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Abstract

The compilation of data on alien species reported from the Turkish coasts yielded a total of 263 species belonging to 11 systematic groups, of which Mollusca had the highest number of species (85 species), followed by Crustacea (51), fishes (43) and phytobenthos (39). The Black Sea is represented by a total of 20 alien species, the Sea of Marmara by 48 species, the Aegean Sea by 98 species and the Levantine Sea by 202 species. The majority of aliens found in the Black Sea and the Sea of Marmara were transported via shipping, whereas the Levantine coast is extensively subjected to Lessepsian migration. Benthic habitats (soft and hard substrata) comprise 76% of the total alien species and the pelagic environment is inhabited by thirty-nine species. Almost 50% of aliens collected from the Turkish coasts were found only at 0-10 m depth. Eight species occur at depths deeper than 100 m. The impacts of aliens on the benthic and pelagic ecosytems are presented.

Keywords: Alien species; Species list; Impact; Black Sea; Sea of Marmara; Aegean Sea; Levantine Sea; Turkey.

Intoduction

Species introduction is one of the major factors adversely affecting biological diversity (ELTON, 1958). The impacts of alien species on their new environment include restructuring established food webs, importing new diseases and competition with native organisms for food and space. Other significant ecological changes may occur when the invading organisms reproduce with native species, altering the gene pool (OCCHIPINTI AMBROGI, 2001). Invaders may belong to any taxonomical group, and are capable of colonizing every ecosystem on earth, changing the ecological relations within communities, altering evolutionary processes and causing dramatic changes in native populations, including extinctions (MACK *et al*., 2000).

The negative effects of aliens experienced world-wide have triggered the social and scientific media to take some precautions against the dispersal of aliens among regions or among localities within a particular region.Thus, compiled data regarding all aliens or a target organism (i.e. *Caulerpa taxifolia* in the Mediterranean Sea) are urgently required by scientists

and decision makers. In addition, monitoring programmes on spatio-temporal structures of communities particularly in the hot spot areas for aliens such as harbours, brackish and polluted waters should be undertaken both on local and global scales.

Turkey is surrounded by four seas with different hydrographical characteristics. The maritime traffic taking place through the Dardanel and Bosphorus straits and among commercial harbours makes the Turkish coasts more susceptible to invasions by aliens. The proximity of Turkey to the Suez Canal has resulted in dense settlements of Lessepsian migrants, especially in habitats along the Levantine coast of Turkey. Alien species and their roles in the benthic and pelagic ecosytems is increasingly becoming a subject of study in the country.

This paper reviews the alien species reported from the Turkish coasts and constitutes the first comprehensive database for future studies.

Methods

Data on alien species along the Turkish coasts

In this study, only reported data on aliens along the Turkish coasts have been taken into account. All calculations are based on species' records up to the end of 2005. Cryptogenic species have not been included in our compiled list. Some of the species in Table 1, which represent uncertainty in their real taxonomic position and distributional pattern, are classified as questionable or excluded. The questionable species will turn into aliens if their real taxonomic and distributional identities are clarified. In all calculations, including number of species per sea, only the established and questionable species have been taken into account. The importance of aliens in the total biota was estimated, based on the authors' databases.

Results and Discussion

List of alien species from the Turkish coasts

Table 1 includes all alien species reported from the Turkish coasts. The species are categorized by their origins, the mode of introduction and their habitat and depth preferences. The establishment success is assigned for each species. The first reported years of the species together with the relavant publications are also given for each sea.

The present data show that a total of 263 alien species, which belong to 11 systematic groups, occur along the Turkish coasts. Among the groups, Mollusca had the highest number of species (85 species), followed by Crustacea (51), fishes (43) and phytobenthos (39). Cnidaria is represented by only two species (*Rhopilema nomadica* and *Cassiopea andromeda*), Ctenophora by 2 species (*Mnemiopsis leidyi* and *Beroe ovata*), Pantopoda by one species (*Anoplodactylus californicus*), Bryozoa by one species (*Rhynchozoon larreyi*) and Echinodermata by 2 species (*Ophiactis savignyi* and *Synaptula reciprocans*).

Thirty-two species are considered as questionable or excluded in Table 1, mainly due to the uncertainty in their real taxonomical status and distributional patterns. The polychaetes, *Branchiosyllis exilis*, *Opisthosyllis brunnea*, *Rhodine loveni* and *Monticellina dorsobranchialis*, which were previously considered as Lessepsian migrants, indeed occur also in the western Mediterranean and the Atlantic Ocean. These species were also previously proposed to be excluded from the list of Lessepsian species (ERGEN *et al*., 2002; ÇINAR, 2003; 2005). RULLIER (1963) found 11 polychaete species with Indo-Pacific affinity from the Sea of Marmara (Table 1). Of the species, *Nereis zonata persica* and *Timarete ancylochaeta* were also reported along the Levantine coast and considered as Lessepsian migrants (BEN-ELIAHU, 1995). The other species have not been subsequently reported from elsewhere in the Mediterranean Sea.

A total of 176 Lessepsian and 48 ship-transferred species were reported along the Turkish

Table 1.

The list of alien species and their first year of reports from the Turkish coasts. The habitat and depth preferences of aliens along the coasts together with their origins and establishment success are also given. The marked species in the list are questionable or excluded ones. BS: Black Sea, SM: Sea of Marmara, AS: Aegean Sea, LS: Levantine Sea, O: Origin (IP: Indopacific, RS: Red Sea, AT: Atlantic, WA: Western Atlantic, ST: Subtropical, IO: Indian Ocean, PG: Persian Gulf, PO: Pacific Ocean, TA: Tropical Atlantic, CT: Circumtropical, BA: Boreal Atlantic) Es: Establishment success (E: Established, Q: Questinable, Ex: Excluded), MI= Mode of Introduction (L: Lessepsian, S: Shipping, G: Gibraltar, Aq: Aquaculture), H: Habitat [Hs: hard substrata (including algae, sponge), Ss: soft substrata (including phanerogams), P: pelagic, Pz: parasite], D: Depth range (I: 0-10 m, II: 11-50m, III: 51-100 m, IV: 101-200 m, V: 201-400, VI: 401-500 m).

	BS	SM	AS	LS	Es	O	MI	H	D
PHYTOPLANKTON									
Alexandrium tamarense (Lebour) Balech 1992	-	-	1984[124]	-	Q	WA	S	P	I
Chaetoceros coarctatus Lauder 1864	-	-	1987[125]	-	E	AT,PO	S	P	I
Gymnodinium cf. *mikimotoi* Miyake et Kominami ex Oda 1935	-	-	2002[44]	-	Q	?	S	P	I
Heterosigma cf. *akashiwo* (Hada) Hada, 1968	-	-	2002[44]	-	Q	?	S	P	I
Rhizosolenia calcar-avis M. Schultze, 1858	1999[71]	1993[123]	-	-	E	AT	S	P	I
Scrippsiella trochoidea (Stein) Loeblich III, 1976	1999[71]	-	-	-	E	AT	S	P	I
Thalassiosira nordenskioeldii Cleve 1873	2002[160]	-	-	-	E	AT	S	P	I
PHYTOBENTHOS									
Cyanophyta (=Cyanobacteria)									
Trichodesmium erythraeum Ehrenberg, 1830	-	-	1996[69]	-	E	IP,RS	L	Hs,Ss	I
Rhodophyta									
Acanthophora nayadiformis (Delile) Papenfuss, 1968	-	1973[177]	1970[103]	1997[20]	E	RS	L	Hs	I,II
Acanthophora muscoides Linnaeus, 1753	-	-	1986[178]	-	E	AT	S	Hs	I,II
Acrochaetium codicolum Børgesen, 1927	1996[28]	1986[178]	1990[55]	1997[19]	E	IP,AT	S	Hs,Ss	I
Asparagopsis armata Harvey, 1855	1973[176]	1986[178]	1973[176]	1969[174]	E	IP,AT	S	Hs	I
Asparagopsis taxiformis (Delile) Trevisan de Saint-Léon, 1845	-	-	2001[27]	-	E	CT	L	Hs	I
Bonnemaisonia hamifera Hariot, 1891	-	1986[178]	-	1997[20]	E	PO,AT	?S	Hs	I
Botryocladia madagascariensis G.Feldmann, 1945	-	-	-	2000[161]	E	IO	?S	Hs	I
Chondria collinsiana Howe, 1920	-	1986[178]	-	-	E	AT, IO	?L	Hs	II
Chondrophycus papillosus (C. Agardh) Garbary & Harper 1998	1973[175]	1957[143]	1969[174]	1969[174]	E	RS	?L	Hs	I
Ganonema farinosum (Lamouroux) Fan & Wang, 1974	1995[21]	1899[91]	1986[26]	1997[19]	Q	IP,RS	?L	Hs,Ss	I

