

# On the occurrence and health risks of the Silver-cheeked Toadfish (*Lagocephalus sceleratus* Gmelin, 1789) in the marine ecosystem of the Gaza Strip, Palestine

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Manuscript received: 15 July 2019. Revision accepted: 23 August 2019.

**Abstract.** *Abd Rabou AFN. 2019. On the occurrence and health risks of the Silver-cheeked Toadfish (Lagocephalus sceleratus Gmelin, 1789) in the marine ecosystem of the Gaza Strip, Palestine. Biodiversitas 20: 2620-2627.* The Silver-cheeked Toadfish (*Lagocephalus sceleratus* Gmelin, 1789) is one of the most recent invaders into the Mediterranean Sea. It represents a serious ecological risk to Mediterranean biodiversity and fisheries resources and a health risk to public health. The current study comes to handle the occurrence and health risks of the species in the Eastern Mediterranean of the Gaza Strip, Palestine. Frequent visits to local fish markets, meetings, and discussions with stakeholders, and chasing of local media reports were the main tools involved to satisfy the goals of the study, which extended from 2010 to 2019. The first record of the Silver-cheeked Toadfish in the Mediterranean coast of the Gaza Strip was in 2006 as claimed by fisheries parties. The by-catch of the species by fishing gear extended over the entire length of the Mediterranean coast of the Gaza Strip (42 km). The species was said to damage fishing nets, lines and hooks by its strong teeth. Prior to its banning in early 2010s, all pufferfishes including the species in question were sold freely in Gaza fish markets. Several cases of hospitalization have been reported in the Gaza Strip after consumption of the Silver-cheeked Toadfish. The symptoms of TTX intoxication included nausea and vomiting, dizziness, headache, abdominal pain, perioral paraesthesia, and tingling over the entire body. No death cases were reported locally. Many awareness campaigns have been conducted by fisheries parties to warn both fishermen and local people from the ecological and health risks associated with the Silver-cheeked Toadfish and TTX intoxication. Finally, the threats imposed by the Silver-cheeked Toadfish on the Eastern Mediterranean countries including Palestine indicate that potential solutions to the problem should be explored.

**Keywords:** Silver-cheeked Toadfish, *Lagocephalus sceleratus*, Mediterranean Sea, marine ecosystem, occurrence, risks, Gaza Strip

## INTRODUCTION

The Mediterranean Sea is home to a wealth of native as well as numerous invasive (exotic or alien) marine species (Abdul Malak et al. 2011). In general, fish diversity of the Mediterranean Sea is known to decrease from west to east because of the effect of straits, various current systems, salinity level and temperature regime. The Mediterranean Sea seems to be one of the main hot spots of marine bioinvasions on Earth, because of the introductions reported (Rilov and Galil 2009; Abdul Malak et al. 2011). The routes of invasive or non-indigenous species include the Suez Canal, the Gibraltar Strait, ship ballast water and accidental release. The most important of which is the Suez Canal of Egypt, which was constructed in 1869 to connect between the Mediterranean and Red Seas. The Canal (162.5 km) provides a limited chance for Red Sea species to migrate to the Mediterranean Sea (Lessepsian migrants) and vice versa (anti-Lessepsian migrants). The number of Lessepsian migrants exceeds by far the number of anti-Lessepsian migrants (Cevik et al. 2002). Some of the Lessepsian migrants have been considered to be very successful colonizers of Mediterranean marine ecosystems (Golani 1996; Golani and Azzurro 2007). In this regard, Lessepsian migration is not only expected to continue but

to increase in intensity as a result of the global climate change and the overall increase of seawater temperature that cause a poleward shift in species distribution. This phenomenon is now described as the tropicalization of temperate regions (Encarnação et al. 2019).

The relatively shallow water (around 10 meters) of the Suez Canal is considered as a major physical barrier for the migration of deep water species from the Indo-Western Pacific Oceans and the Red Sea. Accordingly, most of the invasive species can be found at depths of less than 70 m in the Eastern Mediterranean (Peristeraki et al. 2006). Such Lessepsian migrants impact negatively fisheries, biodiversity, and habitats of the Mediterranean Sea. In spite of its small area, the marine ecosystem of the Gaza Strip in the Mediterranean Sea is vulnerable to the adverse impacts of invasive species; particularly the aggressive predatory Silver-cheeked Toadfish (*Lagocephalus sceleratus*) (Abu Amra 2018), which was considered as one of the fastest expanding Lessepsian immigrants in the Mediterranean Sea up to now (Peristeraki 2006).

