

## Research Article

## *Lagocephalus sceleratus* (Gmelin, 1789) expands through the African coasts towards the Western Mediterranean Sea: a call for awareness

Jamila Ben Souissi<sup>1</sup>, Mouna Rifi<sup>2</sup>, Raouia Ghanem<sup>1</sup>, Lotfi Ghozzi<sup>3</sup>, Wassim Boughedir<sup>1</sup> and Ernesto Azzurro<sup>4\*</sup>

<sup>1</sup>Département des Ressources Animales, Halieutiques et des Technologies Agroalimentaires, Institut National Agronomique de Tunisie, 43 avenue Charles Nicolle, cité Mahrajène, 1082 Tunis, Tunisia

<sup>2</sup>Direction Générale de la Pêche et de l'Aquaculture (DGPA), Ministère de l'Agriculture, 32 rue Alain Savary, Tunis, Tunisia

<sup>3</sup>Agence de la Vulgarisation et de la Formation Agricole (AVFA) Ministère de l'Agriculture, 32 rue Alain Savary, Tunis, Tunisia

<sup>4</sup>ISPRA, National Institute for Environmental Protection and Research, Piazzale dei Marmi 2, 57128 Livorno, Italy

E-mail: [bensouissi.jamila@inat.agrinet.tn](mailto:bensouissi.jamila@inat.agrinet.tn) (JBS), [raouia-ghanem@hotmail.fr](mailto:raouia-ghanem@hotmail.fr) (RG), [boughedir\\_w@yahoo.fr](mailto:boughedir_w@yahoo.fr) (WB), [eazzurr@gmail.com](mailto:eazzurr@gmail.com) (EA)

\*Corresponding author

Received: 28 January 2014 / Accepted: 25 June 2014 / Published online: 8 July 2014

Handling editor: Vadim Panov

### Abstract

The silver-cheeked toadfish *Lagocephalus sceleratus* is one of the most recent invaders in the Mediterranean Sea and a serious risk for public health. In June 2011, an awareness campaign to disseminate information related with this toxic species was launched by the Tunisian Ministry of Agriculture. Whilst providing a step toward the development of an appropriate early warning system, this case highlights a remarkable geographical extension of *L. sceleratus* along the entire Tunisian shoreline (from the island of Djerba to the region of Tabarka). We illustrate how the first step in the process of effectively managing the risks posed by an invasive species is to engage and communicate with the public.

**Key words:** Tetraodontidae, Lessepsian migration, Sicily strait, Tunisia, Tetraodotoxin, Central Mediterranean, Western Mediterranean, non-indigenous species, early warning, biosecurity

### Introduction

The silver-cheeked toadfish *Lagocephalus sceleratus* (Gmelin, 1789) is considered one of the “worst” biological invaders of the Mediterranean Sea (Streftaris and Zenetos 2006), a pest for fisheries and a threat for native biodiversity and human health (EastMed 2010; Kalogirou 2013). This pufferfish (Tetraodontidae), originally distributed along the coasts of the tropical Indo-West Pacific Ocean (Smith and Heemstra 1986) recently entered the Mediterranean through the Suez Canal (Filiz and Er 2004; Akyol et al. 2005). Soon afterwards, it established abundant populations along the coasts of many countries of the eastern basin such as Israel, Lebanon, Turkey (Mediterranean and Aegean coasts), Greece (Aegean and Ionian coasts) and Cyprus (EastMed 2010; Kalogirou 2013 and references therein; Zenetos

et al. 2013). Furthermore, *L. sceleratus* has rapidly expanded westwards, along the coasts of Egypt and Libya (Halim and Rizkalla 2011; Bazairi et al. 2013), reaching to date the Eastern Tunisia (Jribi and Bradai 2012) and the Pelagie islands, Italy (Azzurro et al. 2014). This species is yet to be reported from the central and western Tunisia, or from the western Mediterranean (Golani et al. 2013).