(continued)

Table 1 (continued)

	BS	SM	AS	LS	Es	O	MI	H	D
Gracilaria arcuata Zanardini 1858	-	1986[178]	-	-	E	RS,IP	L	Hs	I
Griffithsia corallinoides (Linnaeus) Trevisan, 1845	-	1993[23]	-	-	E	AT, IP	G	Hs	I
Hypnea spinella (C. Agardh) Kützing, 1847	-	-	1987[18]	-	E	AT,IP	S	Hs	I
Hypnea variabilis Okamura, 1909	-	1986[178]	1986[178]	-	E	PO	S	Hs	I
Laurencia intermedia Yamada, 1931	1986[26]	-	-	-	E	PO,RS	S	Hs	I,II
Lophocladia lallemandii (Montagne) Schmitz, 1893	-	-	1970[103]	1986[53]	E	IP	L	Hs	I,II
Polysiphonia fucoides (Hudson) Greville, 1824	1973[176]	-	1973[176]	-	E	AT, IO	S	Hs	I,II
Polysiphonia paniculata Montagne, 1842	1986[26]	-	-	-	E	AT	S	Hs	I
Polysiphonia kampsaxiii Boergesen, 1939	-	-	1984[17]	1997[20]	E	IP	S	Hs	I
Radicilingua thysanorhizans (Holmes) Papenfuss, 1956	-	1986[178]	1986[26]	1986[53]	E	AT	S	Hs	I
Rhodophysema georgii Batters, 1900	-	1986[178]	-	-	E	AT,PO	?S	Hs	I
Spyridia hypnoides (Bory de Saint-Vincent) Papenfuss, 1968	-	-	1987[18]	1997[19]	E	IO	S	Hs	I
Heterokontophyta									
Chorda filum (Linnaeus) Stackhouse 1797	-	1986[178]	-	-	?	AT,PO	?S	Hs	I,II
Ectocarpus siliculosus (Dillwyn) Lyngbye, 1819	1973[175]	1899[91]	1899[91]	1986[146]	E	AT	S	Hs	I
Halothrix lumbricalis (Kützing) Reinke, 1888	2004[29]	1993[23]	1986[178]	1993[145]	E	AT,PO	S	Hs	I
Pilayella littoralis (Linnaeus) Kjellman, 1872	1998[24]	1993[23]	1985[105]	1985[105]	E	AT	S	Hs	I
Protectocarpus speciosus Boergesen, 1902	-	1993[23]	-	-	E	AT	S	Hs	I
Sargassum latifolium (Turner) C. Agardh, 1820	-	1986[178]	1986[178]	-	E	RS	?L	Hs	I,II
*Sphaerotrichia divaricata (*Agardh) Kylin, 1940	-	1986[178]	1970[103]	1986[178]	E	AT	S	Hs	I
Stypopodium schimperi (Buchinger ex Kützing) Verlaque & Boudouresque, 1991	-	-	-	1997[20]	E	RS,AT	?L	Hs	I
Chlorophyta									
Bryopsis pennata Lamouroux, 1809	-	1986[26]	1978[52]	1978[52]	E	AT	S	Hs	I
Caulerpa racemosa (Forsskål) J. Agardh, 1873	-	-	1991[54]	1986[53]	E	CT	?L	Hs,Ss	I,II
Caulerpa scalpelliformis (R.Brown ex Turner) C. Agardh, 1817	-	-	-	1998[86]	E	AT,IP	?L	Ss	I,II
Cladophora boodleoides Børgesen 1925	-	-	1996[70]	-	E	AT	G	Hs	I

(continued)

Table 1 (continued)

	BS	SM	AS	LS	Es	O	MI	H	D
Codium fragile (Suringar) Hariot ssp. *tomentosoides* (Goor) P.C. Silva, 1955	-	-	1986[178]	-	E	AT,PO	?S	Hs	I
Ulva fasciata Delile, 1813	1990[25]	1986[26]	1977[104]	1996[22]	E	?RS	?L	Hs	I
Phanerogame									
Halophila stipulacea (Forsskål) Ascherson	-	-	1985[105]	1985[105]	E	IO,RS	L	Hs	I
FORAMINIFERA (Benthic)									
Astacolus insolithus (Schwager, 1866)	-	-	2004[132]	-	E	IP,RS	L	Ss	III
Astacolus sublegumen (Parr, 1950)	-	-	2004[132]	-	E	IP,RS	L	Ss	III
Planogypsina acervalis (Brady, 1884)	-	-	2004[132]	-	E	IP,RS	L	Ss	II
Planogypsina squamiformis (Chapman, 1901)	-	-	2004[132]	-	E	IP,RS	L	Ss	II,III
Amphistegina lobifera Larsen, 1976	-	-	2004[132]	2002[133]	E	IP,RS	L	Ss	I,II
CNIDARIA									
Cassiopea andromeda (Forsskål, 1775)	-	-	-	2002[39]	E	IP,RS	L	Ss	I
Rhopilema nomadica Galil, Spanier & Ferguson, 1990	-	-	-	1995[113]	E	IP,RS	L	P	?
CTENOPHORA									
Mnemiopsis leidyi (Agassiz, 1865)	1994[137]	1994[114]	1994[114]	1993[167]	E	WA	S	P	I,II
Beroe ovata Mayer 1912	2001[115]	2004[108]	-	-	E	WA	S	P	I,II
POLYCHAETA									
Lepidonotus carinulatus (Grube, 1870)	-	1963[149]	-	-	Q	IP,RS	?S	?	?
Harmothoe boholensis (Grube, 1878)	-	1963[149]	-	-	Q	IP,RS	?S	?	?
Harmothoe minuta (Potts, 1910)	-	1963[149]	-	-	Q	IP,RS	?S	?	?
Ancistrosyllis rigida Fauvel, 1919	-	1963[149]	-	-	Q	IP,RS	?S	?	?
Sigambra constricta (Southern, 1921)	-	1963[149]	-	-	Q	IP,RS	?S	?	?
Opisthosyllis brunnea Langerhans, 1879	-	-	2002[63]	-	Ex	IP,RS	L	Hs	I
Branchiosyllis exilis (Gravier,1900)	-	-	2002[63]	-	Ex	IP,RS	L	Hs	I
Leonnates persicus Wesenberg-Lund, 1949	-	-	2002[65]	2003[85]	E	IP,RS	L	Ss	II-IV
Nereis zonata persica Fauvel, 1911	-	1963[149]	-	-	Q	IP,RS	?L	?	?
Pseudonereis anomala Gravier, 1900	-	-	2005[64]	1989[33]	E	IP,RS	L	Hs	I
Glycera alba adspersa Fauvel, 1939	-	1963[149]	-	-	Ex	IP	?S	?	?
Eurythoe complanata (Pallas, 1766)	-	-	-	1997[81]	Q	?IP	L	Hs	I
Linopherus acarunculata Monro, 1937	-	-	-	1997[81]	E	RS	L	Ss	I
Lumbrineris debilis Grube, 1878	-	1963[149]	-	-	Q	IP	?S	?	?
Lysidice collaris Grube, 1870	-	-	1998[61]	1997[81]	Q	IP,RS	L	Hs,Ss	I,II
Prionospio saccifera Mackie & Hartley, 1990	-	-		1999[62]	E	IP,RS	L	Ss	III
Polydora cornuta Bosc, 1802	-	-	2005[66]	-	E	?	S	Ss	I,II
Streblospio gynobranchiata Rice & Levin, 1998	-	-	2005[66]	-	E	WA	S	Ss	I,II
Dasybranchus carneus Grube, 1870	-	1963[149]	-	-	Q	RS	?S	?	?
Notomastus aberans Day, 1957	-	-	1983[141]	-	E	IP	L	Ss	I

