avşar et al., 2001; Avşar et al., 2008; Meriç et al., 2008c).

Results

Nine specimens show typical morphological characteristics of *V. striata*, except the aperture morphology. Five of the abnormal specimens have two apertures (Figure 2 and Figure 3) and the others have three (Figure 2). Test and aperture morphologies of two normal *V. striata* specimens are shown in Figure 2, which were collected from Station 1, Line-B, distance 10 m, depth 3.8 m and Line-C, distance 5 m, depth 2.50 m, respectively. A specimen found in

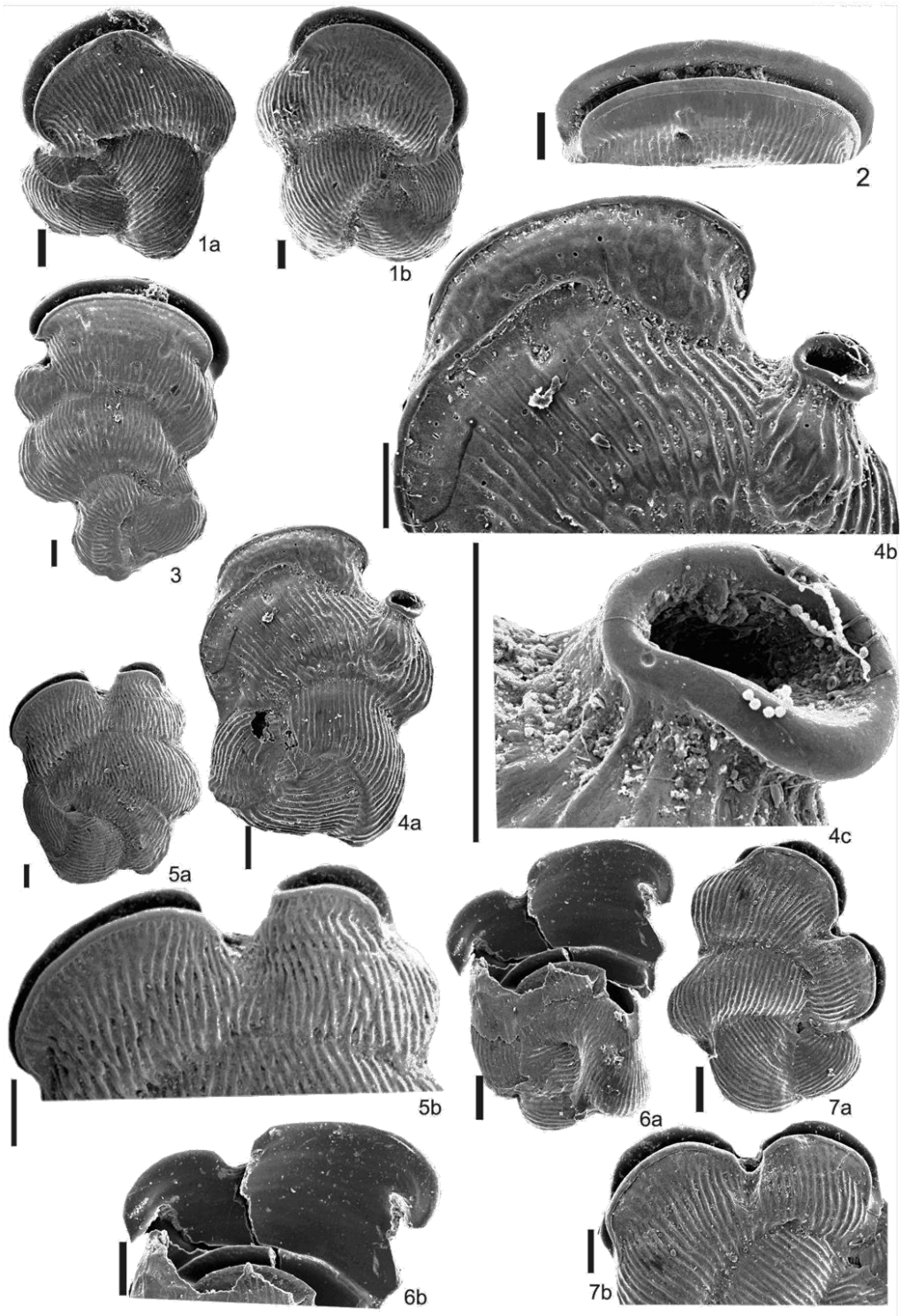

Figure 2. (1) *Vertebralina striata* d'Orbigny: a and b, side views, Station 1, Line-B, distance 10, depth 3.80 m.; (2) *Vertebralina striata* d'Orbigny. Side view of the aperture, Station 1, Line-C, distance 5, depth 2.50 m.; (3) *Vertebralina striata* d'Orbigny. Side view of the abnormal test, Station 1, Line-A, distance 25, depth 3.20 m.; (4) *Vertebralina striata* d'Orbigny. Abnormal test

and aperture, a, side view, b, detailed view of two apertures, c, detailed view of second aperture. Station 1, Line-C, distance 15, depth 1.80 m.; (5) *Vertebralina striata* d'Orbigny. a, side view of the test and b, detailed view of two apertures, Station 3, Line-B, distance 80, depth 3.20 m.; (6) *Vertebralina striata* d'Orbigny. a, side view and b, detailed view of two aperture, Station 2, Line-C, distance 20, depth 2.00 m.; (7) *Vertebralina striata* d'Orbigny. a, side view, b, detailed view of two apertures, Station 2, Line-C, distance 30, depth 2.30 m. (Scale bar: 100μm).

