Cah. Biol. Mar. (2008) 49 : 87-96

Invasion of polluted soft substratum of Izmir Bay (Aegean Sea, eastern Mediterranean) by the spionid polychaete worm, *Pseudopolydora paucibranchiata* (Polychaeta: Spionidae)

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Abstract: The present study reports the first occurrence of an alien spionid polychete worm, *Pseudopolydora paucibranchiata* Okuda 1937, in the Mediterranean Sea. This species, which was previously identified as *P. antennata* Claparède, 1870, formed a dense population in and near Alsancak Harbor (Izmir Bay, Aegean Sea), especially in June 2004. It was also found at some stations in Iskenderun and Mersin Bays in September 2005 (Levantine Sea). The maximum density and biomass (wet weight: ww) of *P. paucibranchiata* in Izmir Bay were 6180 ind.m^{-2} and 4.77 g wwt.m^{-2}, respectively. The seasonal fluctuations of density and biomass of the species were studied in Izmir Bay, indicating that its density and biomass values increased in spring and summer, and drastically diminished in fall and winter. This species is able to reproduce in the area both in winter, spring and summer. Its establishment in the area is most probably transport by ballast water. The morphological, ecological and distributional characteristics of the species as well as its impact on the prevailing ecosystem are analyzed and discussed.

Résumé : *Invasion d'un sédiment pollué de la Baie d'Izmir (Mer Égée, Méditerranée orientale) par l'annélide* Pseudopolydora paucibranchiata *(Polychaeta : Spionidae).* Ce travail décrit la découverte d'une espèce introduite de polychète spionidé, *Pseudopolydora paucibranchiata* Okuda 1937, en Méditerranée. Cette espèce, précédemment identifiée comme *P. antennata* Claparède 1870, a formé une population dense à proximité et dans le port d'Alsancak, particulièrement en juin 2004 (Baie d' Izmir, Mer Égée). Cette espèce a également été trouvée à quelques stations dans les Baies d'Iskenderun et de Mersin (Mer Levantine) en Septembre 2005. La densité et la biomasse maximales de *P. paucibranchiata* en Baie d'Izmir étaient 6180 ind.m^{-2} et 4,77 g ww.m^{-2}, respectivement. Les fluctuations saisonnières de la densité et de la biomasse en Baie d'Izmir sont caractérisées par une augmentation de la densité et de la biomasse au printemps et en été, et une forte diminution en automne et en hiver. Dans la région, l'espèce est capable de se reproduire également en hiver, au printemps et en été. Son établissement dans la région est probablement lié au transport des eaux de ballast. Les particularités morphologiques, écologiques et de distribution de l'espèce, ainsi que son effet sur l'écosystème, sont analysées et discutées.

Keywords: Spionidae • Polychaeta • *Pseudopolydora paucibranchiata* • Invasive species • Aegean Sea • Eastern Mediterranean.

Reçu le 19 novembre 2007 ; accepté après révision le 15 février 2008.
Received 19 November 2007; accepted in revised form 15 February 2008.

Introduction

Some spionid polychaete worms are known to have become invasive, particularly in more or less polluted areas (harbor environment) and estuary zones (Carlton, 1985; Çinar & Ergen, 1999; Bailey-Brock, 2000; Çinar et al., 2005; Radashevsky & Olivares, 2005). They can be transferred by vessels, especially in ballast water (Carlton, 1985; Çinar et al., 2005), via the Suez Canal (Çinar & Ergen, 1999) or through the transport of bivalves (especially oysters) for aquacultural activities (Bailey-Brock, 2000; Radashevsky & Olivares, 2005). A recent study regarding the establishment of the two spionid polychaetes, *Streblospio gynobranchiata* Rice & Levin, 1998 and *Polydora cornuta* Bosc, 1802, in the polluted soft substratum near Alsancak Harbor (Izmir Bay, Aegean Sea) showed how spionids can invade a polluted area. The seasonal density and biomass values of these two species in the region were given by Çinar et al. (2006). In April 2004, the density of *S. gynobranchiata* reached up to 60500 ind.m^{-2} and that of *P. cornuta* up to 1270 ind.m^{-2} in the area. These two species, which were introduced to the area via ballast water of commercial vessels approaching the harbor, accounted for more than 65% of the animal community in the area (Çinar et al., 2006).

During the project (03 SÜF 005), which aimed to study zoobenthic communities near Alsancak Harbor and reported the above-mentioned invasive spionid polychaetes in the area, a number of specimens belonging to the genera *Pseudopolydora*, which was reported as *P. antennata* (Claperède, 1870) by Çinar et al. (2006), were found. However, a detailed investigation on these specimens revealed that the specimens in fact belong to *P. paucibranchiata* Okuda, 1937, not to *P. antennata*. During an ongoing project along the Levantine coast of Turkey (Tubitak Project Number: 104Y065), this species was also found in Iskenderun and Mersin Bays.

The purpose of this paper is to present the taxonomic status, reproduction feature, density and biomass of *Pseudopolydora paucibranchiata* in the area and its impacts on the ecosystem.