(continued)

Table 1 (continued)

	BS	SM	AS	LS	Es	O	MI	H	D
Monticellina dorsobranchialis (Kirkegaard, 1959)	-	-	2006[84]	-	Ex	?	L	Ss	?
Timarete dasylophius (Marenzeller, 1879)	-	1963[149]	-	-	Q	IP	?S	?	?
Timarete anchylochaeta (Schmarda, 1861)	-	1963[149]	-	-	Q	IP	?S	?	?
Metasychis gotoi (Izuka, 1902)	-	-	2002[83]	-	E	IP,RS	?L	Ss	?
Rhodine loveni Malmgren, 1865	-	-	1992[80]	1998[82]	Ex	IP,AT	L	Ss	II
Pista unibranchia Day, 1963	-	-	1998[142]	1997[81]	E	IP,RS	L	Ss	I,II
Ficopomatus enigmaticus (Fauvel, 1923)	-	1952[67]	1976[79]	-	E	ST	S	Hs	I
Hydroides dianthus (Verrill, 1873)	-	-	1865[148]	-	E	WA	S	Hs	I
Hydroides elegans (Haswell, 1883)	-	-	1976[79]	1991[34]	E	A,P	S	Hs	I
Spirorbis marioni Caullery & Mesnil, 1897	-	-	1991[117]	-	E	P	S	Hs	I
PANTOPODA									
Anoplodactylus californicus Hall, 1912	-	-	-	1962[153]	E	CT	L	Hs	I
CRUSTACEA									
Copepoda									
Centropages furcatus (Dana, 1846)	-	2000[164]	-	2002[168]	E	IP,RS	L	P	I-III
*Calanopia elliptica (*Dana, 1846)	-	-	-	2003[157]	E	IP,RS	L	P	I
Calanopia biloba Bowman, 1957	-	-	-	2002[168]	E	IP,RS	L	P	I-III
Calanopia minor Scott, 1902	-	-	-	2002[168]	E	IP,RS	L	P	I-III
Labidocera pavo Giesbrecht, 1889	-	-	-	2003[157]	E	IP,RS	L	P	I
Euchaeta concinna Dana, 1846	-	-	-	2002[168]	E	IP,RS	L	P	I-III
Eucalanus crassus Giesbrecht, 1888	-	-	-	2002[168]	E	IP,RS	L	P	I-III
Eucalanus subcrassus Giesbrecht, 1888	-	-	-	2002[168]	E	IP,RS	L	P	I-III
Parvocalanus latus Andronov, 1972	-	2000[164]	-	2002[168]	E	IP,RS	L	P	I-III
Parvocalanus elegans Andronov, 1972	-	2000[164]	-	2002[168]	E	IP,RS	L	P	I-III
Acartia tonsa Dana, 1848	-	2000[164]	2001[155]	-	E	WA	S	P	?
Acartia hasanii Unal, Shmeleva & Kideys, 2002	-	-	-	2002[163]	Q	?RS	?L	P	I
Paracartia ioannae Unal, Shmeleva & Kideys, 2002	-	-	-	2002[163]	Q	?RS	?L	P	I
Paracartia janetae Unal, Shmeleva & Kideys, 2002	-	-	-	2002[163]	Q	?RS	?L	P	I
Cirripedia									
Heterosaccus dollfusi Boschma, 1960	-	-	-	1997[140]	E	RS	L	Pz	I,II
Amphipoda									
Maera hamigera Haswell, 1879	-	-	1978[121]	1978[121]	E	IP	L	Ss	I,II
Stenothoe gallensis Walker, 1904	-	-	1978[121]	1978[121]	E	IP	L	Ss	I,II
Isopoda									
Sphaeroma walkeri (Stebbing, 1905)	-	-	1976[118]	-	E	IP	L	Hs	I,II

(continued)

Table 1 (continued)

	BS	SM	AS	LS	Es	O	MI	H	D
Tanaidacea									
Apseudes intermedius Hansen, 1985	-	-	1978[119]	-	E	AT	?S	Hs	I,II
Cumacea									
Eocuma sarsii (Kossmann, 1880)	-	-	1983[109]	-	E	IP	L	Ss	I,II
Decapoda									
Marsupenaeus japonicus (Bate, 1888)	-	2001[173]	2001[173]	1930[136]	E	IP	L	Ss	I-III
Melicertus hathor (Burkenroad, 1959)	-	-	-	2002[128]	E	RS,IO	L	Ss	I-III
Metapenaeopsis aegyptia Galil & Golani, 1990	-	-	-	2004[170]	E	IP,RS	L	Ss	I-III
Metapenaeopsis mogiensis consobrina (Nobili, 1904)	-	-	-	2004[170]	E	IP,RS	L	Ss	I-III
Metapenaeus monoceros (Fabricius, 1798)	-	-	-	1961[106]	E	IP,RS	L	Ss	I-III
Penaeus semisulcatus de Haan, 1844	-	-	-	1930[101]	E	IP,RS	L	Ss	I-IV
Metapenaeus stebbingi (Nobili, 1904)	-	-	-	1981[120]	E	RS,IO	L	Ss	I-III
Trachysalambria palaestinensis Steinitz, 1932	-	-	-	1968[95]	E	RS	L	Ss	II,III
Leptochela pugnax de Man, 1916	-	-	-	1981[120]	E	IP,RS	L	Ss	I-IV
Palaemonella rotumana (Borradaile, 1898)	-	-	-	2002[92]	E	IP,RS	L	Ss	I-IV
Alpheus audouini (Coutière, 1905)	-	-	-	2002[92]	E	IP,RS	L	Hs	I,II
Alpheus inopinatus Holthuis & Gottlieb, 1958	-	-	-	1969[93]	E	IO,RS	L	Hs,Ss	I,II
Alpheus migrans Lewinsohn & Holthuis, 1978	-	-	-	1994[122]	E	RS	L	Ss	II,III
Alpheus rapacida de Man, 1908	-	-	-	1981[120]	E	IP	L	Ss	I-III
Urocaridella antonbrunii (Bruce, 1967)	-	-	-	2004[170]	Ex	IP	L	Ss	I,II
Ixa monodi Holthuis & Gottlieb, 1956	-	-	-	1956[107]	E	RS	L	Ss	II,III
Leucosia signata Paulson, 1875	-	-	-	1982[99]	E	IP	L	Ss	I,II
Myra subgranulata Kossmann, 1877	-	-	-	1930[136]	E	IP,RS	L	Ss	I-IV
Micippa thalia (Herbst, 1803)	-	-	-	1995[74]	E	IP	L	Hs,Ss	I-III
Callinectes sapidus Rathbun, 1896	-	-	2001[173]	1961[106]	E	WA	S	Ss	I-III
Charybdis hellerii (Milne Edwards, 1867)	-	-	-	1981[120]	E	IP,RS	L	Hs	I,II
Charybdis longicollis Leene, 1938	-	-	-	1961[106]	E	IP,RS	L	Ss	I-III
Portunus pelagicus (Linnaeus, 1758)	-	-	-	1928[100]	E	IP,RS	L	Ss	I-III
Thalamita poissonii (Audouin, 1826)	-	-	-	1961[106]	E	IP,RS	L	Hs,Ss	I-III
Carupa tenuipes Dana, 1851	-	-	-	2004[170]	?	IP,RS	L	Hs	I-III
Pilumnopeus vauquelini (Audouin, 1826)	-	-	-	1981[120]	E	IP,RS	L	Hs	I
Calappa hepatica (Linnaeus, 1758)	-	-	-	2003[30]	E	IP,RS	L	Ss	I-III
Atergatis roseus (Rüppell, 1830)	-	-	-	1990[76]	E	IP,RS	L	Hs	I,II