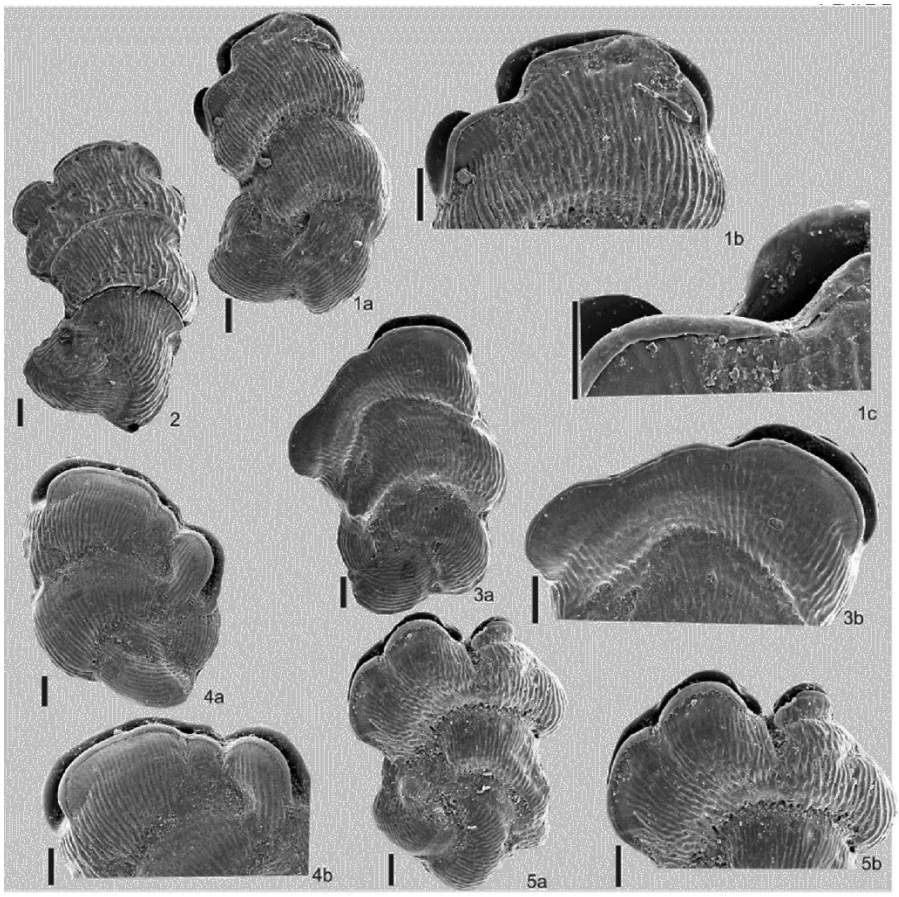

Figure 3. (1) *Vertebralina striata* d'Orbigny. a, side view, b and c, detailed views of two apertures, Station 2, Line-C, distance 45, depth 2.70 m.; (2) *Vertebralina striata* d'Orbigny. Side view, Station 1, Line-B, distance 35, depth 4.10 m.; (3) *Vertebralina striata* d'Orbigny. a, side view and b, detailed view of the aperture, Station 1, Line-C, distance 5, depth 2.50 m.; (4) *Vertebralina striata* d'Orbigny. a, side view, b, detailed views of the aperture, Station 2, Line-C, distance 35, depth 2.40 m.; (5) *Vertebralina striata* d'Orbigny. a, side view, and b, detailed view of the aperture, Station 1, Line-C, distance 60, depth 1.30 m. (Scale bar: 100μm).

Station 1, Line-A, distance 25 m, depth 3.20 m shows abnormal chamber morphology (Figure 2), whereas, another specimen collected from Line-C, distance 15 m, depth 1.80 m has two apertures, one of which is the typical *V. striata* aperture, but the other is distantly located and rounded (Figure 2). On the other hand, *V. striata* individual found on Line-B, distance 80.00 m at a depth of 3.20 m in Station 3 has two apertures (Figure 2). Another specimen with two apertures

were found in Station 2 on Line-C, distance 20 m at a depth of 2.00 m. (Figure 2) and two more specimens with similar abnormalities were found in Station 2, on Line-C, distance 30.00 m at a depth of 2.30 m (Figure 2). Individuals with two apertures were also observed in Station 2, on Line-C, distance 45.00 m at a depth of 2.70 m (Figure 3). Individuals with three distinct apertures were found in Station 2, Line-B, distance 35.00 m at a depth of 4.10 m (Figure 3), Line-C, distance 35.00 m at a depth of 2.40 m (Figure 3) and in Station 1, Line-C, distance 5.00 m at a depth of 2.50 m and Line-C, distance 60 m at a depth of 1.30 m.