The silver-cheeked toadfish can be lethally poisonous when consumed because of its content in Tetrodotoxin (TTX), a heat-stable (hence resistant to heat or cooking) water-soluble neurotoxin (Arakawa et al. 2010) that has paralytic effects on both the nervous and respiratory systems. The poison TTX is present mainly in the skin and viscera of the pufferfish and it can be detected in all the tissues of the species (Z. Kizilkaya, pers. comm.) even if some authors consider it to be

absent from the musculature (Beköz et al. 2013). Symptoms range from mild gastrointestinal disturbance to a progressive paraesthesia with gradual muscle paralysis, dysphagia up to respiratory failure and fatal arrhythmias (Ahasan et al. 2004).

As stressed by Beköz et al. (2013), there are no antidotes and treatment can be supportive only (Sims and Ostman 1986). Because of *L. sceleratus* consumption, several cases of hospitalization have been reported all over the world, mainly in Japan, China and Taiwan where the species is traditionally consumed and where other pufferfishes are prepared by trained and licensed chefs. Yet this risk is now a matter for consumers of the Mediterranean countries, and several cases of hospitalization (Kasapidis et al. 2007; Bentur et al. 2008; Eisenman et al. 2008; Chamandi et al. 2009; Katikou et al. 2009; Golani 2010; Kalogirou et al. 2010) as well as a number of fatal intoxications (Zaki 2004; Beköz et al. 2013) have already been reported. One of the most recent and remarkable cases of poisoning by *L. sceleratus* is the mass hospitalization of the crewmembers of a tanker off Crete Island (see Maritime Bulletin 2013).

Food poisoning can be mainly attributed to the lack of awareness among consumers or due to erroneous conception of detoxification methods (Nader et al. 2012). Reasonably, as the Mediterranean population of the silver-cheeked toadfish grows, as so does the health risk they pose, especially when local people are unaware of the danger. To manage this health risk effectively, biosecurity actions, such as risk assessment and communicating risk and hazards to the public, need to be implemented. In this paper we present a public awareness program that was developed and launched by the Tunisian Ministry of Agriculture, which forms the preliminary step in establishing an early warning system in Tunisia.

## Methods

In June 2011 the Ministry of Agriculture of Tunisia launched, through the 'Agricultural Extension and Training Agency' (AVFA), an awareness campaign aimed to disseminate information about the presence and associated risks of the toxic pufferfish *Lagocephalus sceleratus*. The urgency of this action had been motivated by scientific research institutes that are under the same Ministry of Agriculture, such as INAT (Institut National Agronomique de Tunisie) and INSTM (Institut National des Sciences et Technologies

de la Mer). The four national institutions were directly involved in the awareness programme: AVFA, INAT, INSTM, and the DGPA (Direction Générale de la Pêche et de l'Aquaculture). The awareness campaign used posters (Figure 1) and brochures to spread the message of the toxicity of the species and of the risks associated to its consumption. Posters and brochures were printed en masse (4000 copies) and distributed through 11 coastal governorates (Jendouba, Beja, Bizerte, Tunis, Nabeul, Sousse, Monastir, Mahdia, Sfax, Gabes and Medenine) that covered over 10 large harbours, 22 small ports and nine dykes where landings of artisanal fishery products occurred.

A taskforce composed by 4 scientists of both INAT and AVFA was created and engaged to deliver public presentations over the five 'more important' fishing harbours in Tunisia: Tabarka, Bizerte, La Goulette, Madia, Gabes and Zarzis. At the beginning of each talk the taskforce illustrated the risk posed by *L. sceleratus* and brochures were distributed among participants. Two institutional phone numbers of INAT were dedicated to receive calls (from both fishermen and the general public) regarding the presence of the silver-cheeked toadfish.

