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Lessepsian migrants expanding their distributional ranges; *Pseudonereis anomala* (Polychaeta: Nereididae) in Izmir Bay (Aegean Sea)

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A total of ten specimens of *Pseudonereis anomala* (Polychaeta: Nereididae) were collected on the shallow water hard substratum (0.2 m) at four stations located in the inner part of Izmir Bay (Aegean Sea, eastern Mediterranean) in January 2004. The absence of this species among the material collected previously at the same stations might suggest that it has recently become established in the area. A re-description of the species together with its ecological, reproductive, feeding and distributional aspects are provided.

INTRODUCTION

The opening of the Suez Canal in 1869 connected the two different zoogeographical units, the Red Sea and Mediterranean Sea, resulting in the colonization of habitats of the Mediterranean Sea by Red Sea species. To date, approximately 300 lessepsian species have been recorded from different basins of the Mediterranean Sea, particularly from the Levant Sea where some species, especially fish and shrimps, have formed dense populations that are being exploited by local fishermen. However, there are a few lessepsian species that appear to have acclimated well to the Mediterranean environment, tending to expand their distributional ranges, even to the north Aegean Sea which has a colder temperature and less salinity values. A recent study reported the presence of the lessepsian mantis shrimp, *Erugosquilla massavensis* (Koossmann), in the Sea of Marmara (Katağan et al., 2004) where the surface water is characterized by the cold and brackish Black Sea water and the bottom by the Mediterranean Sea water. In Izmir Bay, Çinar et al. (2002) found mature specimens of the lessepsian nereidid species, *Leonnates persicus* (Wesenberg-Lund), which was previously known only from the Levant coasts. The reports of lessepsian migrants outside the Levant Sea are more common for fish which are active swimmers, in contrast to some groups of invertebrates which are sessile or sedentary. However, these species may utilize passive transport as larvae in ballast water or as adults on hulls of ships to settle a new location far from its distributional borders within the Mediterranean Sea. For example, a lessepsian sabellid worm, *Branchiomma luctuosum* (Grube), which was originally described in the Red Sea, occurs abundantly in ports and polluted environments along the Italian coasts (Giangrande, 1989). Por (1990) postulated that the distributional boundaries of lessepsian migrants will certainly expand or shrink according to climatic evolution in the Mediterranean Sea, and would be considered as a first embryo of the Neo-Tethys in the future. Some of the lessepsian migrants have high adaptation capacities and tend to increase their distributional ranges by stepwise movements to the other basins of the Mediterranean that have different hydrographical conditions when compared with the Levant Sea. This has higher salinity and temperature values than other basins of the Mediterranean Sea, a condition suitable for the species coming from tropical waters.

Pseudonereis Kinberg (type species *Pseudonereis gallapagensis* Kinberg) includes eight species world-wide and has four species in the Red Sea (see Wehe & Fiege, 2002); *Pseudonereis anomala* Gravier, *P. gallapagensis*, *P. rottnestiana* Augener and *P. variegata* (Grube). As *P. gallapagensis* occurs in the Suez Canal–Great Bitter Lake, it was thought to have a potential to invade habitats of the Mediterranean Sea as *P. anomala* does (Ben-Eliahu, 1991). Fauvel (1937) was the first to report *P. anomala* in the Mediterranean Sea (off Alexandria), then it was found along the Israeli coast (Fauvel, 1955, Ben-Eliahu, 1975), the Lebanon coast (Laubier, 1966), the Cypriot coast (Ben-Eliahu, 1972; Çinar, in press) and the Turkish Levant coast (Ergen & Çinar, 1997). In addition to this

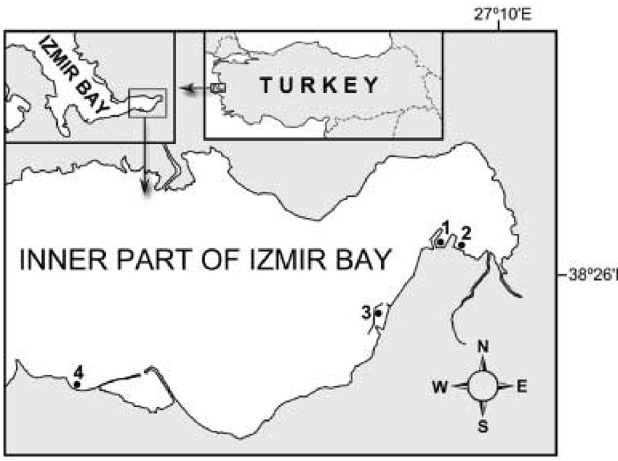

Figure 1. Map of the study area with the location of sampling sites.