The Silver-cheeked Toadfish (*Lagocephalus sceleratus* Gmelin, 1789) is an extremely poisonous marine bony fish belonging to the Tetraodontidae family (pufferfishes). This Lessepsian species is common in the tropical waters of the Indo-Western Pacific Ocean. Nowadays, the fish is

spreading at an alarming rate into the eastern and western Mediterranean, showing easy adaptability to invade new ecological marine habitats and ecosystems. The species was first recorded in 2003 in Gokova Bay of Turkey (Akyol et al. 2005). Soon afterwards, the species established abundant populations along the coasts of nearly, if not all, the Mediterranean countries (Akyol et al. 2005; Golani and Levy 2005; Golani and Azzurro 2007; Kasapidis et al. 2007; Rilov and Galil 2009; Türker-Çakır et al. 2009; EastMed 2010; Kalogirou et al. 2010; Halim and Rizkalla 2011; Torcu-Koç et al. 2011; Yaglioglu et al. 2011; Jribi and Bradai 2012; Milazzo et al. 2012; Nader et al. 2012; Başusta et al. 2013; Beköz et al. 2013; Kalogirou 2013; Azzurro et al. 2014; Ben Souissi et al. 2014; Dulčić et al. 2014; Sulić-Šprem et al. 2014; Tiralongo and Tibullo 2014; Tunçer and Önal 2014; Deidun et al. 2015; Irmak and Altınağaç 2015; Kara et al. 2015; El-Haweet et al. 2016; Akyol and Ünal 2017; Carbonara et al. 2017; Ünal and Göncüoğlu-Bodur 2017).

The Silver-cheeked Toadfish (Figure 1) is considered one of the “worst” biological invaders of the Mediterranean Sea (Nader et al. 2012). Although many species of pufferfishes are economically important and edible in many countries of the Mediterranean region, the Silver-cheeked Toadfish, in particular, is not among the commercial species because of its high toxicity. Therefore, it has been considered to be a serious hazard to consumers since it contains a strong and potent marine toxin called Tetrodotoxin (TTX), which can be very poisonous and even lethal to humans (Sims and Ostman, 1986; Ahasan et al. 2004; Zaki 2004; Bentur et al. 2008; Noguchi and Arakawa 2008; Saoudi et al. 2008; Chamandi et al. 2009; Katikou et al. 2009; Arakawa et al. 2010; Islam et al. 2011; Kheifets et al. 2012; Nader et al. 2012; Kosker et al. 2016; Tamele et al. 2019).

Many morphological and ecological characteristics in addition to feeding and reproduction biology aspects of the Silver-cheeked Toadfish were described by numerous studies (Sabrah et al. 2006; Rilov and Galil 2009; Kalogirou et al. 2010; Aydin 2011; Bariche 2012; Başusta et al. 2013; Kalogirou 2013; Rousou et al. 2014; Ali et al. 2015; El-Haweet et al. 2016; Carbonara et al. 2017). It has two strong teeth in each jaw which are capable of ripping and damaging fishing nets and longlines. The Silver-cheeked Toadfish is carnivorous in the sense that it feeds on a diversity of vertebrate and invertebrate items including fishes, shrimps, crabs, squids, cuttlefish, and other mollusks. In the Mediterranean, the species are being caught as by-catch. Thus, it has no actual economic value and is therefore directly discarded at sea (EastMed 2010). A striking event was mentioned by Kleitou et al. (2018) who reported the incidence of a juvenile Silver-cheeked Toadfish predation by an adult Common Dolphin (*Coryphaena hippurus*) in the Mediterranean Sea. Such an event can potentially guide future management efforts of the invasive Silver-cheeked Toadfish control in the Mediterranean basin.