(continued)

Table 1 (continued)

	BS	SM	AS	LS	Es	O	MI	H	D
Daira perlata (Herbst, 1790)	-	-	-	1995[74]	?	IP	L	Hs,Ss	I
Eucrate crenata de Haan, 1835	-	-	-	1992[75]	E	IP,RS	L	Ss	I-III
Macrophtalmus graeffei Milne Edwards, 1873	-	-	-	1995[74]	?	IP,RS	L	Ss	I-III
Stomatopoda									
Erugosquilla massavensis (Kossmann, 1880)	-	2004[110]	-	1961[106]	E	IP,RS	L	Ss	I-III
MOLLUSCA									
Gastropoda									
Diodora ruppellii (Sowerby, 1834)	-	-	-	1995[72]	E	IP,RS	L	Hs	I
Smaragdia souverbiana (Montrouzier, 1863)	-	-	-	1994[48]	E	IP,RS	?	Ss	I
Trochus erythreus Brocchi, 1821	-	-	-	1995[72]	E	RS	L	Hs	I
Pseudominolia nedyma (Melville, 1897)	-	-	-	1995[72]	E	RS,IO	L	Ss	I,II
Stomatella impertusa (Burrow, 1815)	-	-	-	2000[152]	?	IP,RS	?	Hs	I
Cerithium scabridum Philippi, 1848	-	-	1990[3]	1987[129]	E	RS,IO	L	Hs,Ss	I
Rhinoclavis kochi (Philippi, 1848)	-	-	-	1987[129]	E	IP,RS	?L	Ss	I
Gibborissoa virgata (Philippi, 1849)	-	-	-	2002[1]	E	IP	L	?	?
Finella pupoides Adams, 1860	-	-	-	1990[159]	E	IP	L	Ss	I
Clathrofenella ferruginea (Adams, 1860)	-	-	-	1995[72]	E	IP,RS	L	Ss	I,II
Cerithiopsis pulvis (Issel, 1869)	-	-	-	1990[159]	E	RS	?L	Ss	I
Cerithiopsis tenthrenois (Melvill, 1896)	-	-	-	1990[159]	E	IO	?L	Ss	I
Metaxia bacillum (Issel, 1869)	-	-	-	1995[72]	E	RS	?L	?	?
Rissoina ambigua (Gould, 1849)	-	-	-	2004[135]	?	IP	?	?	II
Rissoina bertholleti Issel, 1869	-	-	-	1991[139]	E	RS,IO	?L	Ss	I
Strombus persicus (Swainson, 1821)	-	-	1991[139]	1983[138]	E	PG	?	Hs,Ss	I,II
Purpuradusta gracilis notata (Gill, 1858)	-	-	-	1983[45]	E	RS,IO	?L	Hs	I
Cycloscala hyalina (Sowerby, 1844)	-	-	-	1999[96]	E	IP,RS	?	?	?
Sticteulima cf. *lentiginosa* (Adams, 1861)	-	-	-	1994[158]	?	IP	?	?	?
Ergalatax obscura Houart, 1996	-	-	-	1995[50]	E	RS	?	Hs	I
Thais lacera (Born, 1778)	-	-	-	1991[139]	E	PG,IO	S	Hs,Ss	I
Rapana venosa (Valenciennes, 1846)	1960[90]	1996[12]	1995[72]	-	E	PO	S	Ss	I
Zafra savignyi (Moazzo, 1939)	-	-	-	1991[139]	E	RS	?L	Ss	I,II
Zafra selasphora (Melvill & Standen, 1901	-	-	-	1993[147]	E	RS,IO	?L	?	?
Lienardia mighelsi Iredale & Tomlin, 1917	-	-	2003[135]	-	?	IP	?	?	III
Murchisonella columna (Hedley, 1907)	-	-	-	1995[46]	?	IP	?	Hs	I
Chrysallida fischeri (Hornung & Mermod, 1925)	-	-	-	1992[134]	E	RS	?L	?	I

(continued)

Table 1 (continued)

	BS	SM	AS	LS	Es	O	MI	H	D
Chrysallida maiae (Hornung & Mermod, 1924)	-	-	-	1990[159]	E	RS	L	Hs,Ss	I
Chrysallida pirinthella (Melvill, 1910)	-	-	-	1992[134]	E	RS	?L	Ss	I
Adelactaeon amoenus (Adams, 1851)	-	-	-	1992[134]	E	IP	?L	Ss	I
Adelacteon fulvus (Adams, A., 1851)	-	-	-	1992[134]	E	IP	?L	Ss	I,II
Styloptygma beatrix Melvill, 1896	-	-	-	1992[134]	E	PG	?L	?	I
Cingulina isseli (Tryon, 1886)	-	-	-	1989[5]	E	RS	?L	?	?
Turbonilla edgarii (Melvill, 1896)	-	-	-	1992[134]	E	IP	?L	?	?
Syrnola cinctella Adams, A., 1860	-	-	-	1998[4]	?	IP,RS	?	?	I
Syrnola fasciata Jickeli, 1882	-	-	-	1989[5]	E	IP	?L	Ss	I
Iolaea neofelixoides (Nomura, 1936)	-	-	-	1998[4]	?	PO	?	Ss	I
Hinemoa cylindrica (de Folin, 1879)	-	-	-	2001[51]	?	IP	?	?	?
Leucotina cf. *eva* Thiele, 1925	-	-	-	2001[96]	?	IP	?	?	?
Acteocina crithodes Melvill & Standen, 1907	-	-	-	2004[135]	?	IP	?	Ss	II
Acteocina mucronata (Philippi, 1849)	-	-	1990[6]	1990[6]	E	RS	?L	Ss	?
Cylichnina girardi (Audouin, 1826)	-	-	1996[49]	1990[159]	E	IP	L	Ss	I
Pyrunculus fourierii (Audouin, 1826)	-	-	-	1989[5]	E	IP,RS	L	Ss	II,III
Bulla ampulla Linnaeus, 1758	-	-	-	2004[171]	E	IP	?L	Ss	II
Haminoea cyanomarginata Heller & Thomson, 1983	-	-	2004[171]	2004[171]	?	RS	?L	Hs	II
Chelidonura fulvipunctata Baba, 1938	-	-	-	1961[154]	E	IP	?L	Ss	I,II
Oxynoe viridis (Pease, 1861)	-	-	-	2004[171]	?	IP	?L	Ss	I
Elysia grandifolia Kelaart, 1858	-	-	-	2004[171]	Q	?IO	?L	Hs	I
Elysia tomentosa Jensen, 1997	-	-	-	2004[171]	?	?IP	?	Ss	I,II
Bursatella leachii Blainville, 1817	-	-	1961[154]	1961[154]	E	CT	?L	Ss	I
Syphonota geographica (Adams & Reeve, 1850)	-	-	-	2004[171]	?	IP	L	Ss	I,II
Plocamopherus ocellatus Rüppell & Leuckart, 1830	-	-	-	2004[171]	E	RS	L	Hs	I
Hypselodoris infucata Rüppell & Leuckart, 1828	-	-	-	2001[56]	E	IP,RS	?L	Hs	I
Melibe viridis Kelaart, 1858	-	-	-	2004[171]	?	IP	?	Ss	I
Flabellina rubrolineata (O'Donoghue, 1929)	-	-	2004[171]	2004[171]	E	IP,RS	?L	Hs	I,II
Siphonaria belcheri Hanley, 1858	-	-	-	2001[13]	E	IP,RS	L	Hs	I
Bivalvia									
Anadara demiri (Piani, 1981)	-	-	1977[68]	-	E	IO	?S	Ss	I,II
Anadara inflata (Reeve, 1846)	-	-	-	2002[60]	?	IO	?S	Ss	?
Anadara inaequivalvis (Bruguière, 1789)	2003[10]	1996[11]	1995[72]	-	E	IP	?S	Ss	I,II
Anadara natalensis (Krauss, 1848)	-	-	-	1991[139]	E	IO,RS	L	Ss	I,II
Brachidontes pharaonis (Fischer, 1870)	-	-	1990[3]	1985[116]	E	IO,RS	L	Hs	I
Septifer forskali Dunker, 1855	-	-	-	2001[13]	?	RS	?	Hs	II