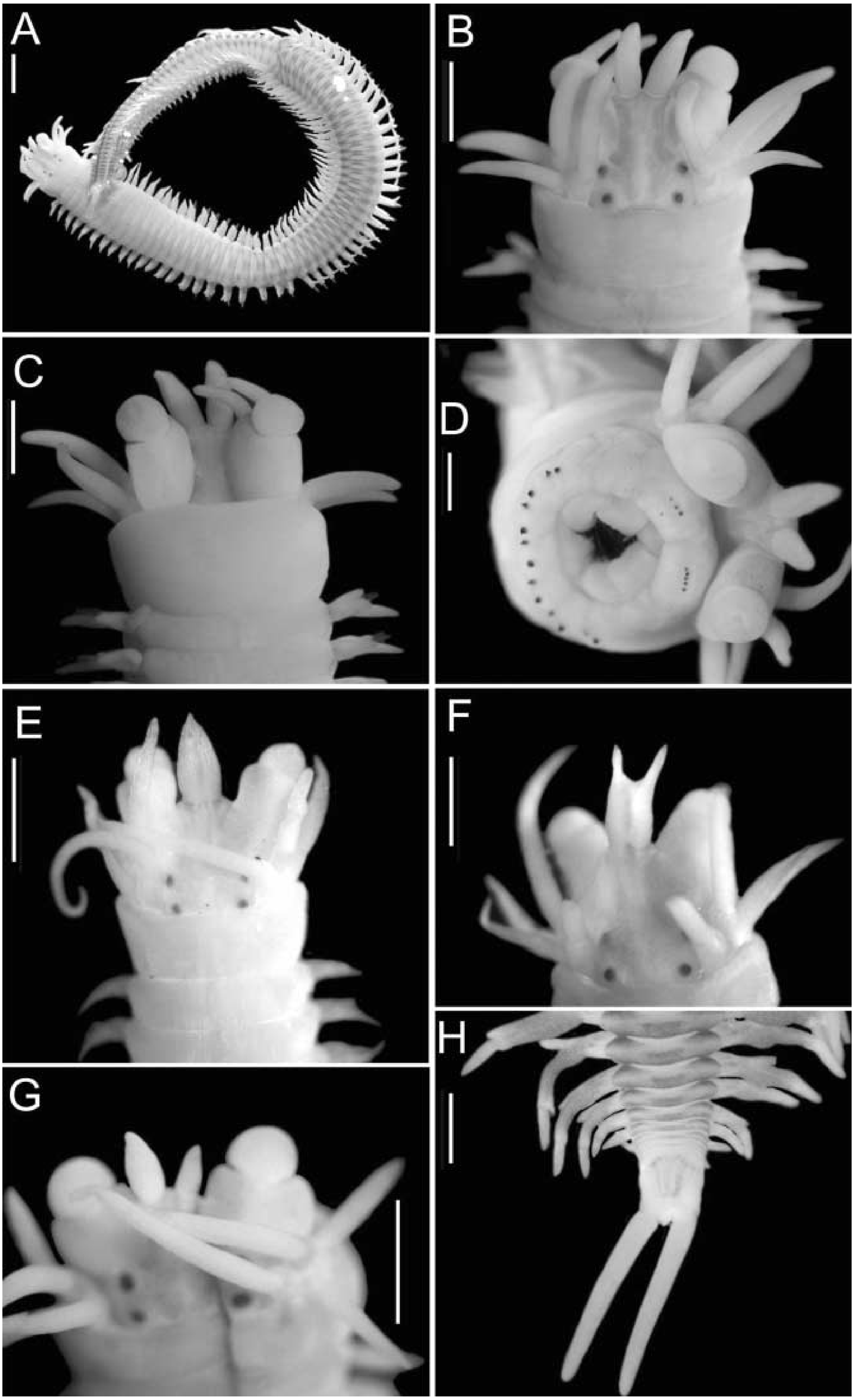

Figure 2. *Pseudonereis anomala*. (A) Dorsal view of whole animal; (B) dorsal view of anterior region; (C) ventral view of anterior region; (D) paragnaths on areas V–VIII of pharynx; (E) dorsal view of anterior region of a specimen from Okurcalar having only one antenna; (F) dorsal view of anterior region of a specimen from northern Cyprus having only one antenna with two tips; (G) dorsal view of anterior region of a specimen from Izmir Bay having asymmetrical antennae; (H) dorsal view of posterior end. Scale bars: A, 2 mm; B,C, 1 mm; D–H, 0.5 mm.