As shown in the previous paragraphs, the studies concerning the Lessepsian Silver-cheeked Toadfish and its adverse impacts on marine habitats and ecosystems,

fisheries resources and public health are increasing day by day worldwide; particularly in the eastern Mediterranean basin. In the Gaza Strip, the studies concerning the species seem to be lacking. Abd Rabou et al. (2007) described the threats facing the marine environment in the Gaza Strip, of which the invasive or alien species were apart. Abd Rabou (2013) highlighted some of the ecological risks associated with the Lessepsian marine biota in the Mediterranean Sea. He paid attention to the importance of surveying the Lessepsian migrants on the marine ecosystem of the Gaza Strip.

Shaheen (2016) surveyed in his M.Sc. dissertation, supervised by the author, the main fishes cultured in the Gaza Strip. He gave a secondary list on many marine bony fishes existing at the marine ecosystem of the Gaza Strip, of which the Half-smooth Golden Pufferfish (*Lagocephalus spadiceus*) is an example. More recently, Abu Amra (2018) surveyed in her M.Sc. dissertation, supervised by the author too, the marine bony fishes of the Mediterranean coast of the Gaza Strip. She recorded as many as 128 bony fish species belonging to 56 families and 15 orders, of which 30.47% were exotic and seem to be Lessepsian migrants. She added that many poisonous and dangerous species were caught and sold at the fish markets of the Gaza Strip, with the Silver-cheeked Toadfish was a striking example. Accordingly, the current study aims at increasing the knowledge on the occurrence and health risks of the Silver-cheeked Toadfish in the Gaza Strip (Eastern Mediterranean). The significance of this study comes from the fact that it is the first of its kind dealing with the dangerous Silver-cheeked Toadfish in the Gaza Strip.

## MATERIALS AND METHODS

### The Gaza Strip

The Gaza Strip (31°25'N, 34°20'E) is an arid strip of the Palestinian land along the southeastern Mediterranean, having an area of 365 km<sup>2</sup>, and a population of about 2.0 million, of whom the majority are United Nations-registered refugees. The Gaza Strip is one of the most densely populated places in the world. With regard to fisheries, the Gaza Strip has a total number of 3,500 fishermen working on more than 800 fishing vessels of different sizes and capacities. The total production of fisheries resources is about 3,480 tons per year. The fishing area is changeable and the accessibility and exploitation of Gazan fishermen to the very limited fishing area is often governed by Israel. The Directorate General of Fisheries, Ministry of Agriculture, is the competent, responsible and authorized authority to ensure the maximum utilization of fishery resources in the Palestinian Territories. Tens of people are working on fisheries resources in the Ministry of Agriculture. More than half of those people are scientists in agricultural disciplines including aquaculture and marine biology.



**Figure 1.** A *Lagocephalus sceleratus* specimen, recently caught from the Mediterranean coast of the Gaza Strip, Palestine



**Figure 2.** A formalin-preserved specimen of *Lagocephalus sceleratus*, encountered at the museum of the Directorate General of Fisheries, Ministry of Agriculture, Gaza Strip, Palestine

### Procedure

The current study is a cumulative in its style, extending from 2010 to 2019. During the study period, tens of visits have been carried out in the early morning hours to the "Hesba" and auction or "Dalala" markets which are the main fish markets of the Gaza City. The two markets lie close to the Gaza fishing port where most catch landings are taking place. It is worth mentioning that a mix of bony, cartilaginous and invertebrate fish species is commonly traded at the places in question. Irregular visits have been carried out to the fish markets of the Gaza and North Gaza Governorates of the Gaza Strip as well.

Meetings and discussions with Gazan fishermen and the staff of the Directorate General of Fisheries, Ministry of Agriculture have been carried out to fill the gaps needed in data collection concerning the occurrence and toxicity of *Lagocephalus sceleratus* in the Gaza Strip. The museums of the Directorate General of Fisheries, Ministry of

Agriculture and the Biology Departments of the local universities were reached as well to investigate the preserved fish specimens (Figure 2). Local media reports regarding the species have been chased by the author as well to collect additional data on the occurrence and health risks of the Silver-cheeked Toadfish in the Gaza Strip. Finally, professional digital cameras have been used throughout the study period and photos were taken for documentary and confirmatory purposes.

