D. Golani & B. Appelbaum-Golani (Eds.) 2010
Fish Invasions of the Mediterranean Sea: Change and Renewal, pp. *189-217*.

Alien marine fishes of Turkey – an updated review

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INTRODUCTION

Modification of the Mediterranean ecosystem by non-indigenous species has become much more evident in the last decades. The picture drawn by a growing number of specific research have revealed the presence of hundreds of alien species – whether established or not, in this oligotrophic sea. The word "hundreds" should be perceived symbolical, attributing to the still unclear diversity of the alien biota, i.e. Zenetos et al. listed 745 alien species during 2005, which has increased to 903 within a few years (Zenetos et al., 2008). It is obvious that there will never be an exact inventory, since the influx of non-indigenous organisms is continuous with an increasing trend, seemingly to slow down only if the relevant niche and habitats becomes saturated.

The eastern basin of the Mediterranean Sea is much more prone to invasions than the western basin and Turkey is among the most influenced countries for a variety of reasons. Concisely, the combination of two main factors make Turkey more susceptible to the establishment of alien organisms – proximity to the Suez Canal and dense maritime traffic occurring through the Dardanelles and Bosphorus Straits (Cinar et al., 2005). Despite the increasing effort in alien species documentation, bioecological studies are still very scarce in Turkey, thus delaying potential governmental precautions that need to be taken.

Fishes are probably the most studied taxa among all alien marine organisms, mainly due to their contribution to local fishery activities. The presence of alien fish in the Mediterranean Sea was mentioned only a few decades after the opening of the Suez Canal (Por, 1978), but it was not until the 1940's that documentation studies at the Anatolian coasts began. Erazi (1943), who recorded *Leiognathus klunzingeri* from Iskenderun Bay, is considered to be the pioneering study, followed by Kosswig (1950, 1956) and Akyüz (1957). The 1960's represent the "period of realization" of the commercial alien species (for example, *Upeneus moluccensis* and *Saurida undosquamis*) at bottom trawling grounds along the northeast Levant (Aasen and Akyüz, 1956; Ben-Tuvia, 1966). No papers on

non-native fishes were published during the 1970's by Turkish scientists. The first efforts to determine biological characters of some abundant aliens were conducted during the 1980's and 1990's, including data on the main components of the local trawl fishery (see Bingel, 1981; Anonymous, 1983; Bingel, 1987; Gücü et al., 1994).

Today, we have a more or less complete picture of the non-native fishes inhabiting Turkey, mostly based on inventory studies compiled by Bilecenoglu et al. (2002) and Cinar et al. (2005). In this chapter, an updated review is presented, together with available biological data (i.e. age, growth, reproduction etc.) published until now, which may be useful in forming a basis for further studies and identifying the gaps yet to be filled.

INVENTORY OF ALIEN FISH

The data presented herein was compiled from a variety of sources, including gray literature (i.e. theses, reports etc.) and previously unpublished observations of the author. However, the backbone of the review is based on Cinar et al. (2005), updated by recent information and taxonomical revisions. Emphasis was placed on the current distribution ranges of alien fishes at Turkish coasts, which may help to improve the maps of Golani et al. (2002). Moreover, available data on the population dynamics parameters of studied species are included.

As of April 2009, there were a total of 49 valid alien fishes reported from Turkey, corresponding to one new species added to the local ichthyofauna every 0.75 years. This time span has decreased to 2.4 species per year since 2000 to date (Fig. 1), a general trend observed also throughout the Mediterranean Sea.

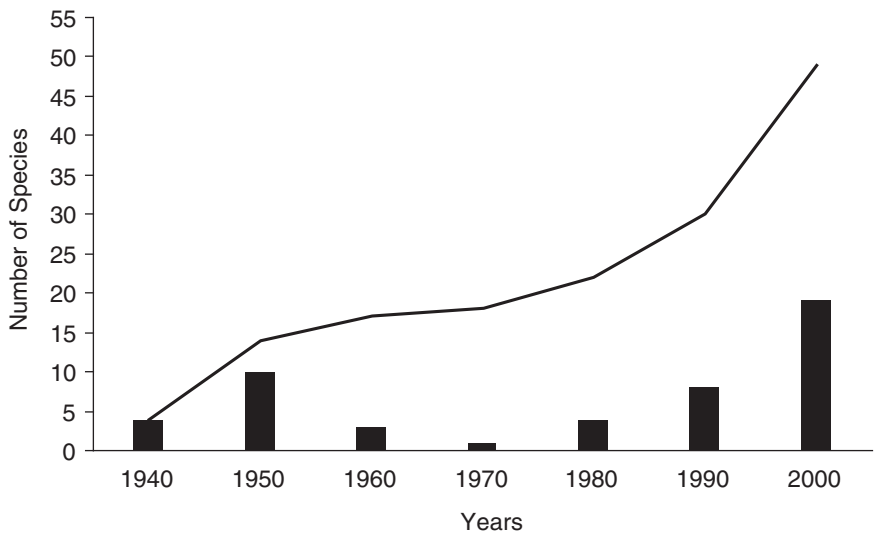

Fig. 1. Rate of introduction of alien fishes along the Turkish coast. Black bars indicate the number of recorded species for the given period and the line represents the cumulative number of species.

When the actual distribution ranges of the fishes are examined, a clear decrease in number of species can be seen from Iskenderun Bay towards the west (Fig. 2). The highest alien fish diversity (41 species) in the northeast Levant is not surprising due to its closeness to the Suez Canal. The northwest Levant region including Antalya city coasts and Fethiye Bay, has a similar alien fauna, which drops to 28 and 9 species in the southern and northern Aegean Seas, respectively. The only alien species inhabiting the Black Sea is Pilengas mullet (*Liza haematocheilus*), which is also in the Sea of Marmara together with the recently recorded pufferfish, *Lagocephalus spadiceus* (Tuncer et al., 2008).

The species accounts are given below, under three subheadings – casual, established and questionable aliens. A casual species is identified as having been recorded no more than twice from Turkey, while fishes recorded three or more times are considered as established.

Casual Aliens

Carcharhinidae

Carcharhinus altimus (Springer, 1950): The Bignose shark is known by two records in the Levantine basin. After its first report from the Levant Sea (Golani, 1996), a 64.3 cm total length specimen was captured from a depth of 20 m in Iskenderun Bay (Basusta and Erdem, 2000). Identification of *C. altimus* is often confused with other sharks, so a wider distribution range can be expected in the Mediterranean Sea (Golani et al., 2006).

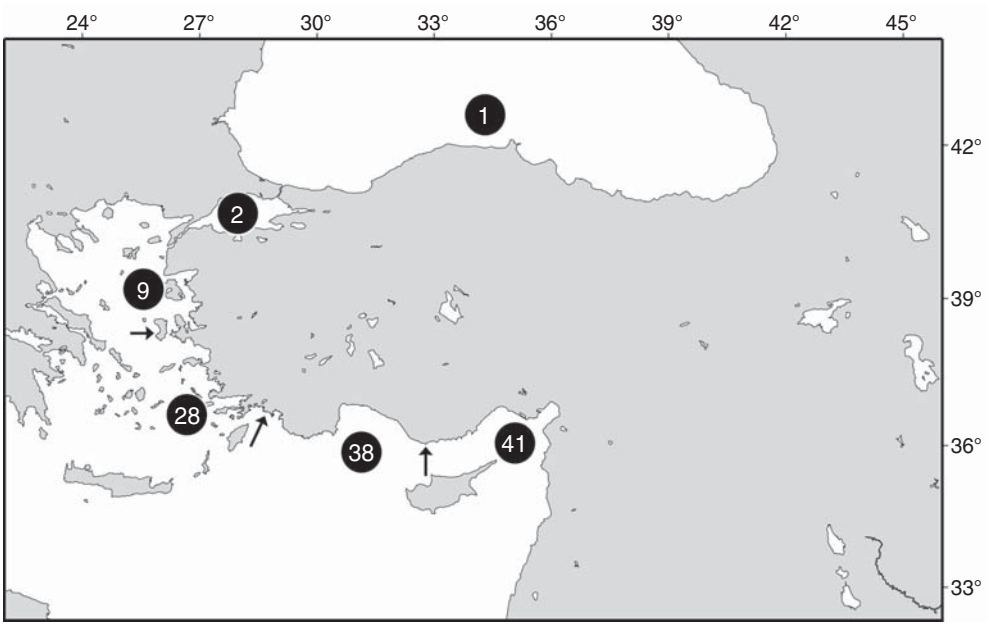

Fig. 2. Number of alien fish species at Turkish coasts.