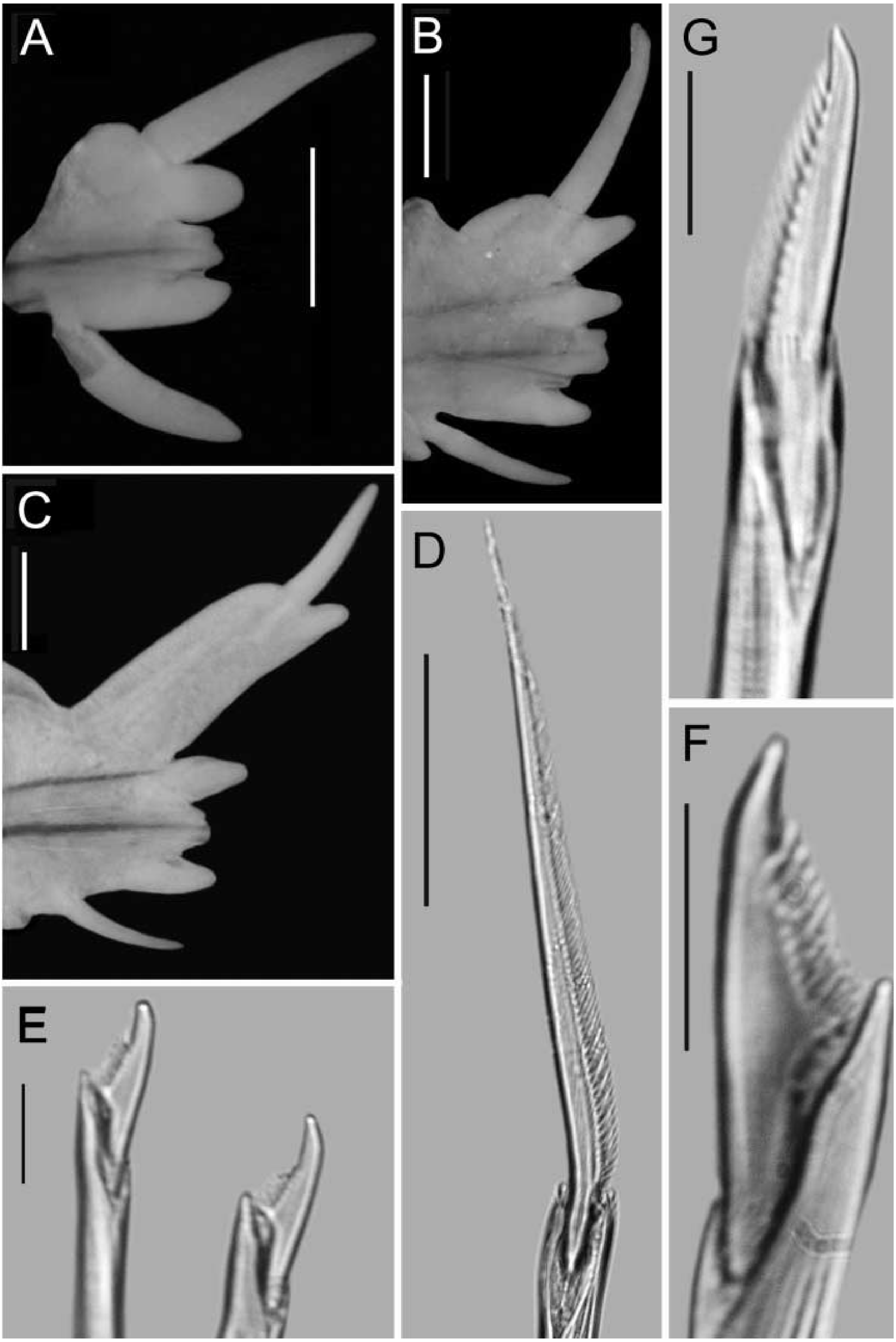

Figure 3. *Pseudonereis anomala*. (A) Anterior view of parapodium 2; (B) anterior view of parapodium 25; (C) anterior view of parapodium 75; (D) neuropodial homogomph spiniger from parapodium 25; (E) neuropodial heterogomph falcigers from parapodium 25; (F) neuropodial heterogomph falciger from parapodium 25; (G) notopodial homogomph falciger from parapodium 80. Scale bars: A–C, 0.5 mm; D, 100 μm; E,F, 30 μm; G, 10 μm.

species, eight other nereidid species belonging to five different genera were also reported from the Levant Sea as lessepsian migrants (see Çinar et al., 2002). Of these species, *P. anomala* is considered to become the most successful nereidid species acclimated to the Mediterranean environment, mainly due to its broad distributional range along the Levant coast and its high frequency and abundance in shallow water habitats (Ben-Eliahu, 1991; Ergen & Çinar, 1997).

The present study provides a new distant locality for *Pseudonereis anomala* and additional information about its morphological, reproductive, feeding and ecological characters.

MATERIALS AND METHODS

Within the framework of the project 'Seasonal dynamics of zoobenthos distributed in and around Alsancak Harbour (Izmir Bay, Turkey) and impacts of probable exotic species introduced by ships on the ecosystem-Project no.: 03 SÜF 005', a total of four stations were chosen for hard bottom samples and sampled in July 2003 and January 2004 (Figure 1). At each station, three replicates were taken in 0.2 m depth by scraping off an area of 400 cm^{-2} using a spatula. At Station 1 located in Alsancak Harbour, samples were taken from a pile of the harbour, which is dominated by the black mussel, *Mytilus galloprovincialis* Lamarck. At Station 2 located in Alsancak Harbour, samples were taken from a rock dumped for constructing a road around the harbour, which is intensively covered with specimens of *M. galloprovincialis*. At Station 3 located in Pasaport Harbour, samples were collected on an artificial platform used for approaching small boats, which is encrusted by tubes of the two serpulid polychaetes, *Hydroides elegans* (Haswell) and *H. dianthus* (Verrill). At Station 4 located near Çakalburnu Lagoon, samples were collected on a concrete block dumped into the sea, which is encrusted by *M. galloprovincialis*. Material was fixed in 4% formaldehyde in the field and washed through a sieve with 0.5 mm mesh size in the laboratory. Afterwards, samples were sorted under a stereomicroscope and preserved in 70% ethanol. *Pseudonereis anomala* was not present among the material collected in the summer period but existed at all stations in the winter period. Additional specimens of *P. anomala*, which were previously collected along the Turkish Levant coast (Okurcalar and Alanya) and the Cypriot coast (Karpas Cape) by diving, were also examined to find out possible morphological discrepancies between the Levant Sea population and the Aegean Sea population. The length of the worms (excluding palps), the length of the head and first ten chaetigerous segments (H+10), the width at chaetiger 10 (excluding parapodia), and blades of compound chaetae (falcigers and spinigers) were measured by using an ocular micrometer. The majority of specimens of *P. anomala* from Izmir Bay and the Levant Sea were dissected to determine its feeding habit and reproductive features. Terminology used for the description of the species follows Hutchings & Reid (1990). The specimens are deposited at the Museum of the Faculty of Fisheries, Ege University (ESFM: **E**ge Üniversitesi **S**u Ürünleri **F**akültesi **M**üzesi).

RESULTS AND DISCUSSION

Pseudonereis anomala Gravier, 1900

Pseudonereis anomala Gravier, 1900: 191–197, figures 50–52, pl. 12; Fauvel, 1937: 24; Fauvel, 1953: 217, figure 110e–g; Day, 1967: 333, figure 14.12.g–j; Fishelson & Rullier, 1969: 67–68; Wu et al., 1985: 223–225, figure 126; Hylleberg et al., 1986: 13–14, figure 7.