Material and Methods

Specimens of *Pseudopolydora paucibranchiata* were collected at 7 stations (Fig. 1) in the inner part of Izmir Bay (Aegean Sea) between January and September 2004, and 4 stations in Iskenderun Bay and 1 station in Mersin Bay (Levantine Sea) in September 2005. The coordinates, depths, sediment and water characteristics of stations in Izmir Bay were presented by Çinar et al. (2006). The collection data for the stations on the Levantine coast of Turkey are given in Table 1. At stations in Izmir Bay, three replicates were taken in each station by means of a van Veen Grab sampling an area of 0.1 m^2. At stations in Iskenderun and Mersin Bays, the benthic material was collected by snorkeling. The benthic material in each bay was sieved through 0.5 mm mesh and the retained material was placed in separate jars containing a 4% seawater formaldehyde solution. In the laboratory, samples were rinsed in fresh water and sorted according to taxonomic groups under a stereomicroscope, and preserved in 70% ethanol. Afterwards, polychaetes were identified and counted under stereo- and compound microscopes. The wet-weight of specimens of *P. paucibranchiata* collected in Izmir Bay was estimated by using a balance of 0.0001 g sensitivity.

Table 1. *Pseudopolydora paucibranchiata.* Coordinates, depths (m) and biotopes in Iskenderun and Mersin bays (Levantine Sea) together with physico-chemical characteristics of stations. S: salinity, T: temperature (°C), O_2: oxygen (mg.L^{-1}).

Tableau 1. *Pseudopolydora paucibranchiata.* Coordonnées géographiques, profondeurs (m) et biotopes dans les baies d'Iskenderun et de Mersin (Mer Levantine), et caractéristiques physico-chimiques des stations. S : salinité, T : température (°C), O_2 : oxygène (mg.L^{-1}).

Station	Coordinates	Depth (m)	Habitat	S	T (°C)	O_2
K7b	36°35'32"N					
	36°10'22"E	0.1	*Padina pavonica*	39.0	31	5.20
K9	36°54'22"N					
	35°58'05"E	0.1 - 2	Rock	39.2	30	4.68
K10	36°45'59"N					
	35°47'32"E	5	Sand	39.1	29.1	6.55
K11	36°33'20"N					
	35°22'44"E	1	Sand	38.4	29.2	5.36
K12	36°46'56"N					
	34°36'49"E	0.1	*Brachiodontes pharaonis*	38.4	28.8	4.42

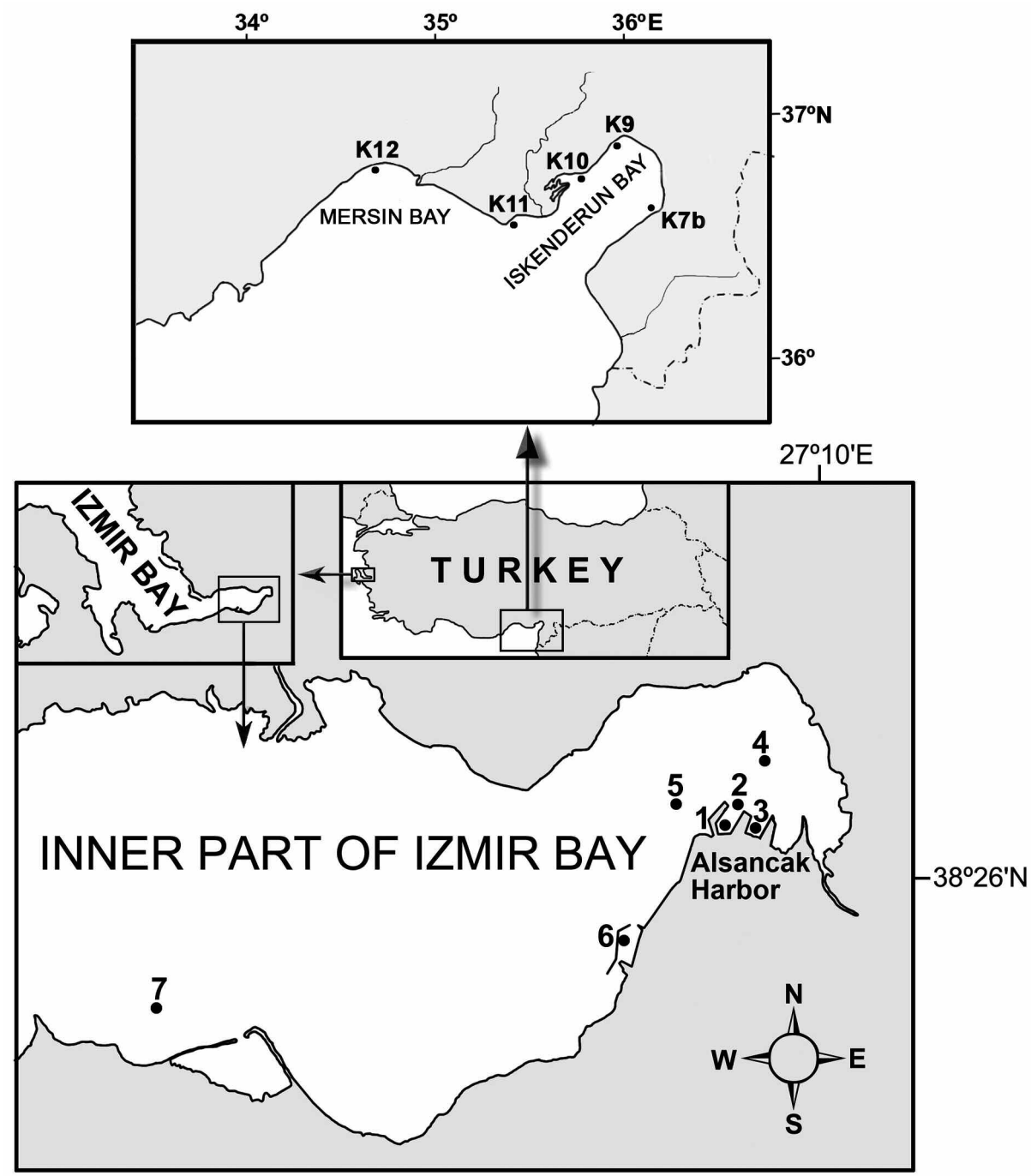

Figure 1. Location of sampling sites.
Figure 1. Localisation des stations d'échantillonnage.