(continued)

Table 1 (continued)

	BS	SM	AS	LS	Es	O	MI	H	D
Crassostrea gigas (Thunberg, 1793)	-	2004[15]	-	2001[57]	E	PO	Aq	Hs	I
Saccostrea cucullata (Born, 1778)	-	-	-	2001[57]	E	IP,RS	?S	Hs	I,II
Dendrostrea frons (Linnaeus, 1758)	-	-	-	2001[59]	E	IP	?	Hs	?
Pinctada radiata (Leach, 1814)	-	-	1990[159]	1985[116]	E	IP,RS	?L	Hs	I
Electroma vexillum (Reeve, 1857)	-	-	-	2005[58]	?	IP,RS	?L	Hs	I
Malvufundus regulus (Forsskål, 1775)	-	-	-	1974[88]	E	IP,RS	L	Hs	I
Spondylus cf. *multisetosus* Reeve, 1856	-	-	-	2001[59]	Q	IP	?	Hs	?
Spondylus spinosus Schreibers, 1793	-	-	-	1999[73]	E	IP,RS	L	Hs	I,II
Chama pacifica Broderip, 1834	-	-	-	2001[59]	E	IP,RS	L	Hs	I,II
Fulvia fragilis (Forrskål, 1775)	-	-	2005[144]	1987[129]	E	IO,RS	?L	Ss	I
Afrocardium richardi (Audouin, 1826)	-	-	-	2000[2]	E	RS	L	Ss	?
Tellina valtonis Hanley, 1844	-	-	-	2001[96]	E	IO,RS	L	Ss	I
Psammotreta praerupta (Salisbury, 1934)	-	-	-	1999[73]	?	WA	?	Ss	IV
Gafrarium pectinatum (Linnaeus, 1758)	-	-	-	1987[129]	E	IP,RS	L	Ss	I
Clementia papyracea (Gray, 1825)	-	-	-	1995[72]	E	IP,RS	L	Ss	III
Paphia textile (Gmelin, 1791)	-	-	-	1991[139]	E	IP,RS	L	Ss	?
Ruditapes philippinarum (Adams & Reeve, 1850)	-	-	2001[14]	-	E	PO	Aq	Ss	I
Antigona lamellaris Schumacher, 1817	-	-	-	1999[73]	?	IP,RS	?	Ss	?
Mya arenaria Linnaeus, 1758	-	1996[11]	-	-	E	WA	?S	Ss	II
Gastrochaena cymbium Spengler, 1783	-	-	-	1991[139]	E	IP,RS	L	Ss	I-III
Laternula anatina (Linnaeus, 1758)	-	-	-	1995[72]	E	IP,RS	L	Ss	I-III
Cephalopoda									
Octopus aegina Gray, 1849	-	-	-	1999[151]	E	IP	?L	Ss	III
Sepioteuthis lessoniana Lesson, 1830	-	-	-	2002[150]	E	IP	L	P	I-III
BRYOZOA									
Rhynchozoon larreyi (Audouin, 1826)	-	-	1979[165]	-	E	IP, RS	L	Ss	I
ECHINODERMATA									
Ophiactis savignyi (Müller & Troschel, 1842)	-	-	1998[61]	-	E	IP,RS	L	Hs	I
Synaptula reciprocans (Forrskål, 1775)	-	-	2001[173]	-	E	IP,RS	L	Hs,Ss	?
PISCES						IP,RS			
Chondrichthyes									
Carcharhinus altimus (Springer, 1950)	-	-	-	2000[31]	Q	TA	G	Ss	I-VI
Himantura uarnak (Forsskål, 1775)	-	-	-	1966[37]	C	IP,RS	L	Ss	I,II
Osteichthyes									
Dussumieria elopsoides Bleeker, 1849	-	-	-	1953[36]	E	IP,RS	L	P	I,II
Etrumeus teres (DeKay, 1848)	-	-	-	1997[32]	E	IP,RS	L	P	I,II
Herklotsichthys punctatus (Rüppell, 1837)	-	-	-	1984[169]	E	RS	L	P	I,II
Enchelycore anatina (Lowe, 1839)	-	-	-	2002[172]	E	TA	G	Hs	I,II

(continued)

Table 1 (continued)

	BS	SM	AS	LS	Es	O	MI	H	D
Saurida undosquamis (Richardson, 1848)	-	-	1973[38]	1966[37]	E	IP,RS	L	Ss	I-III
Parexocoetus mento (Valenciennes, 1846)	-	-	1966[37]	1966[37]	E	IP,RS	L	P	I
Hemiramphus far (Forsskål, 1775)	-	-	1950[126]	1950[126]	E	IP,RS	L	P	I
Hyporhamphus affinis (Günther, 1866)	-	-	-	1954[7]	Q	IP,RS	L	P	I
Fistularia commersonii (Rüppell, 1835)	-	-	2002[43]	2002[42]	E	IP,IO	L	Hs,Ss	I,II
Hippocampus fuscus Rüppell 1838	-	-	-	2004[98]	?	IO,RS	L	Ss	I
Syngnathus rostellatus Nilsson, 1855	-	-	-	2004[98]	Q	BA	G	Hs,Ss	I
Atherinomorus lacunosus (Forster, 1801)	-	-	1969[94]	1950[126]	E	IP,RS	L	P	I
Sargocentron rubrum (Forsskål, 1775)	-	-	1950[126]	1950[126]	E	IP,RS	L	Hs	I-III
Pelates quadrilineatus (Bloch, 1790)	-	-	-	1987[131]	E	IP,RS	L	Ss	I,II
Apogon pharaonis Bellotti, 1874	-	-	-	1987[131]	E	IP,RS	L	Hs,Ss	I,II
Sillago sihama (Forsskål, 1775)	-	-	2004[41]	1994[102]	E	IP,RS	L	Ss	I,II
Alepes djedaba (Forsskål, 1775)	-	-	1969[94]	1957[9]	E	IP,RS	L	P	I-III
Leiognathus klunzingeri (Steindachner, 1898)	-	-	1966[37]	1943[78]	E	RS	L	Ss	I-III
Upeneus moluccensis (Bleeker, 1855)	-	-	1956[127]	1950[126]	E	IP	L	Ss	I-IV
Upeneus pori Ben-Tuvia & Golani, 1989	-	-	-	1950[126]	E	IP,RS	L	Ss	I,II
Pempheris vanicolensis Cuvier, 1831	-	-	1999[130]	1994[102]	E	IP,RS	L	Hs	I,II
Heniochus intermedius Steindachner, 1893	-	-	-	2003[97]	Q	IP,RS	L	Hs,Ss	I
Chelon carinata (Valenciennes, 1836) [=*Liza carinata*]	-	-	-	1956[127]	E	RS,IO	L	P	I
Liza haematocheila (Temminck & Schlegel, 1845) [=*Mugil soiuy* Basilewsky, 1855]	1992[166]	1998[112]	1998[112]	-	E	PO	Aq	P	I
Sphyraena pinguis Doiuchi & Nakabo, 2005 [=*S. chrysotaenia* Klunzinger, 1884]	-	-	1969[94]	1957[9]	E	IP,RS	L	P	I,II
Sphyraena obtusata Cuvier, 1829 [=*S. flavicauda* Rüppell, 1838]	-	-	-	2002[42]	E	IP,RS	L	P	I,II
Pteragogus pelycus Randall, 1981	-	-	-	2000[156]	E	IP,RS	L	Hs,Ss	I,II
Petroscirtes ancylodon Rüppell, 1838	-	-	-	2000[156]	E	IP,RS	L	Hs,Ss	I
Oxyurichthys petersi (Klunzinger, 1871)	-	-	1999[35]	1992[111]	E	RS	L	Ss	I-III
Callionymus filamentosus Valenciennes, 1837	-	-	-	1994[102]	E	IP,RS	L	Ss	I-III
Siganus luridus (Rüppell, 1829)	-	-	1973[38]	1973[38]	E	IP,RS	L	Hs	I,II
Siganus rivulatus Forsskål, 1775	-	-	1950[126]	1950[126]	E	IP,RS	L	Hs	I,II
*Scomberomorus commerso*n Lacepède, 1800	-	-	1997[47]	1987[89]	E	IP,RS	L	P	I,II
Solea senegalensis Kaup, 1858	-	1942[77]	1942[77]	1942[77]	Q	TA	G	Hs	I-III
Cynoglossus sinusarabici (Chabanaud, 1931)	-	-	-	1957[9]	E	RS	L	Hs	I,II