Dasyatidae
Himantura uarnak (Forsskål, 1775): A prevalent species with a stable population in the southeastern Levant (Golani et al., 2002), but apparently very rare in Turkey, since only a few specimen-based records are available. Ben-Tuvia (1966) mentioned a large *H. uarnak* with 120 cm disc length, captured by bottom trawlers near Mersin. On September 1996, a small sized individual (ca. 40 cm disc width) was observed at a depth of 18 m during a scuba dive off Tasucu coasts, Mersin (M. Bilecenoglu, pers. obs.). One male specimen with a 45.9 cm disc width was captured from Iskenderun Bay on May 1997 (Basusta et al., 1998), which represents the last valid observation of the species along Turkish coasts. Current distribution of the species along the eastern Levant coasts of Turkey is restricted to a small area between Iskenderun Bay and Tasucu – Mersin.

Chirocentridae
Chirocentrus dorab (Forsskål, 1775): During ichthyoplankton samplings carried out at the northeast Levant on May 1999, yolk-sac larvae (6.35 mm in length) of the Dorab Wolf herring were collected from a depth of 100 m, but this sample remained unexamined until now (Yesim Ak Orek, pers. comm.). Four eggs and four larvae of *C. dorab* were again collected from Iskenderun Bay and Mersin (off Erdemli and Tasucu) during 2007, representing a first record of the species from the Mediterranean Sea (Ak Orek, 2008). Status and mode of introduction of *C. dorab* is not clear at the moment, however, considering its first observation almost a decade ago, we may assume that the species is relatively rare. Further samplings of adult specimens will doubtless provide more data.

Carangidae
Trachurus indicus Nekrasov, 1966: Two specimens of the Arabian scad were captured from Iskenderun Bay during October 2004 (Dalyan and Eryilmaz, 2009), which have likely entered to the Mediterranean via the Suez Canal. It was probably an overlooked species in previous studies, due to clear morphological similarities with native *Trachurus* spp. Although Smith-Vaniz (1984) mentioned that no occurrence records of *T.indicus* are available at waters colder than 20°C, there are several cases of alien fish successfully adapted to significantly different environmental conditions of the Mediterranean Sea. We should currently assume the species as rare, until additional information is provided from Turkish coasts and rest of the Levantine basin.

Lethrinidae
Monotaxis grandoculis (Forsskål, 1775): A single sub-adult individual was observed during a scuba dive at Antalya Bay (Bilecenoglu, 2007) and no further information exists. Its origin is not clear at the moment, but the possibility of a ship-mediated introduction should not be rejected, in addition to a possible dispersal through the Suez Canal.

Chaetodontidae
Heniochus intermedius Steindachner, 1893: Two specimens of the Red Sea bannerfish were observed in Antalya Bay, one of which was captured and recorded as a new alien in the Mediterranean Sea (Gökoglu et al., 2003). No further observations are available for this unmistakable species since then.

Mullidae
Parupeneus forsskali (Fourmanoir and Guézé, 1976): The first observation of *P. forsskali* was made during 2000 at Mersin coasts, which was later photographed at the same locality (Cinar et al., 2006). Despite extensive bottom trawlings made along the area, no specimens could be captured until now. The species is likely to exist also in Malta, where Sciberras and Schembri (2007) concluded that a specimen obtained in Gozo during 1979 was described well enough to be identified as *P. forsskali*.

Champsodontidae
Champsodon nudivittis (Ogilby, 1895): One specimen (11.4 cm TL) of the Indo West Pacific originated nakedband gaper was recently captured from Iskenderun Bay, at a depth of 50 m (Cicek and Bilecenoglu, 2009). The species is still unrecorded from the Red Sea and the northwest Indian Ocean, which indicates a probable ship-mediated introduction. However, knowledge on the Red Sea gapers is far from being complete, so the possibility that *C.nudivittis* is an overlooked species in the area should not be neglected.

Blenniidae
Petroscirtes ancylodon Rüppell, 1835: This species has long been considered as a rare alien of the eastern Mediterranean, since only two records were available from Israel and Turkey, respectively (Taskavak et al., 2000). Recent findings from Gokova Bay (Okus et al., 2006) indicate a range expansion of the species through the Anatolian coasts to southern Aegean Sea, as far as Rhodes (Corsini et al., 2005).

Ephippidae
Platax teira (Forsskål, 1775): One specimen with 38.9 cm standard length was captured by a speargun from Bodrum (southern Aegean Sea), which represents the single record of the species throughout the Mediterranean Sea (Bilecenoglu and Kaya, 2006). Since many *Platax* species (especially juveniles) are commercially traded worldwide by aquarists, a release from an aquarium is suspected.

Established Aliens

Muraenidae

Enchelycore anatina (Lowe, 1838) (Fig. 3): The occurrence of the Fangtooth moray in Turkey was first mentioned by Yokes et al. (2002), based on specimens observed at Antalya Bay. It was later recorded at various localities along the Datca Peninsula (southern Aegean Sea) (Okus et al., 2004) and Mersin coasts (Can and Bilecenoglu, 2005). A popular magazine article by Altan (1998) has recently been available to the author, where a specimen of *E. anatina* was photographed from Sarigerme (Fethiye Bay). Therefore, it seems highly probable that the Fangtooth moray is an overlooked species in previous studies. Although Golani et al. (2002) regarded the species as very rare in the Mediterranean Sea, underwater observations from Turkey indicate widespread and locally abundant populations.

Clupeidae

Dussumieria elopsoides Bleeker, 1849: Reported first by Ben-Tuvia (1953, as *D. productissima*) from Iskenderun Bay and Mersin coasts, which was followed by several successive records along the Levantine coasts of Turkey. Previous identifications of the species as *D. acuta* are erroneous (Whitehead, 1985). Although mentioned as occurring in the Aegean Sea (Geldiay, 1969), it was not accepted as a valid occurrence record (Bilecenoglu et al., 2002). Distribution of the species covers the entire coastline from Iskenderun Bay to Fethiye Bay, whose abundance is clearly higher at the northeastern Levant and reducing westwards.

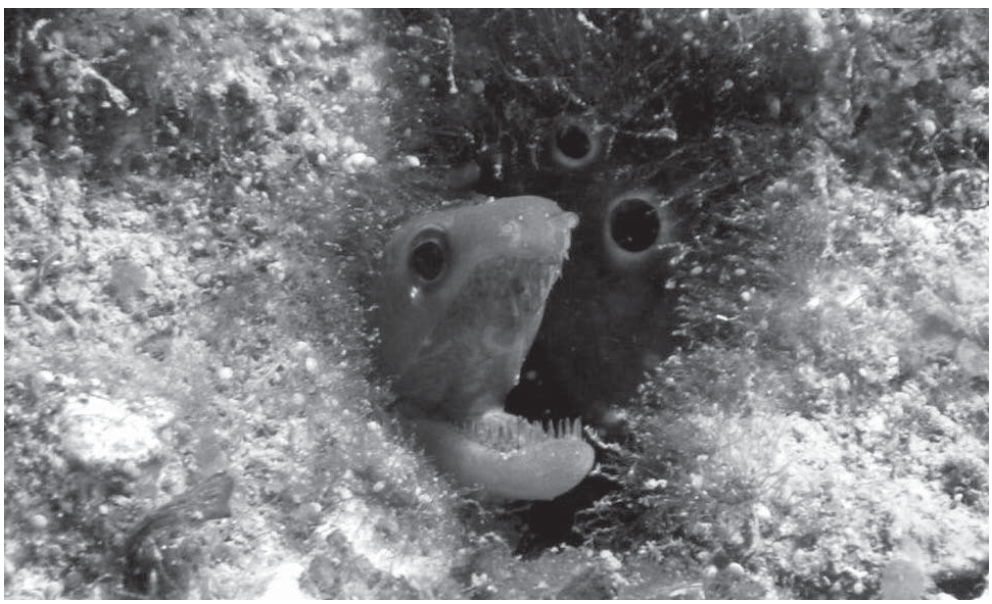

Fig. 3. Fangtooth moray from Kalkan, Antalya (Photograph: Tahsin Ceylan).