The length of worms (excluding palps) and the width at chaetiger 5 were measured using an ocular micrometer. Photographs of specimens of *Pseudopolydora paucibranchiata* were taken using a digital camera (Olympus, Camedia, C-5050) attached to stereo and compound microscopes. Some specimens of *Pseudopolydora paucibranchiata* chosen for scanning electron microscope observations (SEM) were dehydrated, coated with gold and examined in Jeol JFM-5200 SEM in the Faculty of Dentistry, Ege University, Turkey.

The specimens examined were deposited in the Museum of Faculty of Fisheries (ESFM), Ege University.

Results and Discussion

Pseudopolydora paucibranchiata Okuda, 1937
(Fig. 2 A-E)

Polydora (*Carazzia*) *paucibranchiata* Okuda, 1937: 231-233, figures 11-12.
Pseudopolydora paucibranchiata Blake & Woodwick, 1975: 110-118, figures 1-11; Light, 1978: 161-163, figures 162-163; Myohara, 1980: 145-155, plate 1, figures 3-4, plate 2, figures 5-27, plate 3 figures, 28-51; Wu & Mu, 1980: 356-364, figures 1-6; Ramberg & Schram, 1982: 244-246, figure 8; Radashevsky, 1983: 38-45, figures 1-2; Hutchings & Turvey, 1984: 17, figure 7; Britayev & Rzhavskij, 1985: 47-49, figures 1-2; Radashevsky, 1993: 50-53, figure 27.
Pseudopolydora cf. *paucibranchiata* Read, 1975: 414-416, figure 7.

Material examined

Aegean Sea (Izmir Bay): 15 January 2004: Station 3, 1 ind. (ESFM-POL/04-36); Station 4, 26 ind. (ESFM-POL/04-41); Station 5, 131 ind. (ESFM-POL/04-67); Station 6, 254 ind. (ESFM-POL/104); 14 April 2004: Station 1, 445 ind. (ESFM-POL/04-21); Station 2, 285 ind. (ESFM-POL/04-286); Station 3, 72 ind. (ESFM-POL/04-299); Station 4, 1083 ind. (ESFM-POL/04-317); Station 5, 1013 ind. (ESFM-POL/04-329); Station 6, 1175 ind. (ESFM-POL/04-355II); Station 7, 3 ind. (ESFM-POL/04-441); 29 June 2004: Station 1, 208 ind. (ESFM-POL/04-1022); Station 2, 805 ind. (ESFM-POL/04-954); Station 3, 4 ind. (ESFM-POL/04-1042); Station 4, 1233 ind. (ESFM-POL/04-955); Station 5, 774 ind. (ESFM-POL/04-956); Station 6, 4 ind. (ESFM-POL/04-1013); Station 7, 11 ind. (ESFM-POL/04-1012); 16 September 2004: Station 2, 12 ind. (ESFM-POL/04-976); Station 4-5, 8 ind. (ESFM-POL/04-974); Station 6, 9 ind. (ESFM-POL/04-975); Station 7, 1 ind. (ESFM-POL/04-977).
Levantine Sea (Iskenderun and Mersin Bays): 9 September 2005: Station K7b, 5 ind. (ESFM-POL/05-473); 14 September 2005: Station K9, 1 ind. (ESFM-POL/05-279); 15 September 2005: Station K10, 2 ind. (ESFM-POL/05-362); 15 September 2005: Station K11, 1 ind. (ESFM-POL/05-322); 17 September 2005: Station K12, 25 ind. (ESFM-POL/05-1138).

Description

Largest specimen complete, 10 mm long (ESFM-POL/04-974), 0.73 mm wide, with 59 chaetigers. Body slightly dorso-ventrally flattened, enlarged in anterior part, gradually decreasing in width towards posterior end, pale yellowish. Body without pigmentation; fine continuous brown horizontal lines often present on palps (Fig. 2B).

Prostomium anteriorly rounded, caruncle reaching to posterior of chaetiger 3, shorter in small form (Fig. 2A). Nuchal tentacle present on caruncle at level of palps, occasionally short and pointed (Fig. 2A). Two pairs of black eyes present in trapezoid arrangement. Palps long, almost extending to chaetigers 24-28.

Chaetiger 1 with a small notopodial lobe and neuroseta. Notoseta absent on distinct notopodial lobes (Fig. 2A). Chaetigers 2-4 and 6-7 have both noto- and neuropodial capillary setae. From chaetiger 8 to posterior end of body, parapodia with both capillary chaetae and hooded hooks. Notochaetae in anterior segments with 14-16 capillaries, almost 226 µm long, divided into two groups. Chaetiger 5 with 5-6 dorsal capillary chaetae, ventral capillary chaetae and specialized spins. Notochaetae on posterior parapodia thinner and shorter than those on anterior parapodia. Neurochaetae on chaetigers 2-7 with about 9-12 capillaries per fascicle. Neuropodial hooded hook first present on chaetiger 8, reaching up to 12 per fascicle in posterior parapodia. Hooks bidentate, with small distal tooth; a well defined constriction present on shaft; not accompanied by capillary chaetae (Fig. 2D-E).