Material examined

Aegean Sea (Izmir Bay): Station 1, ESFM–POL/04–212, 0.2 m, 15 January 2004 (11°C, 35.1 psu), on *Mytilus galloprovincialis* in Alsancak Harbour, 2 specimens, largest specimen complete, 24 mm long, 1.6 mm wide, H+10=4.58 mm, with 77 chaetigers; Station 2, ESFM–POL/04–213, 0.2 m, 15 January 2004 (13°C, 36.3 psu), on *M. galloprovincialis* in Alsancak Harbour, 7 specimens, largest specimen complete, 33.5 mm long, 2.24 mm wide, H+10=7.45 mm, with 88 chaetigers; one specimen regenerated posteriorly, 14.3 mm long, 1.64 mm wide, H+10= 4.62 mm, with 46 chaetigers (last 16 chaetigers regenerated); Station 3, ESFM–POL/04–215, 0.2 m, 15 January 2004 (11°C, 36.6 psu), among tubes of *Hydroides dianthus* and *H. elegans* in Pasaport Harbour, one specimen, incomplete, 28.8 mm long, 2.34 mm wide, H+10= 5.36 mm, for 73 chaetigers; Station 4, ESFM–POL/04–216, 0.2 m, 15 January 2004 (9°C, 36.3 psu), on *M. galloprovincialis* near Inciralti, one specimen, complete, 51 mm long, 3.75 mm wide, H+10= 9.75 mm, with 90 chaetigers. **Levant Sea**: Okurcalar, ESFM–POL/93–63, 0–5 m, 20 July 1993, among brown algae, 7 individuals, largest complete, 21.6 mm long, 1.79 mm wide, H+10= 5.22 mm, with 68 chaetigers; Alanya, ESFM–POL/93–64, 0–5 m, 19 July 1993, among a variety of algae, 17 individuals, largest complete with the epitokal modification, *Heteronereis*, female, 21.61 mm long, 2.53 mm wide, H+10= 6.71 mm, with 78 chaetigers; Northern Cyprus, Karpas Cape, ESFM–POL/98–141, 0–5 m, 19 July 1998, among algae, two individuals, largest complete, 16.4 mm long, 1.34 mm wide, H+10= 4.53 mm, with 62 chaetigers.

Description

The description is based on the largest specimen (51 mm long, 3.75 mm wide and with 90 chaetigers) found at Station 4 in Izmir Bay. Body cylindrical; anterior part broad, gradually tapering to posterior end. Animal cream-coloured, with dark brownish colour patterns on dorsum of segments, particularly in middle and posterior regions of body; light brownish pigmentation covering on all surface of dorsum of anterior segments, becoming darker towards the middle and posterior segments, localizing intensively at lateral and middle sides of dorsum of segments, even at dorsal cirri on posterior most segments (Figure 2A). Prostomium bottle shaped, posterior part 2.5 times broader than anterior part, notched anteriorly, from where two thick, digitiform antennae emerging; ∼half length of prostomium (Figure 2B). Two pairs of black eyes in rectangular arrangement, with lenses; anterior eyes slightly larger than posterior ones; a non-pigmented area present around eyes. Palps thick, massive, somewhat cylindrical, as long as prostomium, each with rounded, large palpostyle; palpophore almost three times longer than palpostyle (Figure 2B,C). Peristomium well