There are no existing specific studies on the contribution of *D. elopsoides* to Turkish regional fishery activities, but all those captured are marketed mixed with native clupeoids. According to the results of an experimental fishery survey, specimens with fork lengths and weights ranging 9.0 to 16.5 cm and 5 to 45 g, respectively, appear in the catches along the Mersin coast (Anonymous, 1968). Length-weight relationship of the species was given by Taskavak and Bilecenoglu (2001).

Etrumeus teres (Dekay, 1842): The Round herring first occurred along the Turkish coast possibly during the early 1990's, based on interviews made by the local fishermen (M. Bilecenoglu, unpublished data). Worldwide distribution map of the species given by Whitehead (1985) included Mediterranean coasts of Turkey, but this information seems to be erroneous. A valid record of *E. teres* was given during 1997 from Iskenderun Bay (Basusta et al., 1997), where it was already abundant in the local commercial fish catches. The species is currently very common along the northern Levantine coast, which expanded its distribution to Datca Peninsula of southern Aegean Sea coasts (Okus et al., 2004). A single specimen was recently observed in a purse seine catch at Kusadasi Bay, which may be a sign of step-by-step expansion towards northern parts of the Aegean Sea.

Unlike other alien clupeids, the Round herring is generally marketed separately, under the commonly used local name "Akdeniz hamsisi – Mediterranean anchovy". Its proportion within the total clupeid catch of purse seiners is unknown, but Cicek (2006) mentioned that *E. teres* is also captured by bottom trawlers in small quantities, representing only 0.2% of the total alien fish biomass. Length-weight relationship of the species was given in two studies (Taskavak and Bilecenoglu, 2001; Yilmaz and Hossucu, 2003). The single study on the growth of Round herring indicated a short life span (3 years) based on otolith readings (Yilmaz and Hossucu, 2003), however, the von Bertalanffy growth parameters estimated seems to be erroneous (i.e. L_{∞}= 33.8 cm, k= 0.20 $years^{-1}$ and t_0= -1.63 years for pooled samples) – such a low "k" value is unexpected for a fast growing species, which maybe due to biased sampling strategy.

Herklotsichthys punctatus (Rüppell, 1837): No detailed information exists concerning the species, except for a few papers dealing with its distribution (Bilecenoglu et al., 2002). It may be regarded as prevalent in Iskenderun Bay, whose abundance peaks during summer months (Baki Yokes, pers. comm). The westernmost occurrence of *H.punctatus* along the Turkish Mediterranean coasts is Antalya Bay, where the abundance of the species is distinctly very rare.

Synodontidae

Saurida undosquamis (Richardson, 1848): The Brushtooth lizardfish was rather an uncommon species in the Mediterranean Sea until 1955, which then started to appear in large quantities in bottom trawl catches. It was already abundant by 1956 at Mersin coasts and Iskenderun Bay, during its first record from Turkey (Ben-Tuvia, 1966). Current distribution of *S. undosquamis* covers the entire Levantine coast of Turkey and the southern Aegean Sea, where its abundance clearly decreases westwards of Antalya Bay.

Due to its commercial importance and high abundance, the Brushtooth lizardfish was subjected to several biological studies. The value of exponent "b" of the length-weight relationship was reported to range between 2.879 and 3.240 (Bingel, 1981; Türeli and Erdem, 1997; Cicek, 2006; Cicek et al., 2006; Sangün et al., 2007; Akyol et al., 2007). Maximum age was determined as 7 years from otolith readings (Ismen, 2002), and as 6 years from results of length frequency analysis (Gokce et al., 2007). Growth parameters estimated until now are not in accordance, probably due to methods used or the sampling strategy (Table 1); however, reported life spans should indicate a relatively fast growth. The available catch per unit effort (CPUE) data reveals a distinct decrease in the population of the species, i.e. CPUE was ca. 16 kg/hr during 1984 and ca. 4 kg/hr during the 2002-2003 fishing season (Cicek, 2006), which clearly indicates overfishing throughout the area. Stomach content analyses based on percentage numerical abundance show that *S. undosquamis* primarily feeds on teleosts (40.1% Mullidae, 13.5% Sparidae, 12.4% *Leiognathus klunzingeri* and 7.4% *S. undosquamis*) and benthic invertebrates to a lesser extent (such as cephalopods and penaeid shrimps) (Bingel and Avsar, 1988). Piscivorous feeding habits of the species was also noted by Gücü (1995), who reported that the diet consists mainly of *Sardinella aurita* and *Engraulis encrasicholus* (39.6%), *Spicara flexuosa* (16.4%), *Mullus barbatus* (15.6%) and other teleosts in smaller quantities, using percentage weight of prey items. According to the reproductive biology studies, *S.undosquamis* may spawn throughout the year, with two distinct peaks in gonadosomatic index values (April-July and September-November) (Bingel, 1981; Ismen, 2003). Length at first sexual maturity was given as 12.5 cm by Türeli and Erdem (1997) and 16.0 – 16.5 cm by Ismen (2003).

Bregmacerotidae

Bregmaceros atlanticus Goode and Bean, 1886: The status of the Antenna codlet in the Mediterranean Sea has long been a matter of dispute, due to its previous doubtful record from the Straits of Sicily (see Goren and Galil, 2006). In this respect, the recent reports of *B. atlanticus* from Antalya Bay (Yilmaz et al., 2004) and Kusadasi Bay (Filiz et al., 2007) deserves special interest, since the sudden occurrence of the species in the eastern Mediterranean raises a question mark on its origin. Such a distinctive species is hardly

Table 1. A review of von Bertalanffy growth parameters of *Saurida undosquamis* from Turkey.

L_∞ (cm)	k (year^{-1})	t_0 (year)	n	Locality	Reference
46.70	0.133	- 0.160	-	Göksu Delta	Bingel (1981)
45.60	0.185	- 0.007	-	Tirtar	Bingel (1981)
42.80	0.420	-	-	NE Levant	Gücü (1995)
22.43	0.597	- 1.365	333	Iskenderun Bay	Türeli and Erdem (1997)
42.00	0.178	- 1.229	602	Iskenderun Bay	Ismen (2002)
38.05	0.124	- 1.680	275	Iskenderun Bay	Cicek (2006)
42.00	0.510	- 0.290	4711	Iskenderun Bay	Gokce et al. (2007)

to be overlooked in previous studies, thus Goren and Galil (2006) suspected of a ship-mediated introduction of *B. atlanticus*. The Antenna codlet is currently very common at Iskenderun Bay and is also in the southern Aegean Sea coasts. It is possible to observe the species in large schools during night dives, even in very shallow waters. The genus *Bregmaceros* urgently requires a revision, so a change in taxonomy and distribution of some species can be expected.

Atherinidae

Atherinomorus lacunosus (Forster, 1801): Little data is available concerning this species, expect for those on its distribution (Bilecenoglu et al., 2002). It is widespread throughout the Levantine coast of Turkey and locally abundant populations can be observed at the southern Aegean. The species have a minor commercial value, which is sometimes marketed locally.