The presence of Pacific or Red Sea originated alien species, such as *Euthymonacha polita* (Chapman) (Meriç et al., 2010) and *Coscinospira acicularis* (Batsch) (Meriç et al., 2011) in certain locations in the Aegean Sea suggests the presence of different environmental conditions specific to these locations. In contrast to the abundant populations of *Amphistegina lobifera* Larsen along the coasts of Gulf of Kuşadası and both stations on Karaburun Peninsula, no individual of this species have been observed around the submarine spring in Ilıca Bay. Besides, togethernesses observed between *Peneroplis planatus* (Fichtel and Moll) and *Coscinospira hemprichii* Ehrenberg, *Peneroplis pertusus* (Forskal) and *C. hemprichii* in Ayvalık (Meriç et al., 2008d), as well as, togethernesses observed between *V. striata* and *C. hemprichii* in Gulf of Kuşadası (Meriç et al., 2009d) supports the presence of location-specific environmental conditions hypothesis.

Discussion

Individuals with aperture abnormalities do not show any other morpohological anomaly, suggesting that the factors affecting the aperture abnormality do not act on all of the test, but only on certain characteristics, such as aperture morphology.

V. striata is widely distributed in world seas. However, the morphological abnormalities observed in samples from Ilıca Bay and Karaburun peninsula have not been reported from elsewhere, which suggests that these abnormalities may be specific to the locality. The observation of colored tests and morphological abnormalities other than aperture morphology have been observed in samples from the same locations (Meriç et al., 2012a, 2012b), supporting the idea that the thermal springs located around (Erişen et al., 1996; Akkuş et al., 2005) may affect the chemical composition of the sea water locally, leading to test abnormalities. The samples from Ilıca Bay have been collected near a submarine spring. Although there is no known submarine springs around the stations on the Karaburun Peninsula, observation of abnormal *V. striata* test suggests their presence.

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