(continued)

Table 1 (continued)

	BS	SM	AS	LS	Es	O	MI	H	D
Stephanolepis diaspros Fraser-Brunner, 1940	-	-	1950[126]	1950[126]	E	IP,RS	L	Hs,Ss	I,II
Lagocephalus sceleratus (Gmelin, 1789)	-	-	2005[8]	-	E	IP,RS	L	Ss	I,II
Lagocephalus spadiceus (Richardson, 1844)	-	-	1966[37]	1950[126]	E	IP,RS	L	Ss	I,II
Lagocephalus suezensis Clark & Gohar, 1953	-	-	2002[42]	1999[16]	E	RS	L	Ss	I,II
Sphoeroides pachygaster (Müller & Troschel, 1848)	-	-	2003[87]	1999[130]	E	TA	G	Hs,Ss	I-V
Torquigener flavimaculosus Hardy & Randall, 1983	-	-	-	2003[40]	E	IP,RS	L	Ss	I,II

coast. Forty-eight alien Crustaceans (94% of the total aliens) belong to Lessepsian migrants. Most of the plants (29 species) were introduced via ships. The other modes of introduction of species were migration through the Gibraltar straits and Aquaculture.

Distribution of alien species on the Turkish coasts

The number of alien species found along the Turkish coasts and their modes of introduction are presented in Figure 1. The Turkish Black Sea coast possessed the lowest number of species (20 species), whereas the Turkish Levantine coast had the highest (202 species). The importance of shipping as a vector of introduction of species gradually diminishes from the Black Sea to the Levantine Sea. Lessepsian migrants exclusively dominate benthic habitats of the Levantine Sea. The Aegean Sea appears to be more influenced by Lessepsian migration than ship transportation.

The majority (70% of the species) of the marine animals introduced by ships in the Aegean Sea were reported from Izmir Bay; *Polydora cornuta*, *Streblospio gynobranchiata*, *Ficopomatus enigmaticus*, *Hydroides dianthus*, *H. elegans*, *Spirorbis marioni*, *Anadara demiri* and *A. inequivalvis*. This is mainly attributed to two facts; 1) Alsancak Harbour, which is one of the most important commercial harbours in Turkey, is located in the polluted part of Izmir Bay, 2) This bay has been relatively well studied and continuously monitored since the 1970's. Species-poor communities such as polluted or physically degraded environments are known to be more vulnerable to invasion than are other communities (ZIBROWIUS, 1992). Izmir Bay has been subjected to various pollution discharges, intense marine transportation and increasing human populations. Ocean-going ships approaching Alsancak Harbour for loading or unloading processes empty their ballast tanks just before entering the harbour and the weakening in the ecosystem due to pollution greatly facilitates the settlement of alien species in the area.

Rate of invasion

The new additions to the inventory of the marine alien species on the Turkish coasts greatly increased after 1980 and the last five years alone a total of 92 new species were recorded (Fig. 2). A decreasing pattern is obvious in the yearly rate of introduction over the past years (Table 2). While one new alien species was introduced every 15.3 weeks over the period 1981-2000 in the Aegean Sea, the time span has decreased to 8.7 between 2001 and 2005 The special interest in aliens by Turkish and foreign scientists in the last decade has increased and thereby, the real diversity of aliens within the groups of phytobenthos, fishes and crustaceans inhabiting the Turkish coasts seems to be well documented. Nowadays, a number of projects regarding the actual status of aliens along the Turkish coasts

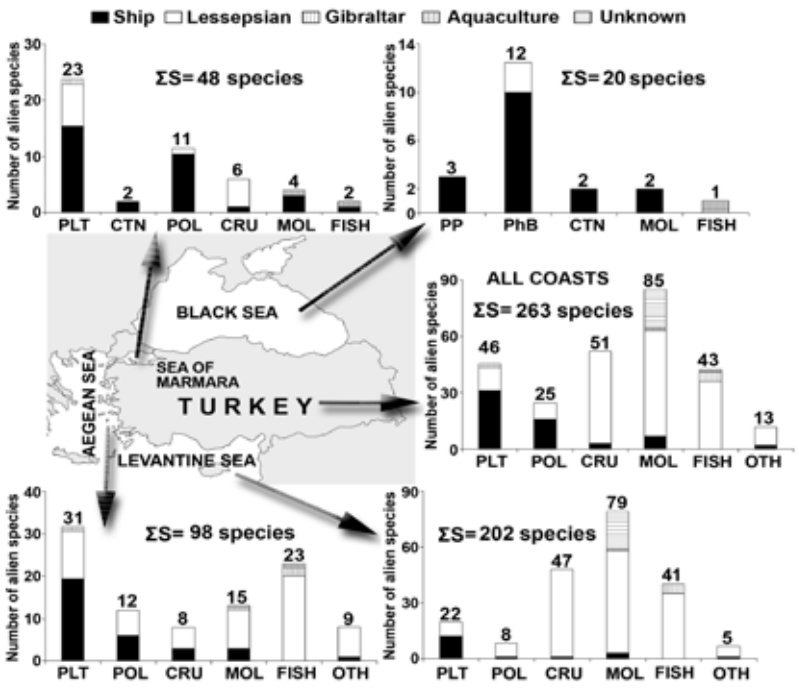

Fig. 1: The number of alien species along the Turkish coasts and their mode of introduction. PLT: All plants, PP: Phytoplankton, PhB: Phytobenthos, CTN: Ctenophora, POL: Polychaeta, CRU: Crustacea, MOL: Mollusca, OTH: Others. ΣS indicates the total number of species reported from the sea.

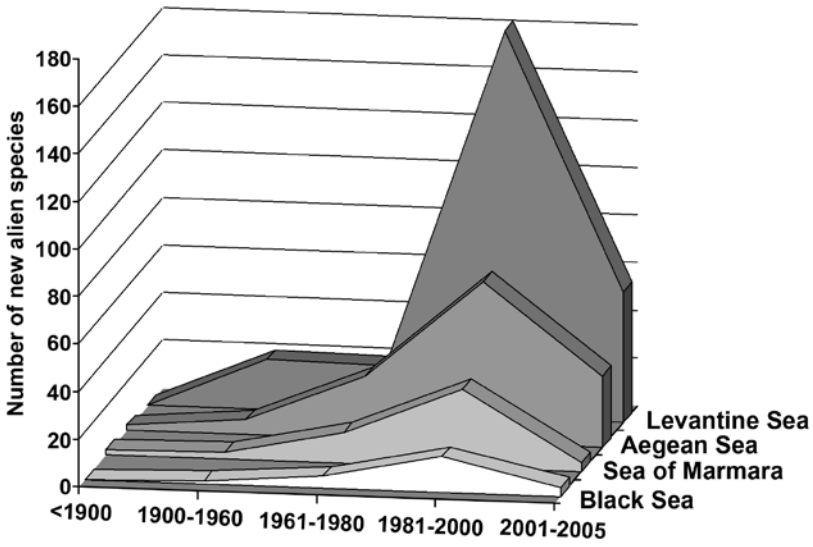

Fig. 2: Rate of introduction of alien species along the Turkish coasts.

Table 2.
Time span (weeks) for alien species introduction along the Turkish coasts.