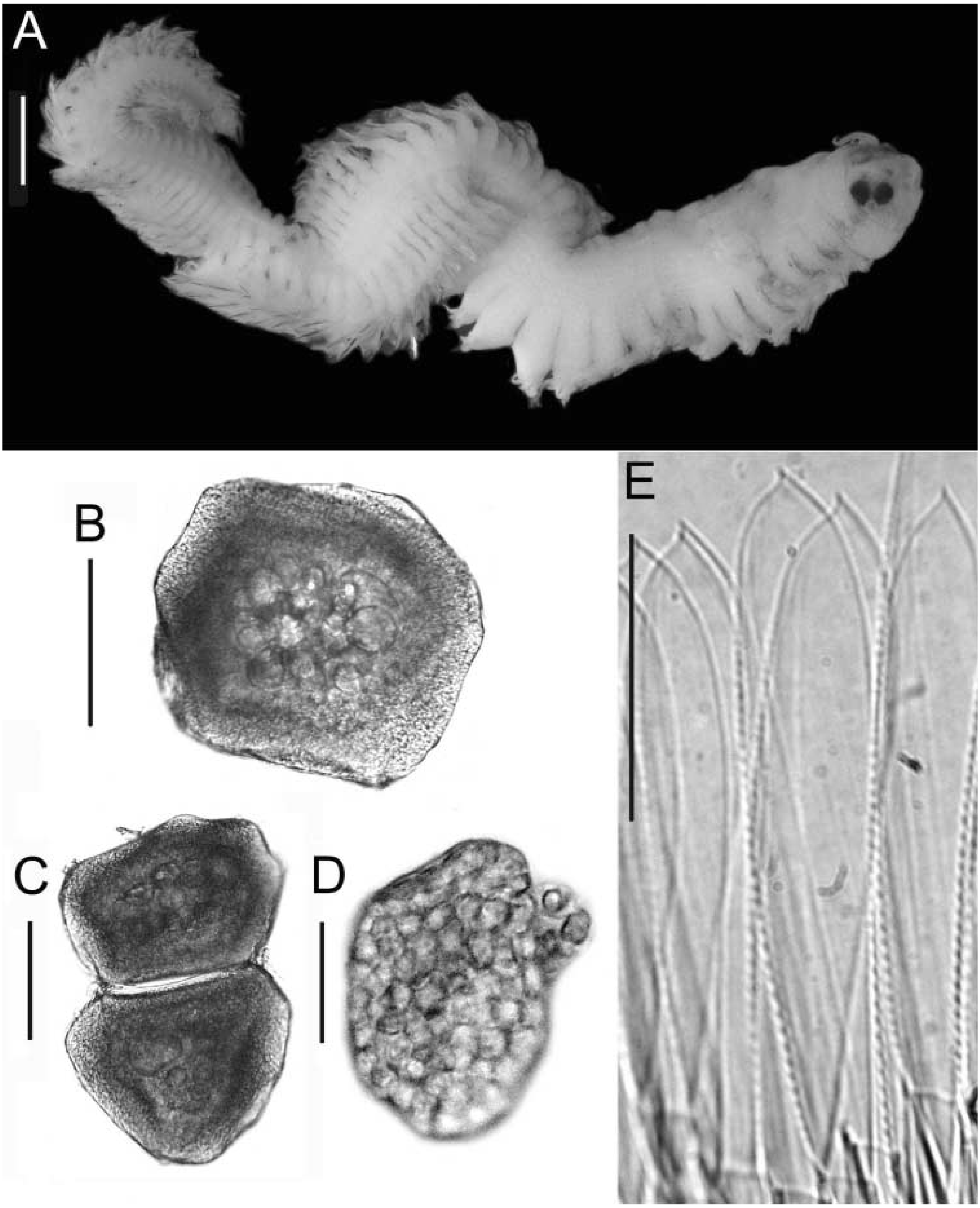

Figure 4. *Pseudonereis anomala*. (A) Dorsal view of a female with the epitokal modification, *Heteronereis*; (B) oocyte with large lipid yolks; (C) two oocytes connected with each other; (D) a sperm capsule; (E) swimming (notatory) chaetae from parapodium 25. Scale bars: A, 2 mm; B,C, 100 μm; D, 10 μm; E, 100 μm.

developed; about 2/3 of prostomium; two times longer than chaetiger 1 on dorsal side, three times longer on ventral side; bearing four pairs of tentacular cirri; thick, slender, tapering towards tip; all short, largest reaching back to chaetiger 1.

Pharynx with a pair of black jaws, with five large teeth on cutting edge. Maxillary and oral rings with conical, black paragnaths arranged as follows: area I=2 in a horizontal line; II=4–5 parallel rows of elongated paragnaths in pectinate pattern (a total of ~18 paragnaths); III=4–5 parallel rows of paragnaths (a total of ~40 paragnaths); IV=4–5 parallel rows of paragnaths (a total of ~30 paragnaths); V=0; VI=5 paragnaths in a transverse row; VII–VIII=12 paragnaths in a transverse row. The shape and distribution of paragnaths on areas V–VIII is shown on the partly everted pharynx of a specimen collected at Station 2 (Figure 2D), as the largest specimen had withdrawn the pharynx.

Parapodia of chaetigers 1–2 without notochaetae. Notopodia only with a rounded dorsal ligule; larger than all ligules and lobes on parapodia (Figure 3A). Dorsal and ventral cirri on anterior parapodia well developed; all thick, slender, gradually tapering, with rounded tip; dorsal cirrus slightly longer than ventral one; all longer than parapodial lobes. Neuropodia with amber coloured spinigers and falcigers; spinigers homogomph, numbering four on chaetiger 2, blades ~210 μm long, with fine, short spines on cutting edges. Falcigers heterogomph, numbering seven; all unidentate, blades similar in size, 52.5 μm long, spines at base of blades fine, long, gradually thickening towards tip, absent at distal part of blade; with very long (1/3 of blade), up-righted naked tip. Neuropodia with acicular lobe and rounded ventral ligule (Figure 3A). Acicular lobe with two unequal small lobes; inferior lobe longer than superior one; all rounded, shorter than ventral ligule. Parapodia on chaetigers 1 and 2 with only one black aciculum.

Parapodium of chaetiger 25 with distinct notopodium and neuropodium. Dorsal cirrus longer, thinner and more slender than those on anterior parapodia (Figure 3B). Ventral cirrus digitiform, as long as parapodial lobe, or slightly shorter than parapodial lobe. Dorsal ligule more expanded than those on anterior parapodia; as wide as all neuropodial lobes, with a digitiform projection just under dorsal cirrus. Superior lobe of notopodium absent. Notopodium with blunt, triangular median ligule, shorter than dorsal ligule (Figure 3B). Notopodium with only homogomph spinigers; numbering three, with blades 180 μm long, morphologically similar to those on anterior parapodia but with more thinner proximal and distal parts. Neuropodium of parapodium 25 with acicular lobe and ventral ligule; acicular lobe with two blunt small lobes almost similar in size; inferior one slightly larger. Ventral ligule triangular with blunt tip; as long as acicular lobe (Figure 3B). Superior part of neuropodium with ten homogomph spinigers and 4–5 heterogomph falcigers; blades of spinigers ~300 μm long (Figure 3D); blades of falcigers 62.5 μm long; morphologically similar to those on anterior parapodia (Figure 3E). Only heterogomph falcigers present on inferior part of neuropodium; numbering six; blades 57.5–65 μm long (Figure 3F). Parapodium of chaetiger 25 with two black aciculae.