A total of 42 presentations were made over three years (2011 to 2013 inclusive). Meetings were organized in collaboration with the Regional Fishery Authorities, which had a key role in contacting fishermen, advertising the meetings and inviting other sea users, such as diving clubs and recreational fishing associations. At each meeting, the presence of each participant was registered by signature. Identification of the silver-cheeked toadfish made by the public was often dubious, due to its morphological resemblance with other Mediterranean puffers. For this reason, phone calls reporting sightings of *L. sceleratus* were generally not used as a proof of the occurrence of this species along the Tunisian coasts. Indeed, the distribution of *L. sceleratus* was updated only when one or more specimens were provided to the authors, who could correctly identify the species.

## Results

The total number of people that assisted to public presentations was of 1048 (784 professional fishermen; 17 recreational fishermen; 56 recreational divers and other 191 sea users). Since the beginning of the campaign, people provided information regarding the occurrence of pufferfishes either



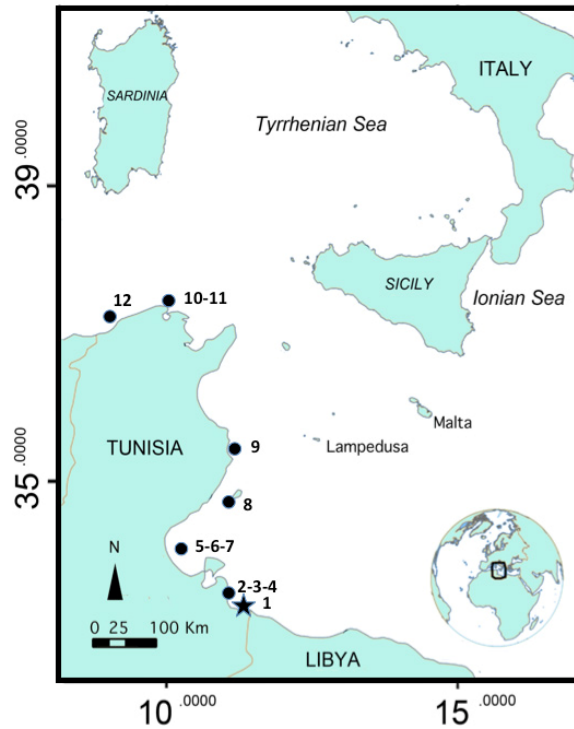
**Figure 1.** One of the posters advertising the toxicity of the *Lagocephalus sceleratus*, as part of the information campaign carried out in Tunisia. The text, written in Arabic language, bans the landing, marketing and consumption of this species and shows how to recognize it from the native *L. lagocephalus*. It explains that the tetrodotoxin is very concentrated in the liver and in the gonads and that it is resistant to cooking. Finally it invites fishermen to contact research institutes.

through phone calls or mobile phone Short Message Service (SMS). In some cases, fishermen directly contacted the local agency responsible of fishery activities. The taskforce received a total number of 314 contacts in the three years of operation, including calls related to the request for information.

According to the fishermen that responded to the campaign, *Lagocephalus sceleratus* is an occasional capture of Tunisian fisheries (mainly via artisanal nets and trawling) since December 2010. In the last few years, the species has increased in abundance, posing a new threat to fishing activity. The silver-cheeked toadfish destroys fishing gear and tackle by its strong teeth. Following the awareness activities we had clear evidence that the species is widespread in Tunisia. Out of the bulk of the received observations, a total of 11

*L. sceleratus* individuals were delivered to the scientific personnel of the INAT for verification of taxonomic identification. The INAT personnel confirmed the species identification, in agreement with the morphological characters given by Akyol et al. (2005). The sites of capture of these specimens extended over the entire length of the Tunisian coast, from the island of Djerba up to the region of Tabarka, in the western Mediterranean (Table 1, Figure 2). Identified fish ranged from 52 cm TL (1340g TW) to 64 cm TL (2410g TW). Among these specimens we observed mature females, with ripe gonads (GW up to 245g), suggesting that a breeding population may be established.