Hemiramphidae

Hemiramphus far (Forsskål, 1775): The Blackbarred halfbeak is among the first alien fishes reported from Turkey. It may be regarded as a prevalent species along all the entire northern Levantine coasts as far as the southern Aegean Sea. Aasen and Akyüz (1956) reported that *H. far* was one of the most common species captured by beach seines in Iskenderun Bay, especially at depths shallower than 10 m. Beach seines are currently forbidden for use in Turkey but large sized individuals (i.e. > 30 cm total length) caught by fishing rods are marketed fresh in some fishery ports.

Exocoetidae

Parexocoetus mento (Valenciennes, 1846): Information on this species is very limited, similar to other flying fishes of the Mediterranean. It sometimes forms very large schools especially in Iskenderun Bay (possibly with a thousand individuals or more), observed leaping out of the water. Two specimens captured from the northern Cilician basin had total lengths of 12.8 and 13.5 cm, slightly over the maximum length (12 cm) mentioned by Golani et al. (2002). The distribution of *P.mento* extends as far as Kusadasi Bay in the southern Aegean Sea.

Holocentridae

Sargocentron rubrum (Forsskål, 1775): A common species reported first by Kosswig (1950) from Iskenderun Bay. Typically inhabits caves and crevices, generally at depths down to 40 m (Golani et al., 2002), but scuba observations at greater depths (50 – 60 m) were also made at several localities (M. Bilecenoglu, pers. obs.). It is currently distributed along the northern Levantine coasts and the southern Aegean Sea. Although the species is not commercially fished, it sometimes appears as a bycatch in gill-net fisheries and may be marketed fresh in local ports. There are no detailed data on its bioecology or fisheries, except for its length-weight relationship given by Taskavak and Bilecenoglu (2001).

Fistulariidae

Fistularia commersonii Rüppell, 1838 (Fig. 4): The Bluespotted cornetfish is among the most rapidly spreading aliens in the Mediterranean Sea. Following its first record in 2000 from the Israeli coast, specimens were subsequently collected from Antalya and Gökova Bays (Bilecenoglu et al., 2002). Underwater observations reveal that the species can occupy a variety of habitats, including seagrass beds, rocky substrates and even sandy bottoms, generally in small schools of up to 20 individuals. It is common along the Levantine and southern Aegean coasts of Turkey while its abundance distinctly decreases towards the northern Aegean Sea. *Fistularia commersonii* is caught as a bycatch in artisanal fisheries and marketed fresh in some local ports.

Syngnathidae

Hippocampus fuscus Rüppell, 1838: The Sea pony was known by a single specimen reported from Antalya Bay (Gokoglu et al., 2004) but recent findings from the same locality indicate that *H. fuscus* is an established alien in Turkey (Zenetos et al., 2008). There is currently no sign of a westwards range expansion of the species.

Terapontidae

Pelates quadrilineatus (Bloch, 1790): All records of the Fourlined terapon are confined to the northeastern Levant (from Iskenderun Bay to Mersin coasts) (Bilecenoglu et al., 2002). Field observations indicate that *P.quadrilineatus* is much more common in the vicinity of estuaries, in agreement with the habitat description of Golani et al. (2002) for

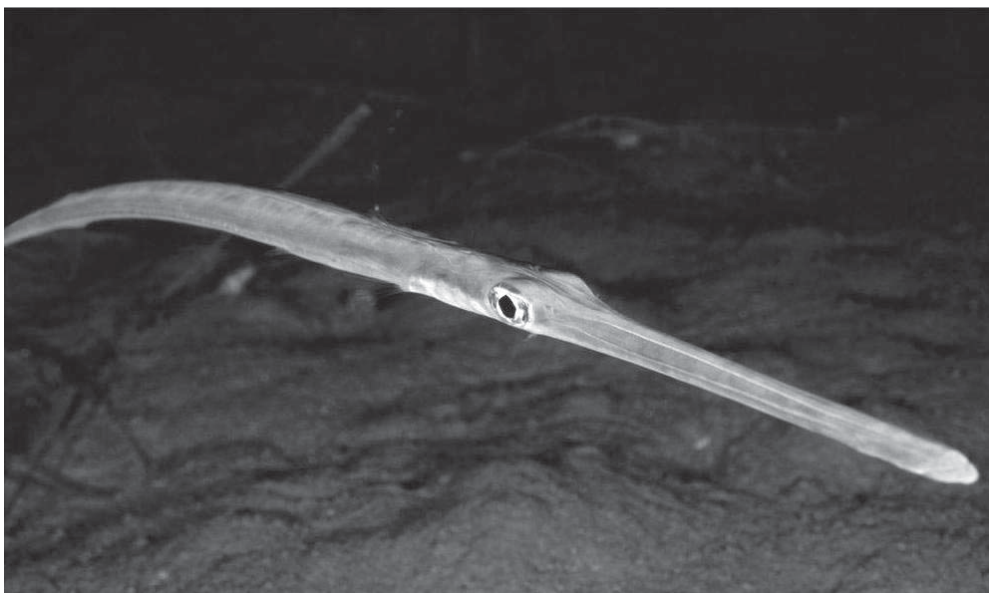

Fig. 4. A Bluespotted cornetfish individual over sandy substrate (Photograph: Tahsin Ceylan)

the species. Bottom trawl studies conducted between 1983 and 1989 indicate a prevalent population in Iskenderun Bay (CPUE ranges from 21.3 to 1091.8 g/h) and a relatively rare population along Mersin coasts (maximum CPUE was 3.7 g/h) (Gücü et al., 1994). The species is not of interest to local fisheries due to its small size.

Apogonidae

Apogon pharaonis Bellotti, 1874: The species has long been known only from the Levantine coasts of Turkey since its first record by Mater and Kaya (1987). Recently it has penetrated to Datca peninsula in the southern Aegean Sea (Okus et al., 2004). It is commonly captured by bottom trawlers, especially in Iskenderun Bay, but always discarded.

Apogon queketti Gilchrist, 1903: This is the second alien apogonid recorded from Turkey by Eryilmaz and Dalyan (2006) who collected two specimens (one with ripe gonads) at depths of 55 – 60 m from Iskenderun Bay. Its recent record from the Israeli coasts indicates that the Spotfin cardinal has successfully established breeding populations in the eastern Mediterranean Sea (Goren et al., 2008). A wider distribution range can be expected for *A. queketti*, which will be examined in further studies.

Apogon smithi (Kotthaus, 1970): Seven specimens with total lengths ranging 96 to 110 mm were collected off Iskenderun Bay (Goren et al., 2008), only one year after its first record in the Mediterranean Sea (Golani et al., 2008). The sudden introduction of *A. smithi* is likely to be followed by a further westward range expansion.

Sillaginidae

Sillago sihama (Forsskål, 1775): A prevalent species at Iskenderun Bay and Mersin coasts, known since 1983 (Gücü et al., 1994). Only a few specimens were collected from Antalya Bay and an exceptional individual from Datca peninsula (southern Aegean Sea) (Bilecenoglu, 2004). Although it was stated to be very common at the eastern Mediterranean Sea (Golani et al., 2002), *S. sihama* forms only a minor proportion of the local commercial fishery catch with a maximum CPUE of 131.2 g/h (Gücü et al., 1994). It is sometimes marketed fresh in local fishing ports.

Carangidae

Alepes djedaba (Forsskål, 1775): The Shrimp scad was first recorded from Iskenderun Bay (as *Caranx kalla*) by Akyüz (1957). It later reached the Aegean Sea coasts (Geldiay, 1969). Local fishermen capture *A. djedaba* sometimes in high quantities (depending on the season), but it is not generally regarded as a very common species, contrary to other parts of the eastern Mediterranean. Except for its length-weight relationship (Taskavak and Bilecenoglu, 2001), no further biological data exists from Turkish coasts. Some recent observations revealed that *A. djedaba* can also enter estuaries and lagoons; a single specimen was caught in brackish water during 2006 (M.Bilecenoglu, pers. obs.).