	1961-1980	1981-2000	2001-2005
	Weeks per 1 alien species		
Black Sea	208	69.3	65
Sea of Marmara	80	31.5	65
Aegean Sea	40	15.3	8.7
Levantine Sea	52	6.4	4.7
Total	16.3	3.7	2.8

and their probable impacts on the native biota are undertaken.

Depth and habitat preferences of alien species

The distribution of alien species by depth and habitat is indicated in Figure 3. The majority of aliens collected from the Turkish coasts were found in shallow waters. A total of 106 species (41% of the total number of aliens) solely occurred at depths ranging from 0 to 10 m, and 180 species (68%) at the depth interval 0-50 m. Species with a wide distributional range in the area are *Leonnates persicus* (10-200 m), *Penaeus semisulcatus* (0-200 m), *Leptochela pugnax* (0-200 m), *Palaemonella rotumana* (0-200 m), *Myra subgranulata* (0-200 m), *Carcharhinus altimus* (0-500 m), *Upeneus moluccensis* (0-200 m) and *Sphoeroides pachygaster* (0-400 m).

Benthic habitats (soft and hard substrata) harboured 76% of the total number of alien species (Figure 3). Thirty-nine species inhabited the pelagic environment. In soft substrata, all major groups, except for algae, are represented by a higher number of species. The majority of hard bottom organisms were reported among algae.

The echinoderm *Ophiactis savignyii* was only reported in canals of the sponge *Sarcotragus muscarum* from the southern part of the Aegean Sea [ÇINAR & ERGEN, 1998 (as *Ophiactis virens* (M. Sars, 1857)); ÇINAR *et al*., 2002). The sweeper, *Pempheris vanicolensis*, prefers cavern habitats (BILECENOĞLU & TASKAVAK, 1999). The shrimp scad, *Alepes djedaba*, is generally associated with the venomous jellyfish *Rhopilema nomadica* (KIDEYS & GÜCÜ, 1995). ØKSNEBJERG *et al*. (1997)

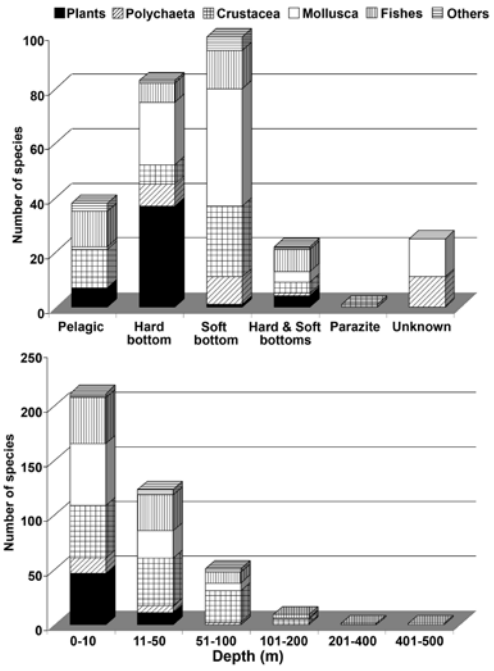

Fig. 3: The habitat (upper graphic) and depth (lower graphic) preferences of alien species along the Turkish coasts.

reported the parasitic cirriped *Heterosaccus dollfusi* on the Lessepsian crab *Charybdis longicollis*. The nudibranch *Flabellina rubrolineata* was found on hydroids (YOKES & RUDMAN, 2004). ALBAYRAK & ÇEVIKER (2001) reported *Septifer forskali* on the bivalve *Spondylus spinosus*. *Electroma vexillum* was encountered in discharge canals of the Iskenderun Iron and Steel Factory, where hot water is discharged into the sea (ÇEVIK *et al*., 2005).

Impacts of alien species

The phytoplankton species, *Alexandrium tamarense*, *Gymnodinium* cf. *mikimotoi* and *Heterosigma* cf. *akashiwo*, which were reported from Izmir Bay and classified as questionable in Table 1, have a potential to cause a toxic and/or harmful bloom along the Turkish coasts (KORAY, 1984; BIZSEL & BIZSEL, 2002).

The green alga *Caulerpa racemosa* invaded soft and hard bottom habitats of the Levantine and Aegean coasts but its impact on the native biota has not yet been documented in the area. However, its occurrence off the Dardanel (salinity: 27 psu) indicates its highly adaptive and invasive character (OKUDAN *et al*., 2002).

The negative effect of *Mnemiopsis leidyi* on the Black Sea ecosystem was summarized by KIDEYS (2002). This zooplanktonic predator reached enormous biomass levels in the summer of 1989, devastating the food chain of the entire Black Sea basin, and subsequently led to a sharp decrease in the anchovy production along the Turkish coast. The other ship-mediated ctenophore, *Beroe ovata*, which largely feeds on ctenophores, appeared in 1997 in the Black Sea and has resulted in the decrease in the population of *M. leidyi*.

The outburst of the population of *Rhopilema nomadica* off the Levantine coast of Turkey was reported to have negative consequences on human health, tourism and fisheries (KIDEYS & GÜCÜ, 1995). Many swimmers were stung and sought medical treatment. The blockage of nets of fishermen by individuals of *R. nomadica* also created major economical losses.

Rapana venosa, which feeds exclusively on bivalves, is responsible for the decrease in stocks of the bivalves *Ostrea edulis* Linné, 1758 and *Mytilus galloprovincialis* (Lamarck, 1819) in the Black Sea (BILECIK, 1990). The fishery of *R. venosa* was intense along the Turkish Black Sea coast, reaching up to 1166 tons in 1986, yielding 3.415.884 US $ (BILECIK, 1990)

Low faunal diversity found on sponge samples collected from the southern Aegean Sea was due to the invasion of the Lessepsian species *Ophiactis savignyi* (ÇINAR *et al*., 2002). The species number and density of other groups within the sponge samples were sharply declined as compared to those collected from the northern sites where this echinoderm was not present. A negative correlation was estimated between number of specimens of the ophiuroid and the total number of specimens of other taxa.

The soft bottom near Alsancak Harbour in Izmir Bay was exclusively dominated by the spionid polychaete *Streblospio gynobranchiata*, which originated from the western Atlantic (ÇINAR *et al*., 2005). Its density reached almost 34 300 ind.m^{-2} in the area and accounted for almost 100% of faunal populations at some stations. The soft bottom benthic community around Alsancak Harbour seems to be restructured by this species.

KOÇAK *et al*. (1999) found dense populations of two alien serpulid species, *Hydroides elegans* and *H. dianthus*, on panels submerged in a polluted marina in Izmir Bay. The species density of *H. elegans* reached up to 98000 ind. m^{-2} and that of *H. dianthus* up to 2 000 ind.m^{-2}. The above authors also reported that an alien serpulid species of eastern Pacific origin, *Spirorbis marioni*, inhabited port environments subjected to relatively less pollution.

The density of *Anadara demiri* was found to be 300 ind.m^{-2} on grey mud and 30 ind.m^{-2} on black mud in Izmir Bay (DEMIR, 1977).

Aliens might bring their own parasites with them. ØKSNEBJERG *et al*. (1997) reported that 90% of the specimens of *Charybdis longicollis* collected between Karatas and Fener Burnu (Levantine coast of Turkey) were infected by the rhizocephalan *Heterosaccus dollfusi*. They also stated that the prevalence of this parasite was estimated at 50-60% in the east of Karatas, with its prevalence gradually declining towards the east into Iskenderun Bay. GALIL & LÜTZEN (1995) found that 55% of the males and 43% of the females of *C. longicollis* were visibly infected by this parasite along the Israeli coast in May 1994.