## RESULTS AND DISCUSSION

### First record and morphometric measurements of the Silver-cheeked Toadfish in the Gaza Strip

As far as the Silver-cheeked Toadfish is concerned, all local fisheries parties confirmed that the first record of the species in the Mediterranean waters of the Gaza Strip, Palestine was in 2006; which means three years after its first record in 2003 in Gokova Bay of Turkey (Akyol et al. 2005). Nowadays, the species has been caught off the coasts of nearly all Mediterranean countries as pointed out by many authors (Golani and Levy 2005; Nader et al. 2012; Alshawy et al. 2019). Local morphometric measurements of a single sample of the Silver-cheeked Toadfish caught in the Mediterranean waters of the Gaza city, Gaza Strip in 2019 were done using a measuring board (Table 1). The relative proportions of the species as shown in Table 1 seem to correspond to those reported by many studies for specimens recorded from the Red and Mediterranean Seas (Kasapidis et al. 2007; Kalogirou et al. 2010 and Deidun et al. 2015).

The Silver-cheeked Toadfish is the worst among other pufferfishes caught from the Eastern Mediterranean coast of the Gaza Strip (Table 2). All these pufferfishes were known to contain toxins in some or all of their tissues as declared by the Directorate General of Fisheries, Ministry of Agriculture and pointed out by Abu Amra (2018). The most severe case of these puffers, having adverse impact on human health is the Silver-cheeked Toadfish. In Egypt, which is a very close country to Palestine, Halim and Rizkalla (2011) pointed out that the species rapidly extended to Egyptian waters where it became abundant in the fish catch. They added that the species proved to be a serious hazard to consumers, causing paralysis of the mouth and limbs. Puffers include approximately 130 species worldwide within the Tetraodontidae family, among which many are found in the eastern and western Mediterranean Sea (Chamandi 2009; Kalogirou et al. 2010; Rousou et al. 2014; Enajjar et al. 2015; Farrag et al. 2015a and b; El-Haweet et al. 2016; Vella et al. 2017 and Alshawy et al. 2019). The Suez Puffer (*Lagocephalus suezensis* Clark & Gohar, 1953), which is considered rare in the Mediterranean waters of the Gaza Strip, was recorded in the by-catch of other Mediterranean countries (Bilecenoglu et al. 2002; Saad 2005; Ben-Abdallah et al. 2011; El-Haweet et al. 2016).

**Table 1.** Morphometric measurements for a Silver-cheeked Toadfish specimen caught from the Mediterranean waters of the Gaza city, Gaza Strip, Palestine (2019)

| Measurements         | Millimeter (mm) | Relative proportions |
|----------------------|-----------------|----------------------|
| Total Length (TL)    | 480             | 100.0 % TL           |
| Fork Length (FL)     | 457             | 94.7% TL             |
| Standard Length (SL) | 395             | 82.2% TL             |
| Head Length (HL)     | 112             | 24.5 % SL            |
| Body Depth (BD)      | 109             | 23.9 % SL            |
| Eye Diameter (ED)    | 36              | 32.1 % HL            |

**Table 2.** Species of poisonous pufferfishes encountered at the marine ecosystem of the Gaza Strip, Palestine

| Order: Tetraodontiformes      |   |                               |
|-------------------------------|---|-------------------------------|
| Family                        | Scientific name   | Common name                   |
| Tetraodontidae (Pufferfishes) | <i>Lagocephalus sceleratus</i>                            | Silver-cheeked Toadfish       |
|                               | Gmelin, 1789  | Toadfish                      |
|                               | <i>Lagocephalus spadiceus</i> , Richardson, 1845          | Half-smooth Golden Pufferfish |
|                               | <i>Lagocephalus laevigatus</i> , Linnaeus, 1766           | Smooth Puffer                 |
|                               | <i>Lagocephalus suezensis</i> Clark & Gohar, 1953         | Suez Puffer                   |
|                               | <i>Torquigener flavimaculosus</i> , Hardy & Randall, 1983 | Yellow-spotted Puffer         |

**Local naming and capture of the Silver-cheeked Toadfish**

Gaza fishermen and local people claimed that the local name of the species and its relatives of the Tetraodontidae family (Table 1) is known locally as *Arnab*, which means rabbit. Such a name refers to the way of removing and cleaning the skin of the fish, which resembles that of the Domestic Rabbit *Oryctolagus cuniculus* and the Cape Hare *Lepus capensis* (Mammalia: Lagomorpha) which are delicious meals for Gazans.