Leiognathidae

Equulites klunzingeri (Steindachner, 1898): The Silverbelly is the first Red Sea immigrant fish species ever reported from the Anatolian coast, under the name of *Leiognathus mediterraneus* by Erazi (1943). It is probable that the Silverbelly reached Turkish coasts much earlier, with reference to previous records from Rhodes (see Golani et al., 2002). Current distribution of the species extends as far as the southern Aegean Sea; its abundance clearly decreases northwest of Fethiye Bay. It is a non-commercial fish due to its small size, forming a significant portion of the discard of the eastern Mediterranean trawl fisheries.

Golani et al. (2002) stated that the taxonomy of the genus *Leiognathus* is unsettled, requiring revision. A phylogeny was recently generated for Leiognathidae, using several characters derived from seven mitochondrial genes. Although a tissue sample was lacking for *L. mediterraneus*, Sparks et al. (2005) tentatively placed the species in the newly described genus *Photoplagios*, based on external morphology and light organ comparisons. However, Kimura et al. (2008) proposed *Equulites* Fowler, 1904 as a senior synonym of *Photoplagios* Sparks, Dunlap and Smith 2005 (in accordance with the principle of priority), since the type species (*Photoplagios elongatus*) share diagnostic characters of the former genus.

Biological information on *E. klunzingeri* from the Turkish coast is limited to a few studies. CPUE values along the Iskenderun Bay and Mersin coastlines ranged from 465 to 12861 g/h, depending on the locality and season (Gücü et al., 1994). Ageing studies indicate that the species is moderately long lived, with a maximum age of 6 for both sexes (Ozütok and Avsar, 2004). Growth parameters were estimated from samples obtained in two different localities in Iskenderun Bay (Table 2). The silverbelly has a short spawning season (from July to September); length at first maturity is 5.5 and 5.8 cm for females and males, respectively, corresponding to an age of 2 – 3 years (Ozutok and Avsar, 2003). Two spawning periods (April – May and August – September) were mentioned by Bingel (1987), which requires confirmation. According to length-weight relationships calculated, the exponent "b" ranges from 2.93 to 3.27 (Bingel, 1987; Taskavak and Bilecenoglu, 2001; Ozutok and Avsar, 2004; Cicek et al., 2006; Sangün et al., 2007).

Nemipteridae

Nemipterus randalli Russell, 1986: After first being recorded in the Mediterranean Sea by Golani and Sonin (2006), *N. randalli* rapidly spread westwards, forming abundant populations in Lebanon (Lelli et al., 2008) and Turkey (Bilecenoglu and Russell, 2008). It is potentially a commercial species, extending as far as Antalya Bay (Gokoglu et al., 2008), but no individuals have yet penetrated the southern Aegean Sea.

Table 2. A review of von Bertalanffy growth parameters of *Equulites klunzingeri* from Turkey.

L_∞ (cm)	k (year^{-1})	t_0 (year)	n	Locality	Reference
10.28	0.290	- 0.420	440	Yumurtalik	Ozutok and Avsar (2004)
11.51	0.262	- 0.841	724	Karatas	Ozaydin and Leblebici (2008)

Mullidae

Upeneus moluccensis (Bleeker, 1855): The Goldband goatfish is among the most successful colonizers in the Mediterranean Sea, forming a remarkable portion of the commercial trawl catches for decades. Only a few years after its first record from Iskenderun Bay (Kosswig, 1950), *U. moluccensis* became a main catch of bottom trawlers (Aasen and Akyüz, 1956). There are distinctive fluctuations in the abundance of the species during the last two decades, which may be related to overfishing. A recent study pointed out that only 3% of the total alien fish biomass was formed by *U. moluccensis* (Cicek, 2006). The species may be regarded as a common alien along the northeast Levant and a rare fish at the southern Aegean Sea. Observations from the central Aegean are limited to a few individuals captured by bottom trawlers, not indicating a well established population in the area.

The "b" values of the length-weight relationship ranged between 2.86 and 3.56 (Anonymous, 1983; Kaya et al., 1999; Ismen, 2005; Sangün et al., 2007). Age estimates from Antalya Bay resulted with a maximum age of 4 (mean fork length = 16.2 cm) (Anonymous, 1983), while Kaya et al. (1999) determined 6 years (mean fork length = 17.5 cm). In a recent study, Ismen (2005) reported a specimen with 7 years of age at a total length of 20.5 cm. There are clear differences in growth parameter estimates (Table 3), likely to be due to sampling strategy (i.e. lack of small sized fish in the sample because of trawl net selectivity) or methods used to construct growth curves (otolith readings vs. length-frequency analysis). Diet of the species from Antalya Bay included Mollusca, Crustacea, Polychaeta and Teleost juveniles, but no quantitative data exists (Anonymous, 1983). Examination of several specimens captured between Iskenderun and Fethiye Bays revealed that *U. moluccensis* prefers Decapod crustaceans as its main food (51.87%), followed by Copepoda (17.29%) and Mysidacea (14.12%) (Kaya et al., 1999). All previous studies indicate that the spawning season begins in June and lasting possibly through September (Anonymous, 1983; Kaya et al., 1999; Ismen, 2005).

Upeneus pori (Ben-Tuvia and Golani, 1989) (Fig. 5): First recorded as *Upenoides tragula* from Iskenderun Bay (Kosswig, 1950), it has currently reached Gokova Bay (Akyol et al., 2006). The species was less abundant throughout the northern Levant than its congeneric *U. moluccensis* (see Gücü et al., 1994), but recent studies indicate a distinct population increase. Cicek (2006) estimated a biomass of 36.7 kg/km^2 and CPUE value of 4.5 kg/h (at depths not exceeding 20 m) for the 2002-2003 fishing season, where the species ranked as the most abundant alien fish within the bottom trawl catch.

Table 3. A review of von Bertalanffy growth parameters of *Upeneus moluccensis* from Turkey.

L_∞ (cm)	k (year^{-1})	t_0 (year)	n	Locality	Reference
25.60	0.621	- 0.270	-	NE Levant	Bingel et al. (1993)
25.60	0.430	-	-	NE Levant	Gücü (1995)
25.98	0.110	- 3.770	711	Northern Levant	Kaya et al. (1999)
25.20	0.197	- 1.002	418	Iskenderun Bay	Ismen (2005)

There are three studies on the age and growth of *U. pori* from Turkey (Table 4), all ow which mention a maximum age of 5. It should be noted that a higher "k" value is expected for such a small sized fish with such a relatively short life span. The gonado-somatic index values remained high between April and June, however the occurrence of mature individuals during September may indicate a prolonged spawning season (Ismen, 2006). The parameter "b" of the length-weight relationship ranges between 2.95 and 3.26 (Taskavak and Bilecenoglu, 2001; Cicek et al., 2002; Ismen, 2006; Cicek, 2006).

Pempheridae

Pempheris vanicolensis Cuvier, 1831: An immediate population explosion was observed for the Vanikoro sweeper following its introduction to the Mediterranean Sea in 1979 (Golani et al., 2002). It was commonly observed in small schools at Mersin coasts during 1983

Table 4. A review of von Bertalanffy growth parameters of *Upeneus pori* from Turkey.

L_∞ (cm)	k (year^{-1})	t_0 (year)	n	Locality	Reference
22.54	0.190	- 1.690	957	Iskenderun Bay	Cicek et al. (2002)
21.94	0.194	- 1.168	247	Iskenderun Bay	Cicek (2006)
19.10	0.360	- 0.812	616	Iskenderun Bay	Ismen (2006)

Fig. 5. *Upeneus pori* specimens from the shallow waters of Iskenderun Bay (specimen total lengths ca. 10 cm) (Photograph: Alp Can).

and 1984 (Gücü et al., 1994). The presence of *P. vanicolensis* at the Dodecanese islands was indicated by Papaconstantinou (1988), who stated that the species has reached the area by following the main current along the Asia Minor. Vanikoro sweeper is currently common at inshore caves throughout the northern Levantine coasts as far as Bodrum peninsula but has not yet expanded its range towards the northern Aegean Sea. It is probably a highly adaptive species that can tolerate a wide range of physico-chemical conditions. Bilecenoglu and Taskavak (1999) reported a population of *P. vanicolensis* inhabiting the brackish water caves in Antalya Bay, where the seasonal salinity ranged between 0.6 and 5‰. The species is generally caught by gill-nets but often discarded since it has no commercial value.