Despite the awareness campaign, a serious case of intoxication by silver-cheeked toadfish



**Figure 2.** One *Lagocephalus scleratus*: Capture locations of 11 individuals delivered to INAT following the awareness campaign. The previous Tunisian record published so far (Jribi and Bradai 2012) is also indicated (★). Please see Table 1 for location information.

**Table 1.** New occurrence records of *Lagocephalus scleratus* along the Tunisian coasts. Numbers and symbols refer to locations represented in Figure 2.

Map ref.	Location name	Location coordinates		Record date	Number of collected fish
		Lat N	Long E		
1*	Southern Tunisia	33,8333	11,8666	December 2010	1
2	Lagoon of Bibans	33,2688	11,3111	June 2011	1
3	Lagoon of Bibans	33,2688	11,3111	September 2011	1
4	Lagoon of Bibans	33,2688	11,3111	October 2012	1
5	Gulf of Gabès	33.5286	11.7413	May 2011	1
6	Gulf of Gabès	33.5763	11.6125	October 2012	1
7	Gulf of Gabès	33.5358	11.4541	June 2013	2
8	Kerkenah Islands	34.5283	10.9886	July 2013	1
9	Mahdia	35.3094	11.2494	June 2012	1
10	Bizerte	37.3277	9.8422	September 2011	1
11	Bizerte	37.3277	9.8422	July 2012	1

was registered in August 12, 2013 in Gafsa, an inland town located about 110 Km (airline) West from the coastline. This incident, immediately reported by national television and newspapers, was attributed to the commercialization of *L. scleratus* in the internal areas of the country, were no specific actions were carried out to inform people about the risks posed by this species.

## Discussion

Raising awareness about the risks associated to the consumption of the silver-cheeked toadfish, is one of the key actions to prevent the impacts of this invasion (Nader et al. 2012). The present awareness campaign, targeted both professional fishermen and the general public, and reasonably

reduced the risks for human health among Tunisian consumers. Moreover, feedback provided by targeted people provided clear evidence of the rapid geographical expansion of *L. sceleratus* along the southern Mediterranean shores. It is remarkable that until a few years ago, the silver-cheeked toadfish was considered to be absent from the entire North African coast (Shakman and Kinzelbach 2007) and that the first sightings of this species from the southern Mediterranean have been reported only in the last three years (Egypt: Halim and Rizkalla 2011; Libya: Milazzo et al. 2012; Bazairi et al. 2013; eastern Tunisia: Jribi and Bradai 2012). According to the specimens provided by people who responded to the campaign, *L. sceleratus* occurs all over the Tunisian shores and it is highly possible this invader is now expanding towards the western side of the basin, along the Algerian coast. Noteworthy, anecdotal evidences (via videos, articles and facebook posts - e.g. Youtube 2011; Tunisvision 2011; Facebook 2001) existed since 2011 and it may be considered as unofficial and unverified warnings about the spread of this fish.

The consumption of the silver-cheeked toadfish has been declared illegal in many nations, including Japan and Malaysia where other pufferfish are traditionally (and legally) consumed. In the Mediterranean, various governmental initiatives in countries such as Egypt, Turkey, Lebanon, (Nader et al. 2012) Cyprus and Greece, with these latter performed in conformity with the European Regulations 853/2004/EC and 854/2004/EC (Pancucci-Papadopoulou et al. 2012), have issued a ban on the fishery, market and consumption of *L. sceleratus*. Civil society should always be informed and involved in issues related to introduced aquatic species (Wittenberg and Cock 2001). By being inclusive of the civil society, management can improve both monitoring capability and public awareness on the issue of exotic fish species in the Mediterranean Sea (Azzurro 2010; Azzurro et al. 2013). Yet, in cases of a potential human health risk, such as what the silver-cheeked toadfish presents, a rapid dissemination of information is crucial.