Chaetiger 5 not modified and almost same in size as chaetigers 4 or 6, without notopodial post chaetal lamellae but with neuropodial ones. Parapodia with two types of specialized spin arranged in a horseshoe-shaped line. Spines constituting inner row simple and blunt tip, those of outer row with a slender curved tip with marked constriction between tip and shaft (Fig. 2C). Up to 11 spines present in outer row and 10 spines in inner row (Fig. 2C).

Branchiae begin on chaetiger 7, extending to chaetiger 14-18. Length of branchiae on parapodia almost same.

Pygidium as a small disc, with large dorsal gap (Fig. 2F). Small tubercles present on dorsal side of pygidium.

Reproduction

Pseudopolydora paucibranchiata constructs a muddy tube. Adult females of *P. paucibranchiata* collected in Izmir Bay deposited 9 to 15 capsules in their tubes, each of them containing 12 to 33 eggs (Fig. 3A). Each capsule is joined to the next and attached to the inner lining of the female tube with a thin extension. Specimens of *P. paucibranchiata* collected in January, April and June have eggs; egg diameters: 62.5-90 µm (mean: 74.2 ± 2.38 SE, N = 15). Ramberg & Schram (1982) postulated that there were two spawning periods for the Atlantic population of this species, one in spring (March/April) and other in August and September.

One mature female (measuring 10 mm and having 59 chaetigers) had oocytes between chaetigers 13 and 46. A male with 56 chaetigers had spermatophores from chaetiger 17 through chaetiger 31. The spermatophore is composed

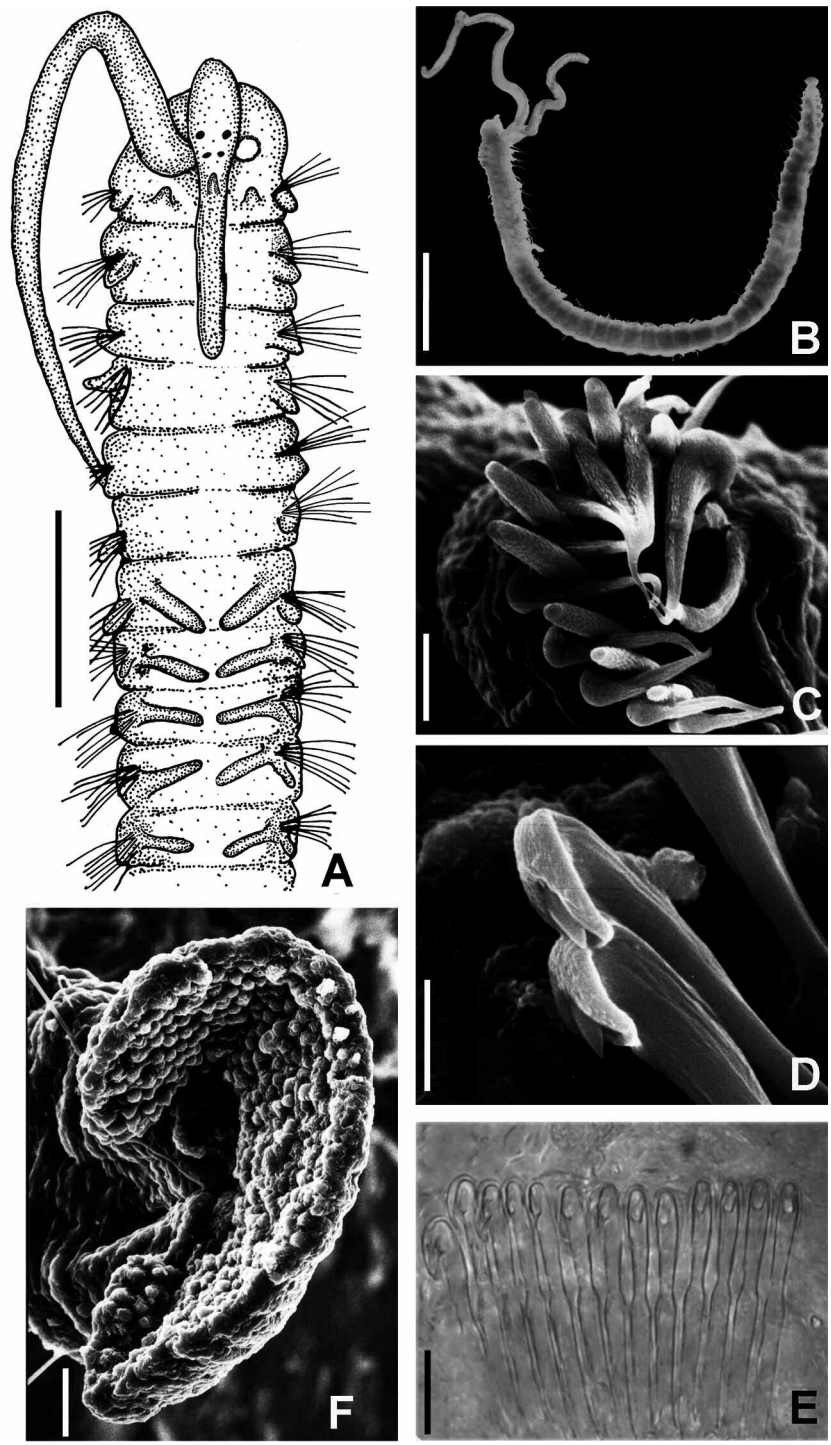

Figure 2. *Pseudopolydora paucibranchiata*. **A.** Anterior end, dorsal view (ESFM-POL/04-104). **B.** Whole animal (ESFM-POL/04-317). **C.** Chaetiger 5 with two types of specialized spines (SEM photograph) (ESFM-POL/04-1042). **D-E.** Hooded hooks on middle chaetigers (D: SEM photograph) (ESFM-POL/04-1042). **F.** Disc-like pygidium with dorsal gap (SEM photograph) (ESFM-POL/04-1042). Scale bars: A: 0.5 mm, B: 2 mm, C, E: 10 µm, D: 5 µm, F: 20 µm.