Mugilidae

Liza carinata (Valenciennes, 1836): The Keeled mullet is confined to the northeastern Levant coasts of Turkey, seemingly not even expanding to Antalya Bay since its introduction during the late 1950's. All previous records from the southern Aegean Sea are probably erroneous (Bilecenoglu et al., 2002). Although its proportion among the local native mullet catch is remarkably low, *L. carinata* is sometimes of interest to artisanal fishermen but with minor commercial value due to its small size.

Liza haematocheilus (Temminck and Schlegel, 1845): Among all alien fishes of Turkey, Pilengas mullet represents an exceptional case because of its origin. The species was anthropogenically introduced to the Azov and Black Seas for aquaculture purposes and subsequently penetrated to Turkish coasts (Unsal, 1992) and then to the Sea of Marmara and the central Aegean Sea (Kaya et al., 1998).

Taxonomy of this species is complicated. According to Parin (2003), previous records from various localities as *Mugil soiuy* (or *M. so-iuy*) refers to *Liza haematocheila*. In a phylogenetic study of mugilids from Greece using mtDNA sequence analysis, the close relationship between genera *Chelon* and *Liza* was demonstrated (Papasotiropoulos et al., 2007), providing support to earlier revisions that consider *Chelon haematocheilus* as a valid name for the Pilengas mullet (Chang et al., 1999). In contrast, the species was clustered together with the native *Mugil cephalus* by Turan et al. (2005), who used allozyme electrophoresis to examine phylogenetic relationships between nine mullets inhabiting Turkey. At this stage, the use of *L. haematocheilus* should be preferred until mugilid taxonomy is settled.

The species became so abundant that large quantities were fished during the late 1990's and marketed in several cities at cheap prices. There is a distinct annual fluctuation in the population of *L. haematocheilus*, which generally provides catches during the early summer and autumn. Unlike the very common occurrence of the species in the Black Sea, a relatively rare population can be observed in the northern and central Aegean Sea. To the best available knowledge, no further specimens have been captured from Homa Lagoon in Izmir Bay since 1998.

Population dynamics of this species was studied by Okumus and Bascinar (1997) who obtained a maximum specimen length of 66.7 cm (corresponding to 6 years of age)

and the following growth parameters were estimated: L_{∞} (cm) = 71.9, W_{∞} (g) = 3412.7, k= 0.26 year^{-1}, t_0 = −1.57 years. (See: Minos et al. in this book for reproduction and other aspects of this species).

Labridae

Pteragogus pelycus Randall, 1981 (Fig. 6): A prevalent species along the Turkish coast, reported from Iskenderun (Taskavak et al., 2000) and Gokova Bays (Bilecenoglu et al., 2002). Studies have shown that *P. pelycus* is more common in the vicinity of Rhodes, but relatively rare elsewhere (Golani et al., 2002). This small sized non-commercial wrasse is not of interest to fisheries.

Callionymidae

Callionymus filamentosus Valenciennes, 1837 : Observed during 1983 for the first time at the trawl grounds of Iskenderun Bay, Mersin and Anamur, with decreasing abundance towards the west (Gücü et al., 1994). It is currently distributed along the entire northern Levant coasts but not in the Aegean Sea. It is a common species in the bottom trawl catch and is usually discarded. Except for its length-weight relationship (Taskavak and Bilecenoglu, 2001) no further data is available.

Gobiidae

Oxyurichthys petersi (Klunzinger, 1871): This Red Sea endemic goby was first found off Mersin coasts (as *O. papuensis* by Kaya et al., 1992), almost a decade after its introduction to the Mediterranean Sea. Commonly captured by bottom trawlers and always discarded since it is a non-commercial fish. There is a clear abundance gradient for *O. petersi* along the Turkish coast while becoming relatively rare towards Fethiye Bay. Although the spe-

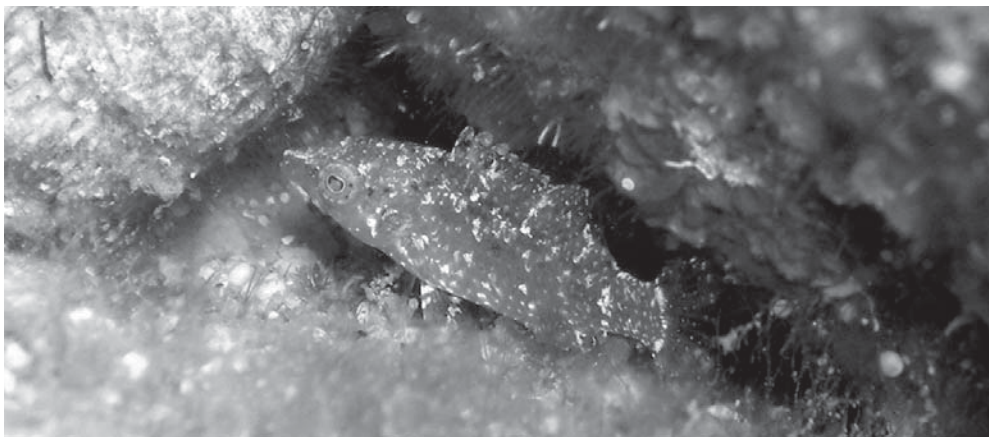

Fig. 6. A juvenile *Pteragogus pelycus* from Fethiye Bay (specimen total length ca. 5 cm) (Photograph: Melih E. Cinar).

cies was presented by Akyol et al. (2006) as a new record from the Aegean Sea, it was previously recorded from the area by Benli et al. (1999).

Vanderhorstia mertensi Klausewitz, 1974 (Fig. 7): The Shrimp-goby is the most recent alien fish in the Mediterranean Sea, first recorded from Fethiye Bay (Bilecenoglu et al., 2008). Sandy and muddy substrates at depths ranging 2 to 52 m were strikingly invaded by *V. mertensi*, which was generally found in association with the Alpheid shrimps, although in smaller quantities, the species also inhabits burrows close to seagrass beds. Since it was observed only at a single locality that is very far from the Suez Canal, its mode of introduction is unclear at the moment. A wider distribution range in the eastern Mediterranean can be expected.

Siganidae

Siganus luridus (Rüppell, 1829): A common species at Turkish coasts, known since the 1970's. Despite its commercial value and widespread distribution along the northern Levant and the southern Aegean Sea, no biological studies have been carried out in Turkey until now. Artisanal fishermen capture the species with a variety of fishing gears, but the other congeneric *S. rivulatus* is much preferred commercially. According to scuba observations, adults may form very large schools of up to 500 or more individuals during late spring (M. Bilecenoglu, pers. obs.).

Siganus rivulatus Forsskål, 1775: The Marbled spinefoot is among the most abundant alien fishes of the northern Levant shores, whose distribution extends as far as Candarli Bay in the northern Aegean Sea. It is captured generally by trammel nets in large quantities and by trawlers to a lesser extent. In several bays, *S. rivulatus* is a target species of artisanal fishermen. Total annual catch remains a question mark, however it is likely to be included in official fishery statistics together with *Sarpa salpa* (Bilecenoglu and Kaya, 2002).