With regard to the capture of the species, Gaza fishermen pointed out that the sites of fisheries efforts including the by-catch of the Silver-cheeked Toadfish and other pufferfishes extended over the entire length of the Palestinian coast in the Gaza Strip from Beit Lahia north to Rafah south (a distance measuring about 42 km in the eastern Mediterranean). They also ensured that the species is an occasional capture of the Palestinian fisheries. It is often by-caught using all kinds of fishing gear such as gill nets, trammel nets, trawling, longlines, etc. In spite of discarding the species in the seawater, they added that the species has increased in abundance in the last couples of years. The fact that the Silver-cheeked Toadfish is commonly by-caught using different fishing gear including nets and longlines was confirmed by other studies along the coasts of Mediterranean countries (Nader et al. 2012; Farrag et al. 2015a, b; El-Haweet et al. 2016; Kosker et al. 2016).

**Impact of the Silver-cheeked Toadfish on fisheries and fishing gear**

Although the impact seems to be minimal in the marine ecosystem of the Gaza Strip because of its small fishing area, desertification, overexploitation, and clear fragility (MEnA 2001; Abd Rabou et al. 2007 and Abd Rabou 2013), many fishermen claimed that this invasive species has the ability to damage their fishing nets, lines and hooks by its strong teeth. They, at the same time, ensured the ability of the Silver-cheeked Toadfish to attack fishes caught in the nets and longlines and as a result, it seriously damages both fishing gear and catches. This phenomenon has also been observed in other countries such as Lebanon, Tunisia, Cyprus, Greece and other Mediterranean countries (EastMed 2010; Nader et al. 2012; Ben Souissi et al. 2014; Ünal et al. 2015 and Öndes et al. 2018). With regard to the impact of the species on the marine catch, Kalogirou et al. (2010) confirmed the destruction of nets in many Mediterranean countries including Turkey, Lebanon and Egypt due to entangling or to predation by the Silver-cheeked Toadfish on already entangled fish. Kalogirou et al. (2010) added that the species can reduce local stocks of squids and octopuses through predation. Such impacts of pufferfishes on fishing gear forced fishermen in many countries to modify their fishing techniques and habits (EastMed 2010). The impacts of the species on fishing gear make it as a major nuisance to fishermen and fisheries. As a result, many Mediterranean countries have banned the fishing and trade of the species. Mitigation measures including fishing in deeper grounds, attaching the hooks to steel lines to prevent their loss to biting, and manufacturing fishing nets with stronger and more resistant material have been suggested as well (Kalogirou et al. 2010).

**Trade of the Silver-cheeked Toadfish in the Gaza Strip**

The author ensured that several specimens of the Silver-cheeked Toadfish have been introduced surreptitiously and very cautiously among other commercial fishes to be sold at the local markets (Figure 3). Before banning the fish in early 2010s, the species was sold freely at many fish markets (Figure 4). Nowadays, there is a state of consciousness was formed by the fishermen, most of them get rid of the poisonous fishes immediately after fishing and they did not mix them with other fish to be sold at markets.

**Dialogue on and uncertainty of the toxicity of the Silver-cheeked Toadfish**

Although all fisheries parties of the Gaza Strip including Gaza fishermen and the Directorate General of Fisheries, Ministry of Agriculture confirmed the toxicity of the Silver-cheeked Toadfish and other pufferfishes for possible consumers, others claimed that they ate fishes belonging to pufferfish family and did not experience any poisoning features. More recently, many fishermen met by the author confirmed their eating to larger pufferfishes including the Silver-cheeked Toadfish after cleaning the fishes from their skins and all poisonous viscera. One added that the heads of the Silver-cheeked Toadfish were used to make soaps. In light of these opinions, many scientific interpretations should be considered.