From a large number of aliens inhabiting the Turkish coasts, only a few possess commercial value, mostly belonging to fishes and crustaceans. Little is known concerning the impact of

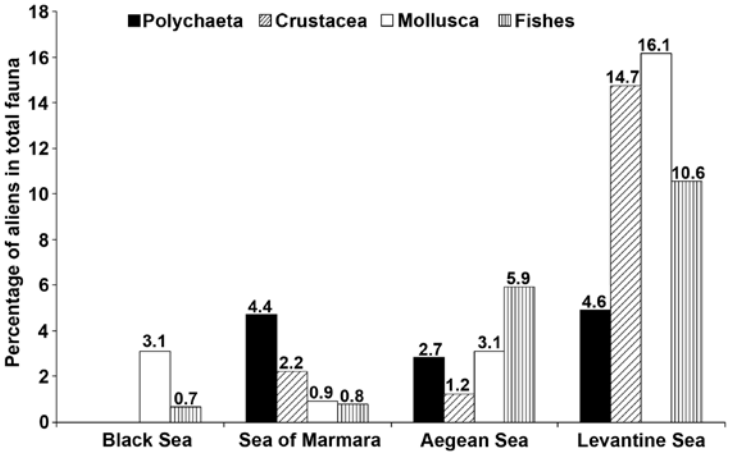

Fig. 4: Percentages of alien species in total fauna along the Turkish coasts.

commercially important alien species on local fisheries, since there is no available catch statistic that distinguishes native and alien species' landings. Due to the great number of species caught during various fisheries activities, governmental statistics tend to present relevant data on a family basis. For example, the "mullids" category includes four species (native *Mullus spp*. and Lessepsian *Upeneus* spp.); a similar situation is valid for sphyraenids (two native species vs. two Lessepsian species). Lessepsian clupeids, especially *Etrumeus teres*, form a remarkable proportion of the pelagic catch along the Levantine coast. The siganids are generally sold together with the native *Sarpa salpa* due to their similar morphologies (BILECENOĞLU & KAYA, 2002). At least seven fish species (*Upeneus moluccensis*, *Saurida undosquamis*, *Scomberomorus commerson*, *E. teres*, *Sphyraena pinguis, Siganus* spp.) are captured in large amounts (mainly by bottom trawls), and consumed throughout the Levantine and southern Aegean Sea coasts. In terms of biomass, *S. undosquamis* is the most prominent species in the bottom trawl catch composition (31.9% of total CPUE in Iskenderun Bay), followed by *U. moluccensis* and *Siganus rivulatus* (GÜCÜ *et al*., 1994).

Some species have relatively smaller catches and thus mostly consumed locally, i.e. *Alepes djedaba*, *Sillago sihama*, *Dussumieria elopsoides*, *Atherinomorus lacunosus*. Among alien crustaceans, the highest annual production belongs to *Callinectes sapidus* (ca. 200 tonnes/year), which is captured especially in lagoons in amounts as much as 2 tonnes/day during summer periods (ÖZCAN *et al*., 2003). *Marsupenaeus japonicus* is one the most valuable shrimp species along the Levantine coast, which is also imported to various cities in Turkey. Since they are not captured in large quantities, other commercial shrimps (*Metapenaeus* spp., *Penaeus semisulcatus*) and brachyurans (*Portunus pelagicus*) are, in general, consumed locally.

Importance of alien species in total fauna

The relative percentages of aliens in total fauna are shown in Figure 4. Mollusca had the highest score in the Black (3.1%) and Levantine (16.1%) Seas, Polychaeta in the Sea of Marmara (4.4%) and fishes in the Aegean Sea (5.9%). The score for Polychaeta in the Sea of Marmara does not reflect its true number as 11 of 12 aliens are questionable. The score seems to be accurate for the better-studied group, fishes, which has more aliens on the southern coasts than the northern coasts due to the influence of Lessepsian migrants. The highest alien percentages for all groups examined were found on the Levantine

coast. This partly shows the impact of Lessepsian migration on the Levantine fauna and partly the lack of detailed works on some groups on the coast. The total number of species given for Mollusca and Polychaeta from the Levantine coast of Turkey is highly underestimated and undoubtedly would increase as further studies are carried out. It is a common assumption that Lessepsian migrants account for at least 10% of the species inventory of the Levantine Sea (POR, 1978). BEN-ELIAHU (1995) estimated that the proportion of migrant polychaetes is almost 9%; for fishes 13% (GOLANI, 1998) and for decapod crustaceans 20% (GALIL, 1986).

Similarity among seas in terms of alien species

The dendrogram and MDS configuration in Figure 5 show that there are two groups in terms of the presence and absence of alien species in the Turkish seas. The Black Sea and the Sea of Marmara constitute one group, in which 16 species (mainly algae) are common. The other group with a similarity of 40% is composed from the Aegean and Levantine Seas, where 63 species (mainly lessepsian fishes) are common. There is a very weak similarity (20%) between the groups, which are placed at different corners of the MDS plot. As pointed out earlier, the southern seas seem to be more affected by Lessepsian migrants than ship-borne species, whereas shipping is the main vector in the transportation of aliens to the northern seas. The difference in the way of introduction seems to be the main reason for similarity or dissimilarity among the seas.

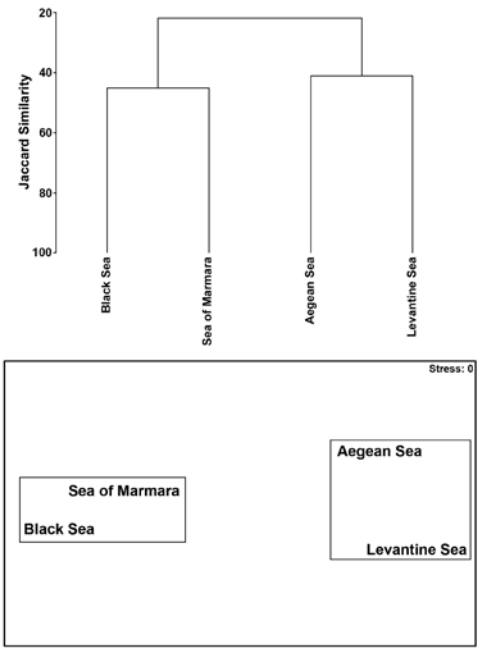

Fig. 5: Dendrogram and MDS plot showing affinities of the seas in terms of alien species they included.

Conclusions

The compiled data show that a total of 263 established or questionable alien species inhabit the coast of Turkey, with the Levantine Sea having the majority of them (202 species). Detecting new aliens depends totally on accurate taxonomic identifications and the knowledge of local biodiversity. This requires the availability of systematic experts on biotal components in the area and a close cooperation among scientists both on local and global scales. The wealth of data accumulated on aliens depicts the importance of monitoring studies on the understanding of ecological and functional roles of aliens in the ecosystems. Finally, results of studies and projects should not be concealed among pages of reports and papers. They should be presented to governmental establishments and politicians to force them to take immediate precautions on the dispersal of aliens, particularly via ballast water discharges.

Addendum

Before the publication of this contribution, a total of 14 new alien species were reported from the Levantine (13 species) and Aegean [1 species (*Platax teira*)] coasts of Turkey (BILECENOĞLU & KAYA, 2006; ÇEVIKER & ALBAYRAK, 2006; ÇINAR *et al*., 2006; ÖZTÜRK & CAN, 2006). These species belong to Hydrozoa (*Macrorhynchia philippina* (Kirchenpauer, 1872), Anthozoa (*Oculina patagonica*

De Angelis, 1908), Polychaeta (*Branchiomma luctuosum* Grube, 1869), Gastropoda (*Amathina tricarinata* (Linnaeus, 1767), *Aplysia dactylomela* Rang, 1828, *Chromodoris quadricolor* (Rüppell & Leuckart 1830)], Bivalvia [*Cardites akabana* (Sturany, 1899) and *Petricola hemprichi* Issel, 1869], Echinodermata [*Synaptula reciprocans* (Forsskål, 1775)], Tunicata [*Phallusia nigra* Savignyi, 1816, *Pyura* (=*Herdmania*) *momus* (Savignyi, 1816) and *Symplegma brakenhielmi* (Michaelsen, 1904)] and Osteichthyes [*Parupeneus forsskali* (Fourmanoir and Guézé, 1976) and *Platax teira* (Forsskål, 1775)]. These findings increased the number of alien species known from the coast of Turkey from 263 to 277, and from 202 to 216 on the Levantine coast of Turkey.

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