Due to its large body size *L. sceleratus* is often caught by fishermen, who unwittingly consume its flesh and inner organs (Golani 2010). Nevertheless, along the Mediterranean coasts of Egypt (Halim and Rizkalla 2011), Lebanon (Michel Bariche pers. Info), Turkey (Aydin 2011), *L. sceleratus* is illegally sold beheaded and eviscerated with subsequent risk of poisoning to the unknowing

public. This is a serious biosecurity risk and management steps need to prevent that illegal sales of this fish occur.

Next measures to manage the issue of *L. sceleratus* in Tunisia are to conceive specific preparedness actions for coastal hospitals. The Ministry of Agriculture of Tunisia is planning to display posters in coastal hospitals and to train personnel to promptly identify the symptoms associated to TXT and to distinguish among the different species of Tetraodontidae.

In conclusion, the case of *L. sceleratus* in Tunisia provides a step toward the development of an appropriate early warning system aimed to prevent dramatic consequences on human health. At the same time, the feedback received by the targeted community; provides evidence of a remarkable geographical extension of this species along the southern Mediterranean shores. Hopefully this example will be taken into consideration by other Mediterranean countries that are subjected or potentially subjected to the invasion of this toxic, and highly invasive, pufferfish.

## Acknowledgements

The awareness campaign has been funded by the Agency for Agricultural Extension and Training (AVFA). The authors wish to thank all fishermen which provided *Lagocephalus sceleratus* specimens to the authors. We also acknowledge two anonymous referees for providing useful suggestions that significantly improved our manuscript.

## References

- Ahasan HA, Mamun AA, Karim SR, Bakar, MA, Gazi EA, Bala CS (2004) Paralytic complications of puffer fish (tetraodontin) poisoning. *Singapore Medical Journal* 45: 73–4
- Arakawa O, Hwang DF, Taniyama S, Takatani T (2010) Toxins of Pufferfish That Cause Human Intoxications. Coastal Environmental and Ecosystem Issues of the East China Sea, Eds., A. Ishimatsu and H.-J. Lie, pp 227–244
- Akyol O, Ünal V, Ceyhan T, Bilecenoglu M (2005) First confirmed record of the silverside blaasop, *Lagocephalus sceleratus* (Gmelin, 1789), in the Mediterranean Sea. *Journal of Fish Biology* 66: 1183–1186, <http://dx.doi.org/10.1111/j.0022-1112.2005.00667.x>
- Aydin M (2011) Growth, Reproduction and Diet of puffer fish (*Lagocephalus sceleratus* Gmelin, 1789) from Turkey's Mediterranean Sea Coast. *Turkish Journal of Fisheries and Aquatic Sciences* 11: 589–596, <http://dx.doi.org/10.4194/trjfas.2011.0318>
- Azzurro E (2010) Unusual occurrences of fish in the Mediterranean Sea: an insight on early detection. In: Golani D, Appelbaum-Golani B (eds), *Fish Invasions of the Mediterranean Sea: Change and Renewal*. Pensoft Publishers, Sofia-Moscow, pp 99–126
- Azzurro E, Broglio E, Maynou F, Bariche M (2013) Citizen science detects the undetected: the case of *Abudefduf saxatilis* from the Mediterranean Sea. *Management of Biological Invasions* 4: 43–50, <http://dx.doi.org/10.3391/mbi.2013.4.2.10>