**Figure 3:** The Silver-cheeked Toadfish was sometimes displayed among other bony fishes for sale in a fish market in North Gaza, Palestine



**Figure 4:** Free trade of the Silver-cheeked Toadfish before its banning in the Gaza Strip, Palestine in early 2010s

One way to interpret such claims is that the most caught individuals of the Silver-cheeked Toadfish and other pufferfishes in the Gaza Strip have small sizes (Personal Observations). In this regard, many studies showed a significant positive correlation between toxicity levels and size of pufferfishes. Katikou et al. (2009) pointed out that the toxicity levels of individuals smaller than 16 cm in length are not lethal to humans. Several studies supported such results and pointed out that younger specimens contain low amount of TTX or even no toxin at all (Sabrah et al. 2006; Saoudiet al. 2008; Katikou et al. 2009; Simon et al. 2009; Ali et al. 2011). By contrast, larger specimens are known to be poisonous and lethal to humans (Katikou et al. 2009). This means that the Silver-cheeked Toadfish accumulates TTX as a biological defense agent with time as it matures. Accordingly, the larger samples seem to be more poisonous than smaller ones (Ahasan et al. 2004; Noguchi and Arakawa 2008; Saoudi et al. 2008; Arakawa et al. 2010 and Rambla-Alegre et al. 2017). Another way to interpret such surprising results is the fact that TTX of the Silver-cheeked Toadfish concentrates mainly in the gonads and liver and to a lesser extent in the skin, muscles and other organs. This was confirmed in an Egyptian study conducted by Ali et al. (2011) who revealed that the toxicity of the Silver-cheeked Toadfish showed the highest value for ovaries, intestine, and liver, while the muscle and skin had lowest toxicities. Locally, the gonads, skin, liver and even the head itself are commonly not eaten and they are thrown before cooking. This may contribute to lower the risks of poisoning by consumers. In contrast, such gonads and livers are considered vey delicious in certain areas of the world, and their eating by some people causes hospitalization and even deaths (Arakawa et al. 2010; Nader et al. 2012 and Tamele et al. 2019).

#### **Local cases of hospitalizations because of TTX intoxication**

In spite of the previous dialogue, several cases of hospitalization have been reported in the Gaza Strip after consumption of the Silver-cheeked Toadfish as pointed out by the Directorate General of Fisheries, Ministry of Agriculture and many fishermen and local people. In contrast, death cases following the consumption of the

Silver-cheeked Toadfish have never been stated to happen in the Gaza Strip as claimed by both fishermen and people. A lot of studies pointed out cases of hospitalization and even fatal intoxications related to the consumption of the Silver-cheeked Toadfish worldwide including the Mediterranean countries (Zaki 2004; Bentur et al. 2008; Chamandi et al. 2009; Katikou et al. 2009; Kalogirou et al. 2010; Nader et al. 2012; Beköz et al. 2013; Ben Souissi et al. 2014; Kosker et al. 2016 and Ünal and Göncüoğlu-Bodur 2018). In spite of these health risks, the Silver-cheeked Toadfish was encountered to be illegally sold along the Mediterranean coasts of Turkey, Lebanon, Egypt, and many other countries as stated by Aydin (2011) and Halim and Rizkalla (2011). According to Aydin (2011), the severity of the intoxication depends much on the amount of TTX ingested, in addition to the age, health status, and sensitivity of the person ingesting TTX. Arakawa et al. (2010) pointed out that there is no fundamental treatment focusing on eliminating the toxin completely from the body, and no antidotes or antitoxins exist for TTX.

Even in Japan and its neighboring countries, where pufferfishes including the Silver-cheeked Toadfish are highly consumed, still cases of intoxication and deaths occur because the fishes in question are prepared sometimes by unlicensed cooks or uncertified handlers (Ahasan 2004 and Chamandi 2009). Based on the Japanese regulations, which are considered as the most elaborate regarding pufferfish species consumption, the Silver-cheeked Toadfish is labeled as a non-edible fish due to its high toxicity (Nader et al. 2012).