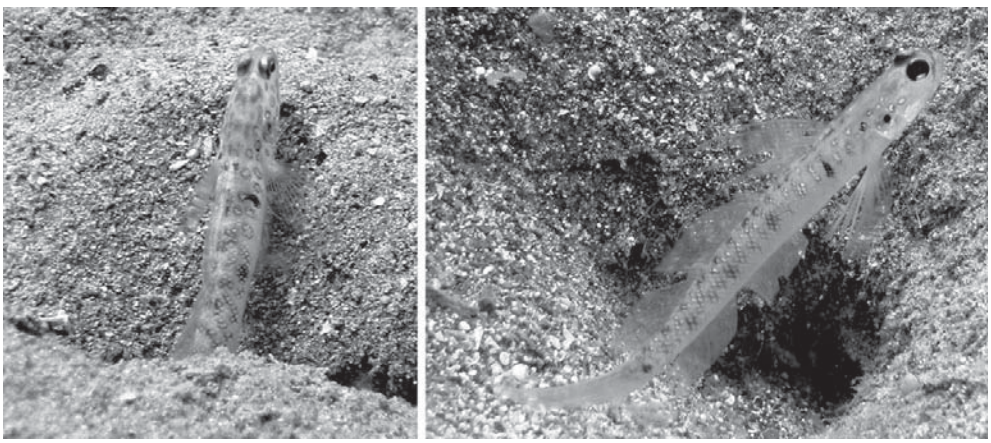

Fig. 7. A presumed female (left) and male (right) specimen of *Vanderhorstia mertensi* from Fethiye Bay (specimen total lengths about 7 – 8 cm) (Photographs: Serdar Sozen and Alper Dogan).

Despite its commercial importance and abundance, biological information on *S.rivulatus* from Turkey is scarce. A maximum age of 8 was determined using posterior body scales and growth parameters estimated as: L_{∞} (cm) = 22.3, W_{∞} (g) = 137.9, k= 0.28 year^{-1}, t_0 = –0.50 years (Bilecenoglu and Kaya, 2002). In a recent study from Lebanon, Bariche (2005) indicated that ageing of the Marbled spinefoot by scales does not seem to be an accurate method and he found larger individuals with smaller corresponding ages (i.e. 26.7 cm / 6 years) by otolith readings. According to results of the length-weight relationship, the value "b" ranges between 3.13 and 3.22, indicating a positive allometric growth (Bilecenoglu and Kaya, 2002). The species' spawning season begins in July and continues until the end of August (Yeldan and Avsar, 2000).

Sphyraenidae

Sphyraena obtusata Cuvier, 1829: Only a single record of the Obtuse barracuda (as *S.flavicauda*) by Bilecenoglu et al. (2002) exists from Turkey, based on two specimens collected off Antalya Bay. In recent taxonomical revisions based on morphological (Doiuchi and Nakabo, 2005) and molecular characteristics (Doiuchi and Nakabo, 2007) of the "*S. obtusata*" group, *S. flavicauda* Rüppell, 1838 was considered as a synonym of *S. obtusata*. Unlike its alien congeneric *S. pinguis*, the species did not form an abundant population along the northeastern Mediterranean but a wider distribution range can be expected. Recent findings from Rhodes (Corsini et al., 2005) revealed that *S. obtusata* was most probably overlooked in previous studies.

Sphyraena pinguis Günther, 1874: This species is commonly observed in the northern Levant since the late 1950's. The species name *S. chrysotaenia* was widely used previously in literature and is currently considered a synonym of *S. pinguis* (Doiuchi and Nakabo, 2005, 2007). Contribution of this species to trawl catch composition is limited; maximum CPUE was 99.5 g/h during 1983 along Mersin coasts (Gücü et al., 1994) and formed only 0.48% of the total alien fish biomass (Cicek, 2006). Larger quantities are generally fished with purse seiners. Current distribution of this species includes the entire northern Levant and up to Izmir Bay in the central Aegean Sea.

Scombridae

Scomberomorus commerson (Lacepède, 1800): Since the early 1980's, the Narrow-barred Spanish mackerel has become abundant in the eastern Mediterranean Sea almost five decades since its first record (Golani et al., 2002). Gücü et al. (1994) obtained two specimens from Mersin coasts by gill-nets during 1981 and indicated its increasing commercial importance in the local fisheries. By 1994 the species reached Gokova Bay, providing a catch of up to 200 individuals per day (Buhan et al., 1997). On a few occasions, *S. commerson* was also observed off the Cesme peninsula (central Aegean Sea). It is currently considered a prevalent species along the Levantine and southern Aegean Sea coasts, becoming common only during the late autumn and winter. Available data on the species include only its length-weight relationship and condition factor from Gokova bay (Buhan et al., 1997).

Cynoglossidae

Cynoglossus sinusarabici (Chabanaud, 1931): Although this species is one of the earliest alien fishes of Turkey (Akyüz, 1957), it has a limited distribution between Iskenderun Bay and Mersin coasts, not extending westwards. Said to be common in the eastern Mediterranean (Golani et al., 2002), but relatively less abundant in northeastern Levant, with a proportion of 1.2% in the total alien fish biomass (Cicek, 2006). Often discarded from the trawl catch due to its non-commercial value and small size.

The "b" value of the length-weight relationship ranges between 2.41 and 2.96 (Cicek et al., 2006; Sangün et al., 2007). Length at first maturity is 6.8 – 6.9 cm for males and females, respectively; spawning takes place in two seasons (May – July and September – December) (Yeldan et al., 2006). The authors also determined ages, with a maximum of 5 years for a 15.1 cm length specimen.

Monacanthidae

Stephanolepis diaspros Fraser and Brunner, 1940: The Reticulated filefish was an early colonizer of Anatolian coasts, dispersing to Kusadasi Bay in the southern Aegean Sea. The species is commonly observed in the bottom trawl catch composition, having no commercial value and usually discarded. It seems to present a spawning aggregation during late autumn and winter, since its biomass within the total of alien fishes increases two or three folds in November and December (Cicek, 2006).

No detailed biological information is available from Turkey, except for some few data on the length-weight relationship (Taskavak and Bilecenoglu, 2001; Sangün et al., 2007). Two specimens of *S. diaspros* collected from Antalya and Iskenderun Bays had total lengths of 21.5 and 22.0 cm (M. Bilecenoglu, unpub. data), slightly higher than the value reported by Golani et al. (2002).

Tetraodontidae

Lagocephalus spadiceus (Richardson, 1844): This species is distributed along the northern Levant coasts and the southern Aegean Sea, being common at Iskenderun and Antalya Bays, but less abundant elsewhere. A recent paper reports a single specimen of *L. spadiceus* from the Sea of Marmara, representing the first occurrence of a Red Sea originated fish in the area (Tuncer et al., 2008). Bottom trawlers of the northeast Levant capture the species frequently, generally in small quantities that are always discarded. Similar to its confamilial members, *L. spadiceus* is potentially a lethal fish with several toxic organs (Golani et al., 2002).

Lagocephalus suezensis Clark and Gohar, 1953: Only a few occurrence records are available from the eastern Mediterranean Sea, however, the species is currently the most abundant pufferfish of the northern Levant (together with *L. sceleratus*). Although it was first recorded a decade ago by Avsar and Cicek (1999) (misidentified as *Sphoeroides cutaneus*), *L. suezensis* was probably introduced to Anatolian coasts much earlier. It is possible to see the species in every bottom trawl catch, including very small sized specimens with lengths

between 4 – 6 cm. The current distribution of *L. suezensis* includes the entire northern Levant shores and the southern Aegean Sea (Bilecenoglu et al., 2002). During night dives, several individuals can be observed resting on the sandy grounds of inshore waters (Fig. 8).

Lagocephalus sceleratus (Gmelin, 1789): This species can be regarded as one of the "worst alien fishes" of the entire Mediterranean Sea; harmful to both human health and fishing gears. Only a single individual from Gokova Bay was known until 2004, followed by successive records throughout a large coastline covering the entire northern Levant, southern and central Aegean Seas (Bilecenoglu et al., 2006). In terms of biomass, *L. sceleratus* is currently the most common pufferfish at Turkish coasts. Due to its large size, the species was marketed in some fishing ports and some cases of poisonings have been observed especially at the northeast Levant shores (see Eisenman, 2008 and Bentur et al., 2008). The Turkish Ministry of Agriculture and Rural Affairs has recently banned the fishing and marketing of *L. sceleratus* in Turkey. In addition to its toxic nature, this species has powerful jaws that can easily cut bottom longlines; complaints of local fishermen on this matter have been published several times in newspapers. A hobby fishing attempt in Fethiye Bay resulted with three broken fishing lines, ten missing hooks and one *L.sceleratus* caught (slightly over 1 kg), just within five minutes (Fig. 9).