- Azzurro E, Castriota L, Falautano M, Giardina F, Andaloro F (2014) The silver-cheeked toadfish *Lagocephalus sceleratus* (Gmelin, 1789) reaches Italian waters. *Journal of Applied Ichthyology* 30: 1050–1052, <http://dx.doi.org/10.1111/jai.12471>
- Bazairi H, Sghaier YR, Benamer I, Langar H, Pergent G, Bourass EM, Verlaque M, Ben Soussi J, Zenetos A (2013) Alien marine species of Libya: first inventory and new records in El-Kouf National Park (Cyrenaica) and the neighbouring areas. *Mediterranean Marine Science* 14(2): 451–462, <http://dx.doi.org/10.12681/mms.555>
- Beköz AB, Beköz S, Yılmaz E, Tüzün S, Beköz U (2013) Consequences of the increasing prevalence of the poisonous *Lagocephalus sceleratus* in southern Turkey. *Emergency Medicine Journal* 30(11): 954–955
- Bentur Y, Ashkar J, Lurie Y, Levy Y, Azzam Z, Litmanovich M, Gurevych B, Golani D, Eisenman A (2008) Lessepsian migration and tetrodotoxin poisoning due to *Lagocephalus sceleratus* in the eastern Mediterranean. *Toxicon* 52: 964–968, <http://dx.doi.org/10.1016/j.toxicon.2008.10.001>
- Chamandi SC, Kallab K, Mattar H, Nader E (2009) Human Poisoning after Ingestion of Puffer Fish Caught from Mediterranean Sea. Case Report – USEK Medical School - Lebanon
- EastMed (2010) Report of the Sub-Regional Technical meeting on the Lessepsian migration and its impact on Eastern Mediterranean fishery. GCP/INT/041/EC – GRE – ITA/TD-04
- Eisenman A, Rusetski V, Sharivker D, Yona Z, Golani D (2008) An odd pilgrim in the Holyland. *American Journal of Emergency Medicine* 26(3): 383.e3–383.e6
- Facebook (2011) [https://www.facebook.com/permalink.php?story\\_fbid=228301627181527&id=153823178019607](https://www.facebook.com/permalink.php?story_fbid=228301627181527&id=153823178019607)
- Filiz H, Er M (2004) Akdenizin yeni misafiri (New guests in the Mediterranean Sea). *Deniz Magazini* (Istanbul) 68: 52–54
- Golani D (2010) Colonization of the Mediterranean by Red Sea fishes via the Suez Canal – Lessepsian migration. In: Golani D, Appelbaum-Golani B (eds), *Fish Invasions of the Mediterranean Sea: Change and renewal*. Pensoft Publishers, Sofia-Moscow, pp 145–188
- Golani D, Orsi-Relini L, Massuti E, Quingnard JP, Dulčić J, Azzurro E (2013) CIESM Atlas of Exotic Fishes in the Mediterranean. <http://www.ciesm.org/atlas/appendix1.html> (Accessed October 15th, 2013)
- Halim Y, Rizkalla S (2011) Aliens in Egyptian Mediterranean waters. A check-list of Erythrean fish with new records. *Mediterranean Marine Science* 12: 479–490, <http://dx.doi.org/10.12681/mms.46>
- Jribi I, Bradai MN (2012) First record of the Lessepsian migrant species *Lagocephalus sceleratus* (Gmelin, 1789) (Actinopterygii: Tetraodontidae) in the Central Mediterranean. *BiolInvasions Records* 1(1): 49–52, <http://dx.doi.org/10.3391/bir.2012.1.1.11>
- Kalogirou S (2013) Ecological characteristics of the invasive pufferfish *Lagocephalus sceleratus* (Gmelin, 1789) in Rhodes, Eastern Mediterranean Sea. A case study. *Mediterranean Marine Science* 14: 251–260, <http://dx.doi.org/10.12681/mms.364>
- Kalogirou S, Corsini-Foka M, Sioulas A, Wennhage H, Pihl L (2010) Diversity, structure and function of fish assemblages associated with *Posidonia oceanica* beds in an area of the Eastern Mediterranean Sea and the role of nonindigenous species. *Journal of Fish Biology* 77: 2338–2351, <http://dx.doi.org/10.1111/j.1095-8649.2010.02817.x>