Figure 2. *Pseudopolydora paucibranchiata*. **A.** Vue antérieure et dorsale (ESFM-POL/04-104). **B.** Animal complet (ESFM-POL/04-317). **C.** Cinquième sétigère avec deux type d'épines spécialisées (MEB) (ESFM-POL/04-1042). **D-E.** Crochet à capuchon sur les sétigères de milieu du corps (D : MEB) (ESFM-POL/04-1042). **F.** Pygidium discoïdal avec une fente dorsale (MEB) (ESFM-POL/04-1042). Échelle : A : 0,5 mm, B : 1 mm, C, E : 10 µm, D: 5 µm, F : 20 µm.

of a bundle of spermatozoa: the bundle diameters were 26-30 µm (mean: 28 ± 1.63 SE). Blake & Woodwick (1975) reported that *P. paucibranchiata* had eggs, ranging from 96 to 105 µm (mean: 96.2 µm) in diameter, deposited in 7-10 capsules, each of them containing 35-50 eggs. Myohara (1980) also observed that this species had 7-10 eggs capsules containing 35-50 eggs each, which were 95-100 µm in diameter. Myohara (1980) measured the diameters of the spermatophore bundle of this species as 15-25 µm. Yokoyama (1997) and Wu & Mu (1980) measured the diameter of eggs of this species as 95-100 µm and 106-118 µm, respectively. Blake & Woodwick (1975) reported that gametes were present on chaetigers 15-30 in specimens from the Pacific, whereas in our specimens gametes were present on chaetigers 21-46.

Larvae at different stages of development were found in the tubes of some female specimens of *Pseudopolydora paucibranchiata* collected in Izmir Bay. Larvae, which had 3 chaetigerous segments, were closely associated with the body of female specimens (Fig. 3B). These larvae measured approximately 148.3 µm long and 85.6 µm wide (Fig. 3C). The larvae had three pairs of black eyes, comprised of one pair of lateral eyes and two pairs of median eyes (Fig. 3C). Chaetae on chaetiger 1 longest, extending posteriorly beyond pygidium.

Remarks

Pseudopolydora paucibranchiata was first described by Okuda (1937) from Japan. Morphological characteristics of specimens of *P. paucibranchiata* from the eastern Mediterranean coincide with the original description of the species. However, we found some differences worth mentioning. Okuda (1937) reported that a small dorsal lobe with a few very fine bristles situated on the first chaetiger, whereas our specimens have no capillary notochaetae on chaetiger 1. The subsequent descriptions of this species after Okuda (1937) also reported that notopodia of chaetiger 1 lack chaetae (Read, 1975; Ramberg & Schram 1982; Hutchings & Turvey, 1984). In addition, Okuda (1937) pointed out that dorsal capillary chaetae of this species are composed of three kinds and are arranged in three rows in the anterior 11-13 chaetigers. However, we found that the eastern Mediterranean specimens of the species have two kinds of notopodial capillary setae and arranged in two rows on the anterior part of the body. This was also noted by Read (1975).

Ramberg & Schram (1982) first reported *Pseudopolydora paucibranchiata* from the north-eastern Atlantic (Oslofjord, Norway). They reported that the Atlantic specimens had no nuchal tentacle, whereas the original (Okuda, 1937) and subsequent (Read, 1975; Radashevsky, 1993; Radashevsky & Hsieh, 2000 and present study) descriptions of this species reported a nuchal tentacle on the caruncle.

The number of neuropodial hooded hooks on specimens of *P. paucibranchiata* collected in Wellington Harbor, New Zealand (Read, 1975) reached up to 20 per fascicle, whereas our specimens have up to 13 per fascicle.

Density and Biomass

The population density of *Pseudopolydora paucibranchiata* varied among stations and seasons in Izmir Bay (Fig. 4). Its density ranged from 10 ind.m^{-2} (station 3) to 1260 ind.m^{-2} (station 6) in winter; 10 ind.m^{-2} (station 7) to 5150 ind.m^{-2} (station 4) in spring; 10 ind.m^{-2} (stations 6 & 7) to 6180 ind.m^{-2} (station 5) in summer; and 10 ind.m^{-2} (stations 4, 6 & 7) to 120 ind.m^{-2} (station 2) in autumn. It seems that the spring and summer conditions of the inner part of Izmir Bay facilitated the dense settlement of *P. paucibranchiata* in the area. Çinar et al. (2006) showed that the inner part of Izmir Bay in the spring period was characterized by species with high population densities. On the Levantine coast of Turkey, the maximum density (625 ind.m^{-2}) of this species was found at station K12, which is located near Mersin Harbor. This species seems to form a scarce population (maximum 125 ind.m^{-2} at K7, near Iskenderun Harbor) in Iskenderun Bay. Tamaki (1987) reported the maximum density of this species as 70112 ind.m^{-2} on the tidal sand flat in Tomioka Bay (Amakusa Shimoshima Island, east China Sea). The maximum density of *P. paucibranchiata* was reported to be 7000 ind.m^{-2} in the Yellow Sea (Wu & Mu, 1980) and 210 ind.m^{-2} on the coast of Gokasho Bay (Sea of Japan) (Yokoyama, 1997).