#### **Symptoms of TTX intoxication in the Gaza Strip**

Poisoning after eating the Silver-cheeked Toadfish containing TTX is widespread worldwide. In the Gaza Strip, many people were poisoned and hospitalized. They were said to show many symptoms of poisoning including nausea and vomiting, dizziness, headache, abdominal pain, perioral paraesthesia, and tingling over the entire body. More or less of these symptoms were encountered among people after consuming pufferfishes containing TTX as pointed out by many authors (Bentur et al. 2008; Islam et al. 2011 and Kheifets et al. 2012). In Israel, Eisenman et al. (2008) pointed out that a total of 13 cases of TTX

poisoning were registered by Israel Poison Information Center in December 2008 due to the consumption of the Silver-cheeked Toadfish. The symptoms of poisoning were more or less similar to those revealed by Gaza poisoning cases. The symptoms included perioral paraesthesia, tingling over the entire body, nausea and vomiting, dizziness, headache, abdominal pain, and muscular paralysis of the limbs. Although a few persons died from rapidly developing respiratory arrest in many countries (Bentur et al. 2008), death was not developed in the Gaza Strip after TTX intoxication as previously mentioned.

#### Local efforts discussing the toxicity of the Silver-cheeked Toadfish

In spite of the toxicity of the Silver-cheeked Toadfish, many awareness campaigns have been carried out mainly by the Directorate General of Fisheries, Ministry of Agriculture; in order warn fishermen and local people from the health risks associated with the consumption of pufferfishes in general and the Silver-cheeked Toadfish in particular. The author himself participated in a workshop dealing with such events on October 20, 2014. Moreover, inspectors and observers from the Directorate General of Fisheries, Ministry of National Economy, Ministry of Health and marine police usually visit fish markets to prevent the sale of poisonous pufferfishes to consumers. At the same time, the inspectors warn against the dangers of pufferfishes, especially the Silver-cheeked Toadfish fish on the marine environment and the public health.

The author himself held several scientific meetings with news and radio sites to warn against handling and eating the exotic Silver-cheeked Toadfish because of its health risks. Additionally, the author wrote some short essays and Facebook posts aimed at showing the dangers of the Silver-cheeked Toadfish on the marine ecosystem and public health and disseminating them to some local websites. These public awareness campaigns launched by the different parties form a good step in establishing an early warning system against pufferfishes in the Gaza Strip. According to Nader et al. (2012) and Azzurro et al. (2016a and b), public awareness campaigns are very essential to prevent the ecological and health impacts of the Silver-cheeked Toadfish. In a developed country like Italy, Azzurro et al. (2016b) pointed out that escalating public campaigns were set to inform Italian citizens on the health risks associated with TTX intoxication due to consumption of the Silver-cheeked Toadfish. Both news media and local communities responded rapidly to the initiative generating an increasing flow of information. In Spain, the number of web pages bearing information on the Silver-cheeked Toadfish jumped from 73 in 2015 to 1220 in 2016 (Azzurro et al. 2016a). In Tunisia, the Tunisian Ministry of Agriculture was found to conduct information campaigns regarding the Silver-cheeked Toadfish. The Ministry publishes posters advertising the toxicity of the species, written in Arabic language. The poster bans the landing, marketing, and consumption of this species. It explains to the public that the TTX is very concentrated in the gonads and liver of the fish and that it is resistant to cooking (Ben Souissi et al. 2014).

In conclusion, the Silver-cheeked Toadfish is considered a highly toxic species and therefore it is not targeted for human consumption in the Gaza Strip as the case in other Mediterranean and non-Mediterranean countries. With the exception of some violations, the Silver-cheeked Toadfish along with other pufferfishes are not landed on the local markets as a commercial species and do not have any economic value as stated by the Directorate General of Fisheries, Ministry of Agriculture. The need for continuous public information campaigns dealing with the ecological, socio-economic and health risks imposed by the Silver-cheeked Toadfish and the development of an early warning system of its spread is very essential. The species poses threats on several levels in the Eastern Mediterranean countries and therefore potential solutions to the problem should be explored.

#### ACKNOWLEDGEMENTS

The author would like to thank the staff of the Directorate General of Fisheries Resources, Ministry of Agriculture, and all Gaza fishermen who provided the current study with the valuable information needed.

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