- Kasapidis P, Peristeraki P, Tserpes G, Magoulas A (2007) First record of the Lessepsian migrant *Lagocephalus sceleratus* (Gmelin 1789) (Osteichthyes: Tetraodontidae) in the Cretan Sea (Aegean, Greece). *Aquatic Invasions* 2: 71–73, <http://dx.doi.org/10.3391/ai.2007.2.1.9>
- Katikou P, Georgantelis D, Sinouris N, Petsi A, Fotaras T (2009) First report on toxicity assessment of the Lessepsian migrant pufferfish *Lagocephalus sceleratus* (Gmelin, 1789) from European waters (Aegean Sea, Greece). *Toxicon* 54(1): 50–55, <http://dx.doi.org/10.1016/j.toxicon.2009.03.012>
- Maritime Bulletin (2013) Mass poisoning on board of Ukrainian tanker Tamanskiy, Med. December 24 2013. Online publication <http://www.news.odin.tc/index.php?page=view/article/1080/Mass-poisoning-on-board-of-Ukrainian-tanker-Tamanskiy-Med> (Accessed May 5th, 2014)
- Milazzo M, Azzurro E, Badalamenti F (2012) On the occurrence of the silverstripe blaasop *Lagocephalus sceleratus* (Gmelin, 1789) along the Libyan coast. *BiolInvasions Records* 1: 125–127, <http://dx.doi.org/10.3391/bir.2012.1.2.08>
- Nader MR, Indary S, Boustany L (2012) The puffer fish *Lagocephalus scleratus* (Gmelin, 1789) in the Eastern Mediterranean. Greece: Food and Agriculture Organisation of the United Nations. GCP/INT/041/EC – GRE – ITA/TD-10
- Pancucci-Papadopoulou MA, Raitso DE, Corsini-Foka M (2012) Biological invasions and climatic warming: implications for South Eastern Aegean ecosystem functioning. *Journal of the Marine Biological Association UK* (JMBA UK) 92(4): 777–789, <http://dx.doi.org/10.1017/S0025315411000981>
- Shakman E, Kinzelbach R (2007) Commercial fishery and fish species composition in coastal waters of Libya. *Rostocker Meeresbiologische Beiträge* 18: S63–S78
- Sims JK, Ostman DC (1986) Pufferfish poisoning: emergency diagnosis and management of mild human tetrodotoxification. *Annals of Emergency Medicine* 15: 1094–1098, [http://dx.doi.org/10.1016/S0196-0644\(86\)80135-4](http://dx.doi.org/10.1016/S0196-0644(86)80135-4)
- Smith MM, Heemstra PC (1986) *Smith's Sa Fishes*. Grahamstown: Smith Institute of Ichthyology Press, 1047 pp
- Streftaris N, Zenetos A (2006) Alien marine species in the Mediterranean - the 100 'worst invasives' and their impact. *Mediterranean Marine Science* 7: 87–118, <http://dx.doi.org/10.12681/mms.180>
- Tunisvision (2011) <http://www.corbusmilchasse.com/forum/viewtopic.php?f=17&t=5037> (Accessed on October 15th, 2013)
- Wittenberg R, Cock M (2001) *Invasive Alien Species: a Toolkit of Best Prevention and Management Practices*. GISP/CAB International, Wallingford, the United Kingdom
- Youtube (2011) [http://www.youtube.com/watch?v=fs9JQiTtN6w&feature=player\\_embedded#!](http://www.youtube.com/watch?v=fs9JQiTtN6w&feature=player_embedded#!) (Accessed on October 15th, 2013)
- Zaki AM (2004) Tetrodotoxin poisoning associated with eating puffer fish in Suez City (Egypt). In: First International Conference on Natural Toxins, October 6 University, 18–19 December 2004, Egypt, pp 72
- Zenetos A, Koutsogiannopoulos D, Ovalis P, Poursanidis D (2013) The role played by citizen scientists in monitoring marine alien species in Greece. *Cahiers de Biologie Marine* 54: 419–426