The mean biomass value (wet weight) of the specimens of *Pseudopolydora paucibranchiata* ranged from 0.001 ± 0.01 g.m^{-2} (station 7, in June 2004) to 1.98 ± 2.47 g.m^{-2} (station 4, April 2004). The maximum biomass value of the species was estimated as 4.77 g m^{-2} at station 4 in June 2004 (Fig. 4). Wu & Mu (1980) reported its biomass value as 33 g.m^{-2} (wet weight) in the Yellow Sea.

Habitat

Pseudopolydora paucibranchiata was previously reported to form dense populations on muddy bottom in estuaries (Radashevsky, 1993) or in marine environments (Tamaki, 1987). It was moreover found in a variety of shallow water benthic habitats (2-4 m); on organically enriched sand at low tide level; associated with *Boccardia syrtis* (Rainer, 1973) population (Read, 1975); on muddy sand (Radashevsky, 1993); on sand (Radashevsky & Hsieh, 2000); and in seagrass bed (Hutchings & Turvey, 1984). Ramberg & Schram (1982) reported it as a common species on mud bottom at depths of 15-25 metres in the middle and outer parts of the inner Oslofjord (Norway). We collected it on the muddy bottom between 7 and 11 m depths in the

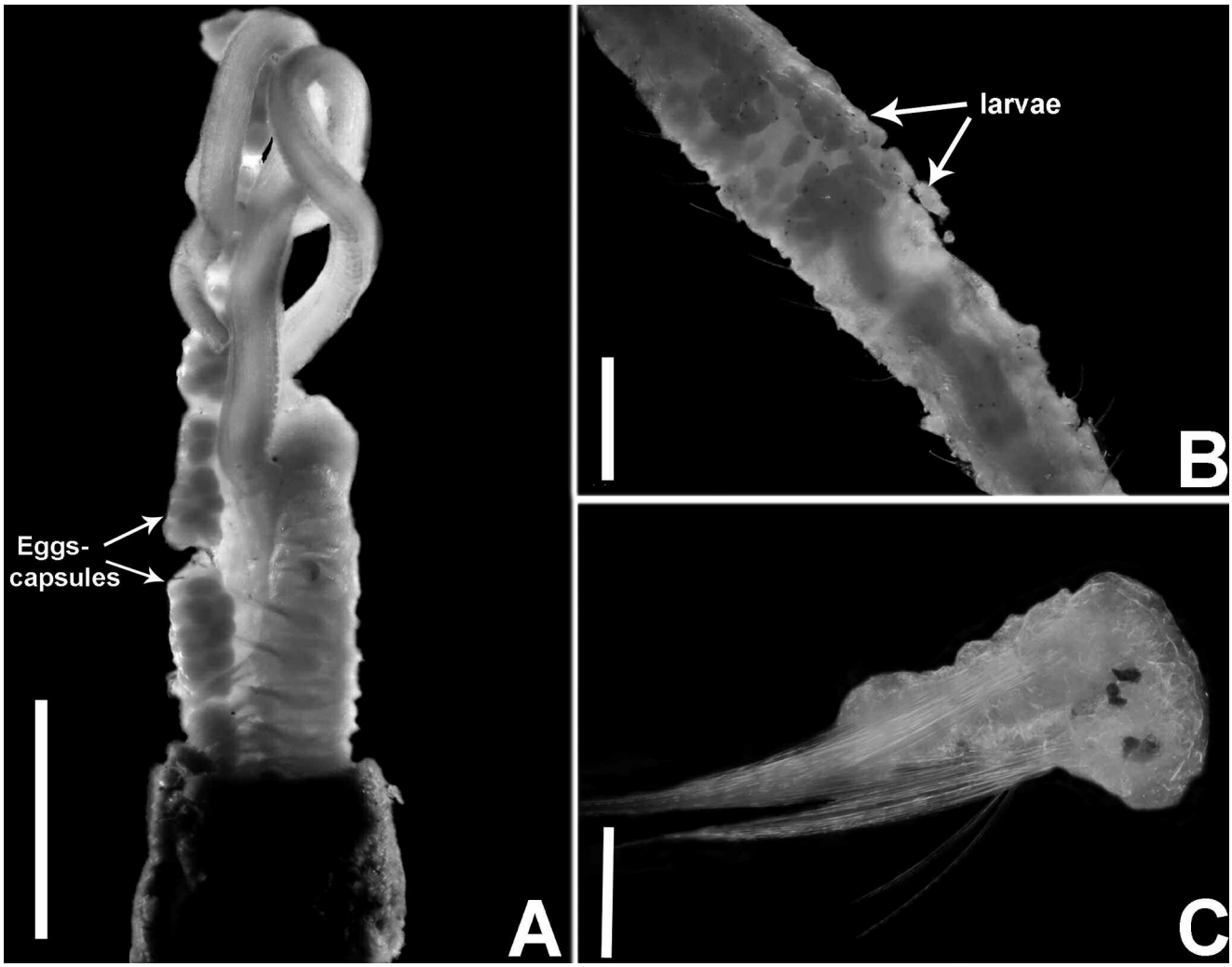

Figure 3. *Pseudopolydora paucibranchiata* (ESFM-POL/04-329). **A.** Specimen inside the tube to which egg capsules are attached. **B.** Specimen having larvae on the body wall. **C.** Dorsal view of a larva having 3 chaetigers. Scale bars: A: 1 mm, B: 0.5 mm, C: 50 µm.