Parapodium of chaetiger 65 with well developed dorsal ligule, extending far beyond parapodial lobe (~1.3 mm long), dorsal cirrus becoming shorter, located at tip of ligule with a blunt, triangular projection ventrally (Figure 3C). Notopodium without superior lobe. Median ligule of notopodium larger than those on parapodia in anterior and middle regions. Notopodium with two homogomph spinigers; morphologically similar to those on anterior and middle parapodia; blades 150 μm long. Neuropodium with somewhat rectangular acicular lobe and bluntly triangular ventral ligule; acicular lobe reduced on this parapodia, clearly shorter than ventral ligule. Superior part of neuropodium with six homogomph spinigers and two heterogomph falcigers; blades of spinigers 250–260 μm long; blades of falcigers missing. Inferior part of neuropodium with two homogomph spinigers and six heterogomph falcigers; spinigers and falcigers morphologically similar to those on anterior and middle parapodia; amber coloured; blades of spinigers 250 μm long; blades of falcigers 52.5–55 μm long.

Notopodia of parapodia of last 15 chaetigers with one homogomph falciger; blades 32 μm long; unidentate; fine, small spines on cutting edge; with naked tip (Figure 3G).

Pygidium rounded with two long anal cirri; 1500 μm long (Figure 2H).

Morphological variations

The morphological characters of specimens of *Pseudonereis anomala* from Izmir Bay coincide well with the original description of the species (type locality: Red Sea). However, our specimens represent some morphological discrepancies that are of significant importance as the present record comprises its northern distributional limit; one row of paragnaths in area VI [in agreement with original description by Gravier (1900)], versus two rows reported by Hylleberg et al. (1986). Gravier's specimens also had slightly curved terminal pieces of homogomph falcigers of posterior chaetigers, versus quite straight terminal pieces in our material and Thai material (Hylleberg et al., 1986).

The specimen from Station 4 in Izmir Bay is larger than those from the Levant Sea (maximum 51 mm long, 3.75 mm wide with 90 chaetigers in Izmir Bay, versus maximum 21 mm long, 2.53 wide, with 78 chaetigers in the Levant Sea). The largest specimen from Izmir Bay is also larger than Red Sea specimens [Gravier (1900): maximum 27 mm long; Fishelson & Rullier (1969): maximum 45 mm long], Thai specimens [Hylleberg et al. (1986): maximum 32 mm long] and Chinese specimens [Wu et al. (1985): maximum 32 mm long], but smaller than specimens from the Indian Ocean [Fauvel (1953); Day (1967): maximum 65 mm long]. The largest body dimension of the specimen from Izmir Bay might be explained by the fact that the specimen was collected in a polluted environment where competition among species is low and food is ample.

Examination of populations of *Pseudonereis anomala* from Izmir Bay and the Levant Sea showed that there are some morphological differences among the populations. First of all, the colour of specimens from Izmir Bay is conspicuous and different from that of specimens from the Levant Sea; dark brownish colour patterns especially on dorsum of posterior chaetigers and dorsal cirri (see Figure 2H), although this pattern is hardly discernible on the juvenile specimen collected at Station 1. However, such colour pattern was not observed on specimens from the Turkish Levant and Cypriot coasts; they are generally pale yellowish but specimens from Okurcalar and Cyprus have a dark brownish pigmentation on dorsal, median and ventral ligules of parapodia; no pigmentation was observed on specimens from Alanya. Gravier (1900) also noted the distinctive brownish colour pattern on the Red Sea specimens that we found on the specimens from Izmir Bay. Wu et al. (1985) also reported specimens of *P. anomala* with brownish spots solely on ligules of parapodia.

The other significant difference is the arrangement of paragnaths especially on the areas VII–VIII of pharynx that have generally 13–14 conical paragnaths of similar size in a transversal line on the majority of specimens

Table 1. *Density and biomass values of* Pseudonereis anomala *at stations and the relative importance of the density and biomass of* P. anomala *within the total nereidid fauna, vagile polychaete fauna, total polychaeta fauna, vagile fauna and total fauna found at stations.*

Stations	1	2	3	4
	NUMBER OF INDIVIDUALS			
Number of replicates	3	3	3	3
Total number of individuals	2	6	1	1
Mean density (ind m^{-2}) ± standard errors	16.7 ±16.7	50 ±28.9	8.3 ±8.3	8.3 ±8.3
Minimum and maximum density (ind m^{-2})	0–50	0–100	0–25	0–25
% of nereidid populations	7.407	2.899	2.273	20
% of vagile polychaete populations	3.030	1.007	0.038	2.5
% of total polychaete populations	1.504	0.846	0.018	0.741
% of vagile faunal populations	2.597	1.007	0.024	0.118
% of total faunal populations	0.159	0.325	0.013	0.035
	BIOMASS			
Total biomass	0.0184	0.2292	0.0424	0.1633
Mean biomass (g m^{-2}) ± standard errors	0.15 ±0.15	1.91 ±1.17	0.35 ±0.35	1.36 ±1.36
Minimum and maximum biomass (g m^{-2})	0–0.46	0–4.04	0–1.06	0–4.08
% of nereidid biomass	6.360	13.546	3.019	98.373
% of vagile polychaete biomass	5.968	10.641	0.297	74.532
% of total polychaete biomass	4.360	6.575	0.213	27.276
% of vagile faunal biomass	4.921	7.486	0.037	2.317
% of total faunal biomass	0.0009	0.016	0.003	0.008

examined, except for one specimen collected at Station 1 that has 14 conical paragnaths of unequal sizes; alternatively arranged, large ones in a line, smaller ones in a different line. Such arrangement of paragnaths on the areas were also reported on Thai specimens (Hylleberg et al., 1986).