Sphoeroides pachygaster (Müller and Troschel, 1848): The Blunthead puffer has penetrated the Mediterranean Sea via Gibraltar and then reached the Levant Sea (Golani et al., 2002). Recorded from only a few localities along the Turkish coasts, it is possibly absent from the coastline between Iskenderun Bay to Mersin; however, some specimens were obtained from Antalya Bay, Gokova Bay (M. Bilecenoglu, unpub. data) and Saros Bay (northern Aegean Sea) (Eryilmaz et al., 2003).

Fig. 8. A *Lagocephalus suezensis* specimen (total length ca. 15 cm) observed during a night time scuba dive at Fethiye Bay (Photograph: Melih E. Cinar).

Torquigener flavimaculosus Hardy and Randall, 1983: Since its first record in the eastern Mediterranean Sea, the Dwarf blaasop have been reported only from a few localities. Despite extensive surveys along the northern Levant coasts, *T. flavimaculosus* can only be observed in Turkey in Fethiye Bay (Fig. 10), where the population is regarded

Fig. 9. *Lagocephalus sceleratus* is a nuisance alien species, harmful to human health and small scale fisheries. The photograph shows a specimen caught by a fishing line from Fethiye Bay (Photograph: Betil Ergev).

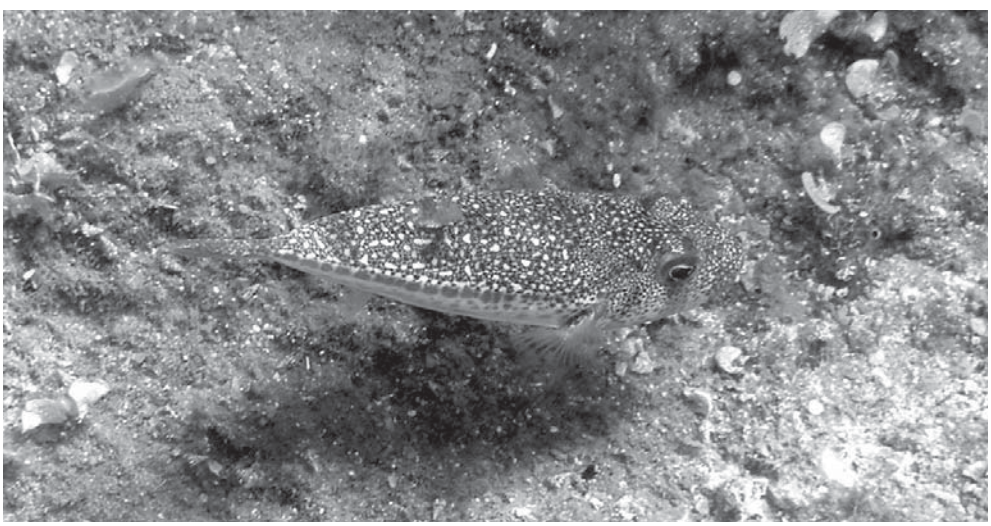

Fig. 10. The Dwarf blaasop – the most abundant pufferfish of Fethiye Bay (specimen total length ca. 10 cm) (Photograph: Melih E. Cinar).

as common. In a single paper related to its biology, its burrowing behavior was observed, which is apparently a strategy for predator avoidance or an adaptation to increase foraging success (Bilecenoglu, 2005).

QUESTIONABLE ALIENS

There are several cases of fish species previously reported from Turkey where essential information is not available to support their occurrence. In the checklist of Turkish marine fishes, Bilecenoglu et al. (2002) listed 45 doubtful records, including the following 10 alien species: *Hyporhamphus affinis* (Günther, 1866), *Tylosurus choram* (Rüppell, 1837), *Platycephalus indicus* (Linnaeus, 1758), *Epinephelus tauvina* (Forsskål, 1775), *Pomadasys stridens* (Forsskål, 1775), *Crenidens crenidens* (Forsskål, 1775), *Parupeneus barberinus* (Lacepède, 1801), *Rastrelliger kanagurta* (Cuvier, 1816), *Bothus pantherinus* (Rüppell, 1828) and *Diodon hystrix* Linnaeus, 1758. No specimens of the above mentioned species have yet been collected from the region and they should not be treated as a part of the local ichthyofauna until a relevant individual specimen has been provided.

A further species, *Solea senegalensis* Kaup, 1858, listed from the Sea of Marmara and the Aegean and Levantine coasts of Turkey during 1942 should also be considered as doubtful (Cinar et al., 2005). The actual distribution range of *S. senegalensis* is confined to the western Mediterranean Sea and no data of even a single occurrence is available from the eastern basin (Golani et al., 2002).

The recent report of Boreal-Atlantic originated *Syngnathus rostellatus* Nilsson, 1855 from Antalya Bay (Gokoglu et al., 2004) seems to be based on a misidentification. In the photograph presented, the elevated median dorsal postorbital region is conspicuous and the long snout is clearly seen. According to Dawson (1986), the head is not elevated in *S. rostellatus* and the snout length is less than half head length. Moreover, the total length of the Antalya Bay specimen (187 mm) is longer than the maximum length of *S. rostellatus* reported to date (170 mm; Dawson, 1986).

Finally, *Carangoides bajad* (Forsskål, 1775) was recorded by Ozturk (2005) from a photograph presumed to be taken from Fethiye Bay but is clearly erroneous (Golani, 2006).

CONCLUSIONS

The influx of alien species to the Mediterranean is a continuous phenomenon, with an increasing trend. A total of 33 non-native fish was reported by Bilecenoglu et al. (2002) from Turkey, within the next six years the number increased to 49. It is almost certain that several species have already arrived to Anatolian coasts, waiting to be recognized and recorded.

There are 10 casual aliens versus 39 established ones. Although suitable ecological conditions (i.e. unsaturated habitats, sufficient food resources etc.) do not guarantee a suc-

cessful establishment for an alien species, several fish species seem to carry out step-by-step colonization over time. Some species previously regarded as rare have now prevalent or common populations, but there is always a possibility that they could have been overlooked.

At least a dozen fish species can be listed among the commercial aliens, some of which are treated as a target species since the 1970's. Although official capture fish statistics may provide a good basis in demonstrating the impact of non-native fishes, lack of species-specific landing data of Turkey is a big gap for the relevant analysis. Only a few studies on the contribution of non-native species to trawl fisheries of the northeastern Levant was published and fishery related status of aliens along rest of the Anatolian coast is still a question mark.

Life history parameters of alien fishes deserve special interest, in order to understand their biological characteristics and role in local food webs. Published papers on the subject are few, dealing generally with commercial species such as *Upeneus spp*., *S. undosquamis* and *E. teres*. Discrepancies in growth parameters as mentioned above are good indicators of the necessity for more detailed and meticulous studies. Except for a single attempt to provide a model of northeastern Mediterranean fisheries (Gücü, 1995), no ecological models were constructed until now. Such models can serve to demonstrate predator-prey relationships and provide essential information for regulation and management of local fisheries.

ACKNOWLEDGEMENTS

I am grateful to Prof. Dr. Melih E. Cinar, Tahsin Ceylan, Prof. Dr. Alp Can, Serdar Sozen, Alper Dogan and Betil Ergev for the photographs. Some observations mentioned in the text were carried out during the TUBITAK project no. 104Y065 and the Fethiye Bay marine biodiversity project (Ministry of Environment and Forestry, Republic of Turkey).

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