Figure 3. *Pseudopolydora paucibranchiata* (ESFM-POL/04-329). **A.** Spécimen dans le tube auquel sont fixées des capsules d'oeuf. **B.** Spécimen ayant le corps recouvert de larves. **C.** Vue dorsale de larve à 3 sétigères. Échelle : A : 1 mm, B : 0,5 mm, C : 50 µm.

polluted zone of Izmir Bay (Aegean Sea). However, this species was also found on sands, and in sediments accumulated on rocks and among shells of the bivalve *Brachiodontes pharaonis* (P. Fischer, 1870) and the alga *Padina pavonica* (Linnaeus) between 0.1 and 3 m depths in Mersin and Iskenderun Bays (Levantine Sea) (Table 1). As this species forms dense populations in disturbed benthic environments, it was regarded as an indicator of semi-polluted zones by Reish (1955) in South California, Pearson & Rosenberg (1978) in South California, Myohara (1980) in Japan, Yokoyama, (1997) in Japan and Wu & Mu (1980) in Yellow Sea, China.

Distribution and way of introduction in Izmir Bay

Pseudopolydora paucibranchiata was originally described from Japan (Onomichi, Hiroshima Prefecture) and was subsequently reported from the Pacific Ocean [Sea of Japan, Yellow Sea, Inland Sea, California, Australia, New Zealand] (Radashevsky, 1993) and the northeastern Atlantic [Norway] (Ramberg & Schram, 1982). This species has not been reported from the Mediterranean so far. This species was previously reported to have been introduced to the Australian waters from the Japan by ships (Polland & Hutchings, 1990).

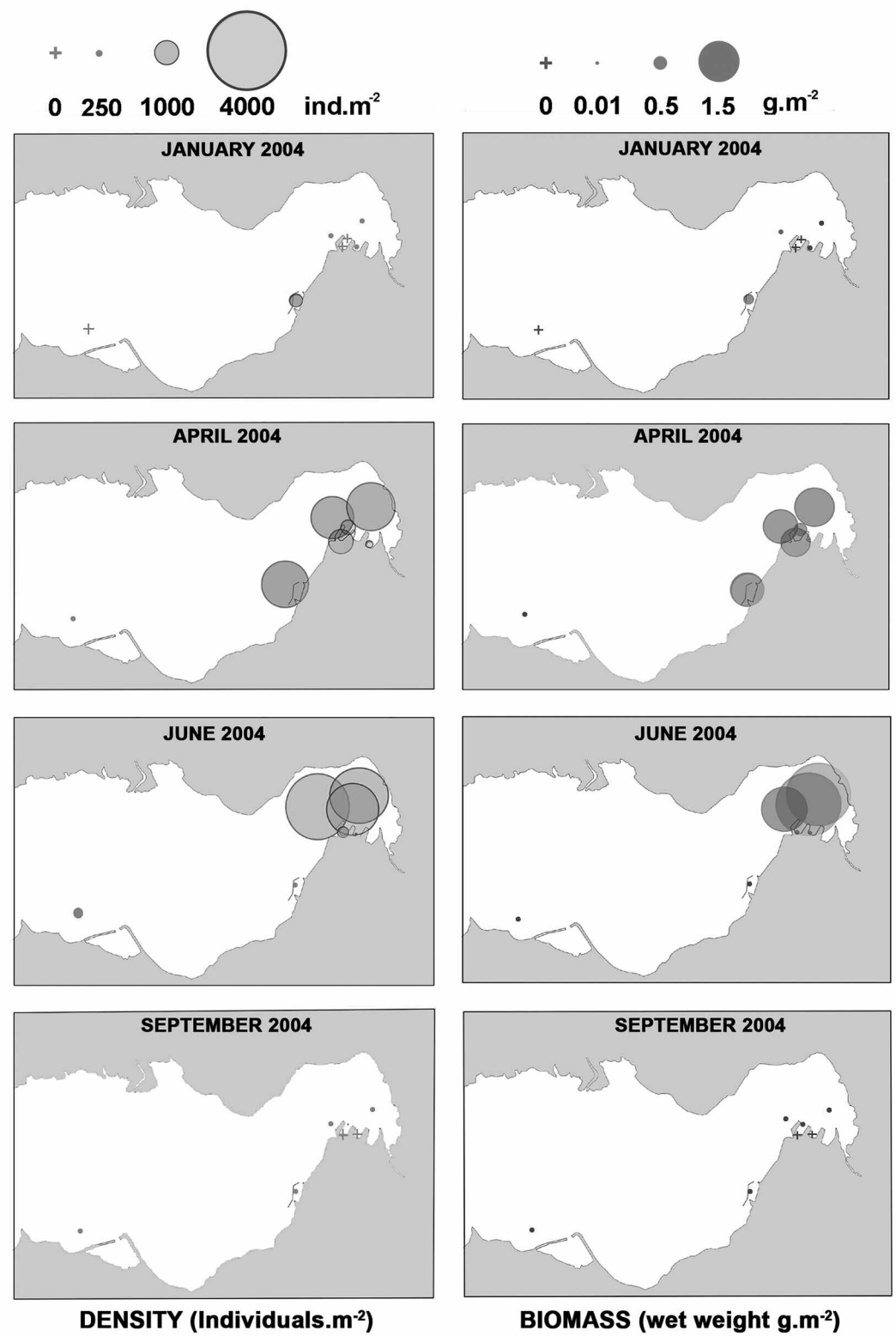

Figure 4. *Pseudopolydora paucibranchiata*. Spatio-temporal distributions of density (ind.m^{-2}) and biomass (g wwt.m^{-2}) in Izmir Bay between January and September 2004.

Figure 4. *Pseudopolydora paucibranchiata*. Distribution spatio-temporelle de la densité (ind.m^{-2}) et de la biomasse (g wwt.m^{-2}) dans la Baie d'Izmir de janvier à septembre 2004.