A number of morphological characters of *Pseudonereis anomala* such as the length of blades of falcigers and spinigers, and the length of prostomium and dorsal cirri are size dependent, according to Pearson product-moment correlation analysis (significant at $P<0.05$). However, the length of antennae (longest one) and tentacular cirri seemed to be size-independent characters; the value of the correlation coefficient is moderate (r=50, 60) and not statistically significant ($P>0.05$). It is clearly evident on the largest specimen from Izmir Bay that the longest tentacular cirri of the specimen reach chaetiger 1, whereas those on the other smaller specimens examined reach chaetigers 3–6.

The specific name (epithet) of the species, *anomala*, was given due to the fact that one of the type specimens from the Red Sea has an anomaly in the number of antennae; three antennae instead of two, middle one larger than lateral ones, all smaller than 'normal' antennae (Gravier, 1900). We observed three different kinds of anomaly among specimens from Izmir Bay and the Levant Sea: (1) one specimen from Okurcalar has only one antenna; pointed distally, larger than 'normal' antennae (Figure 2E); (2) one specimen from Cyprus possesses only one rectangular antenna with two asymmetrical tips situated at corners (Figure 2F); and (3) one specimen at Station 2 in Izmir Bay has two asymmetrical antennae (Figure 2G).

Density and biomass

It is essential to determine the actual population density and biomass of a lessepsian species newly established in a new environment in order to predict its temporal variations over the course of time and also its possible impact on the native fauna. Unfortunately, because there are no data regarding the density and biomass values of *Pseudonereis anomala* in the literature, we cannot make a comparison between populations from different parts of the world.

A total of ten specimens of *P. anomala* was found at stations located in the inner part of Izmir Bay. It occurred in a total of six samples out of 12 (frequency: 50%). The density of the species ranges from 25 ind m^{-2} (Stations 4 and 3) to 100 ind m^{-2} (Station 2). At Station 2, which was located in the innermost part of the bay and has a *Mytilus galloprovincialis* community, the species was present in three samples out of four (frequency: 75%). The densities and biomass values of *P. anomala* at stations as well as its relative importance within total nereidid, polychaete and faunal populations and biomass are given in Table 1. It attained its highest mean density at Station 2 (50 ind m^{-2}). The species comprised 20% of the nereidid populations at Station 4, 3.03% of the vagile polychaete populations at Station 1, 1.50% of the total polychaete populations at Station 1 and 0.33% of the total faunal populations at Station 2 (Table 1).

The mean biomass values of *Pseudonereis anomala* ranges from 0.15 g m^{-2} (Station 1) to 1.91 g m^{-2} (Station 2) (Table 1). As the specimen from Station 4 has the highest biomass value (0.16 g) among polychaetes, it comprised 98% of the total nereidid biomass, 75% of the vagile polychaete biomass and 27% of the total polychaete biomass.

Feeding habit

There are no data concerning the feeding habit of *Pseudonereis anomala*. However, understanding its feeding mode and foraging behaviour is crucial for assessing its functioning role in the benthic ecosystem and its possible competitors. Dissections of digestive tracts of specimens

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from Izmir Bay revealed that it largely consumed plants and detritus. Long, brownish plant remnants, might be dead rhizomes of small sized phanerogames such as *Cymodocea nodosa* (Ucria) Aschers and *Zostera* spp. that were observed as the drifting material at Stations 1, 2 and 3, were gathered at the posterior part of digestive tracts, near the anal opening of specimens. Two diatom species were also identified among detritical material within the tract: *Achnantes* sp. and *Navicula* sp. While eating floral components (may be also *Ulva* sp. that is the dominant alga in the habitat), it also took some animals associated with them; a specimen of harpacticoid copepod (almost digested), and a specimen of *Eponides* sp. (Foraminifera).

Some specimens of *Pseudonereis anomala* from the Levant coast were also dissected to be sure about its feeding habit. One red and three brown algae were determined within digestive tracts of specimens: *Janua rubens* (Linnaeus) Lamouroux, *Dictyota* sp., *Halopteris* sp. and *Sphacelaria* sp. The coralline red alga, *J. rubens*, almost blocked digestive tracts of specimens collected in the shallow water benthic habitats of Okurcalar, due to its calcareous structure that is difficult to digest. No pieces of animals were determined within the tracts of the specimens dissected.

Reproduction

Specimens of *Pseudonereis anomala* from Izmir Bay have no reproductive products but a juvenile specimen from Station 1 (eyes are pinkish, a character for juvenile specimens as pointed out by Fishelson & Rullier (1969), and notopodial dorsal ligule is not expanded; 7.9 mm long, 0.74 mm wide for 40 chaetigers) suggests that it is able to spawn in Izmir Bay.

One specimen from Okurcalar (Levant Sea) in July (complete, 15.7 mm long, 2.09 mm wide, with 45 chaetigers) has oval oocytes within parapodia and coelomic cavity; 110–160 μm in diameter (mean=135.85 μm $\pm$3.03 SE, N=20). However, the specimen is not within the *Heteronereis* stage, with relatively enlarged black eyes but without strong epitokal modifications in parapodia such as swimming chaetae and paddle like lobes of parapodia, suggesting that it has not fully developed. We found also a male individual at the same station (complete, 21.6 mm long, 1.8 mm wide, with 68 chaetigers), with sperm capsules within coelomic cavity; diameter =20–27.5 μm, with $\sim$45 spermatozoid inside, ect-aquasperm type. The male specimen represents slight epitokal modifications; dorsal side of dorsal ligules of notopodia is relatively expanded, and postchaetal lobe is protruded and rounded like a paddle, but no swimming chaeta was observed on parapodia. A highly modified, fully developed female (complete, 21.6 mm long, 2.53 mm wide, with 78 chaetigers) was found in Alanya (Figure 4A); eyes black, greatly enlarged, parapodia from chaetiger 18 to the end of body highly modified, bearing swimming chaetae on notopodia and neuropodia; numbering 27 in notopodia, 36 in neuropodia, all homogomph, with greatly expanded blades, $\sim$250 μm long, saw-like teeth on cutting edge, terminated with a pointed tip (Figure 4E); eggs pentagonal or hexagonal, attached to each other (Figure 4C); the longest axis 160–195 μm (mean =178.3 $\pm$2.09 SE, N=20). Oocytes have large lipid yolks, each almost 20 μm in diameter (Figure 4B). Gravier (1900) described a female specimen with epitokal modification from the Red Sea. Our specimen in the *Heteronereis* stage coincides with that reported by Gravier, in terms of shape of parapodia, but cutting edges of blades of swimming chaetae in our specimen bear coarser teeth than those in Gravier's specimen.