The pathway through which this species become established in Izmir Bay is probably by ballast water as it formed particularly dense populations in and around Alsancak Harbor, which is one of the biggest commercial harbors in Turkey. This species also forms relatively dense populations at stations near harbors on the Levantine coast of Turkey (at K7 near Iskenderun Harbor, at K12 near Mersin Harbor). As this species incubates eggs in their tube and has a relatively short pelagic life of larvae, the transportation of this species as larvae in ballast tanks appears unlikely. However, their settlement in sediment accumulated at bottom of ballast tanks and producing larvae just before the tanks are being emptied in donor area might lead to its introduction to the new region.

As this species was previously reported from the different parts of the world (eastern and western parts of the Pacific and the northeastern part of the Atlantic), it is difficult at this species where the Mediterranean population has been originated from. A genetic study on the populations of the species between the regions could shed more light on this subject.

Pseudopolydora paucibranchiata was previously identified in the area as *P. antennata* (see Çinar et al., 2006). The examination of the older benthic material, which was collected in the inner part of Izmir Bay and deposited in the Museum of Faculty of Fisheries, Ege University (ESFM), revealed that specimens collected in 1997, 2003 and 2004, and originally identified as *P. antennata*, infact belong to *P. paucibranchiata*. Consequently, the arrival time of *P. paucibranchiata* could have been 1997, but the reports of *P. antennata* in the polluted zone of the Mediterranean Sea (Zenetos & Bogdanos, 1987; Nicolaidou et al., 1993; Simboura & Zenetos, 2002) should be re-examined to find out its first settlement time in the Mediterranean Sea. The original description of *P. antennata* by Claparède (1870) was relatively poor and the figure given by the author (prostomium with four antero-lateral processes rather than two) resulted in mistakes in the identification of this species. Specimens of this species from Turkish coasts indicated that this species has only two antero-lateral processes. The main differences between *P. paucibranchiata* and *P. antennata* are as follows; *P. paucibranchiata* has a rounded prostomium without antero-lateral processes (two lateral processes in *P. antennata*); 11-13 pairs of branchiae (more than 20 pairs of branchiae in *P. antennata*); a disk like pygidium (both dorsal and ventral median portions notched in *P. antennata*); hooks with well defined constriction on shaft (ill defined construction in *P. antennata*).

Impact of the native fauna

The determination of the impact of *Pseudopolydora paucibranchiata* on the native fauna is difficult as it co-occurs with the other spionid invaders (*Streblospio gynobranchiata* and *Polydora cornuta*) in the area. These three spionid polychaetes comprised almost 73% of the total zoobenthic populations in and near Alsancak Harbor. They constituted more than 95% of the total community and 70% of the total biomass at some stations (Fig. 5). Çinar et al. (2005) indicated that these species have a great impact on the ecosystem and seem to have replaced some opportunistic species previously known from the polluted Izmir Bay such as *Capitella capitata* Oersted, 1843 and *Malacoceros fuliginosus* (Claparède, 1868). As these species are deposit feeders, the wealth of organic matter in the inner part of Izmir Bay (see Çinar et al., 2006) supports them a good place for the settlement. As they only dominated stations in the inner-most part of Izmir Bay, which is close to pollution sources, and were represented by low number of specimens at station 7, which is far from the harbor and had more diversified faunal components, it can be concluded that these species are less competitive and could only invade areas where perturbations due to high loads of organic matter or the freshwater influx occur. These species play a major role in recycling organic matter in the area and constituted an excellent food for higher predators.

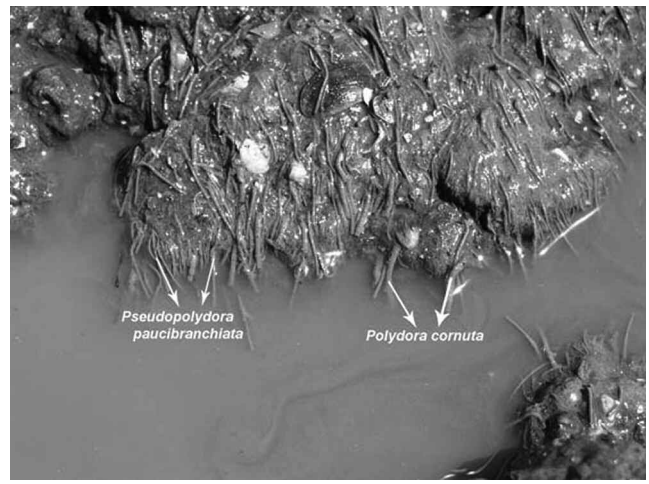

Figure 5. *Pseudopolydora paucibranchiata.* Photograph of a grab sample taken in June 2004 at station 5 in Izmir Bay, showing dense settlements of *Pseudopolydora paucibranchiata* and *Polydora cornuta*.

Figure 5. *Pseudopolydora paucibranchiata.* Photographie d'un échantillon prélevé en juin 2004 à la station 5 dans la Baie d'Izmir, montrant des populations denses de *Pseudopolydora paucibranchiata* et de *Polydora cornuta*.

Acknowledgements

We are much indebted to Dr. Vasily Radashevsky (Institute of Marine Biology Vladivostok, Russia) for confirmation of the species, to personnel of R/V EGESUF for their help

in collecting the benthic material in Izmir Bay, to colleagues at the Department of Hydrobiology, Ege University for their help in collecting and sorting the benthic material. This work has been financially supported by Scientific Research Projects of Ege University (Project number: 03 SUF 005) and TUBITAK (Project number: 104Y065).

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