Distribution and the way of its introduction to Izmir Bay

Pseudonereis anomala was originally described from the southern Red Sea (Djibouti) by Gravier (1900), then reported from the Indian Ocean (Fauvel, 1953; Day, 1967), Pacific Ocean (Hylleberg et al., 1986; Wu et al., 1985) and Suez Canal (Ben-Eliahu, 1991). This species was first reported off Alexandria (Egypt) in the Mediterranean Sea (Fauvel, 1937), then found along the Israeli coast (Fauvel, 1955, Ben-Eliahu, 1975), Lebanon coast (Laubier, 1966), Cypriot coast (Ben-Eliahu, 1972; Çinar, in press) and the Turkish Levant coast (Ergen & Çinar, 1997). The reproductive feature of *P. anomala*, having a pelagic duration in its life cycle by means of the epitokal modifications and planktotrophic larvae that allows it to spread over large areas by currents, shows that it is using stepwise migration to colonize habitats of the Mediterranean Sea. There is no previous report concerning its presence in the Aegean Sea, which has a proximity to the Levant Sea. Therefore, its occurrence in the north Aegean Sea is noteworthy, but could not be simply explained by the stepwise migration. As the sampling stations are located in/near Alsancak Harbour, which houses a number of interoceanic ships, its introduction to Izmir Bay by ballast waters and hulls of ships could not be excluded. However, its presence in the southern Aegean coasts should be checked to assure its way of introduction to Izmir Bay.

Habitat

Pseudonereis anomala was found in a variety of shallow water benthic habitats (0–4 m); on sand in an estuary area, within crevices of dead corals, under stones associated with the polychaetes *Eunice afra* Peters and *Eupolymnia nebulosa* (Montagu) (Fishelson & Rullier, 1969), among coral blocks (Hylleberg et al., 1986), on algae and sandy bottom (Wu et al., 1985), among rocks and algae (Ergen & Çinar, 1997). Ben-Eliahu (1991) reported it as a dominant nereidid species on biofouling reef, under littoral rocks and on algae in the Suez Canal, and considered it as an 'ecological generalist' as regards habitats, a character for successful migrant species. We collected it among the mussel *Mytilus galloprovincialis* (Stations 1, 2 and 4) and tubes of *Hydroides dianthus* and *H. elegans* in the polluted zone of Izmir Bay. It is the first time this species has been reported from a polluted environment. Disturbed conditions, particularly harbour environments are known to support the colonization success of introduced species (Zibrowius, 1991).

Impact on native fauna

Ben-Eliahu (1989) reported that a native nereidid species of the Mediterranean, *Perinereis cultrifera* (Grube), was excluded from the habitats of the Levant Sea by *Pseudonereis anomala*, probably due to an 'inferior' dispersal method; *Perinereis cultrifera* is of direct, non-pelagic reproduction and its dispersal is consequently more restricted than that of the migrant species (*Pseudonereis anomala*) which has the *Heteronereis* stage able to swarm in the open sea. There is no record about the occurrence of *Perinereis cultrifera* in the very polluted waters of Izmir Bay, thus *Pseudonereis anomala*, a herbivorous species, would probably compete with other herbivorous species for space and food. As *P. anomala* has very strong jaws, it is possible that, for space, it can compete with species that are carnivorous or deposit feeders, when it builds up a dense population in the area. However, we found a few individuals of it in Izmir Bay, might suggest two facts: (1) it might be newly introduced here and is within the period of adaptation to the new environment, and (2) its population density is being controlled by the native species. As the specimens were collected from the heavily eutrificated environment of Izmir Bay, the competition among species for food and space is predicted to be comparatively low. However, a specimen at Station 1 that is regenerating posteriorly suggests that the species is under predation in the habitat, probably by invertebrates or fish. The vagile fauna of stations were mostly composed of the species resistant to high loads of pollutants such as the polychaetes *Neanthes succinea* (Frey & Leuckart) (its maximum density= 800 ind m^{-2} at Station 2), *Nereis falsa* Quatrefages (its maximum density=1125 ind m^{-2} at Station 2), *Schistomeringos rudolphi* (Delle Chiaje) (its maximum density= 14,700 ind m^{-2} at Station 3), *Ophiodromus pallidus* (Claparède) (its maximum density= 4925 ind m^{-2} at Station 3), the amphipod *Elasmopus affinis* (Della Valle) (5225 ind m^{-2} at Station 4) and the isopod *Sphaeroma serratum* (Fabricius) (its maximum density=3125 ind m^{-2} at Station 3). As the above-mentioned species are omnivorous, it is impossible at this stage to assess which species indicated above are/would be competing with the lessepsian nereidid species. Future studies to be undertaken in the area would enable us to realize the result of possible competition between the lessepsian migrant and the native faunal components.

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