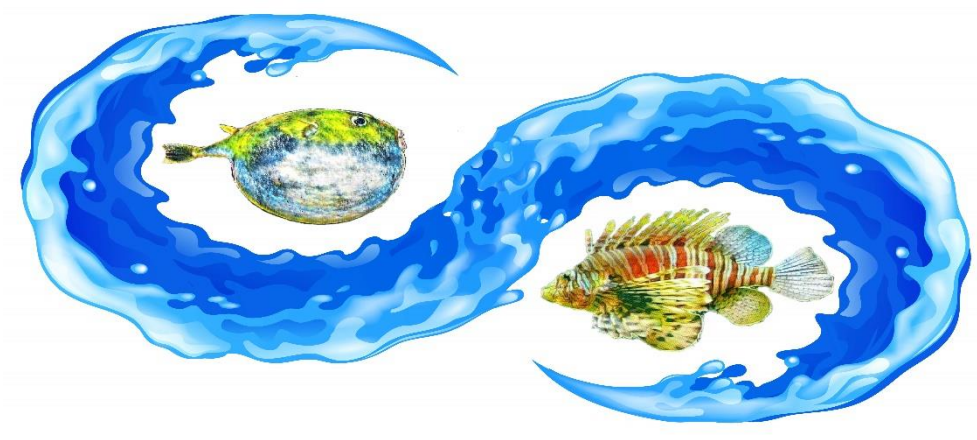
ISSN: 2458-8989

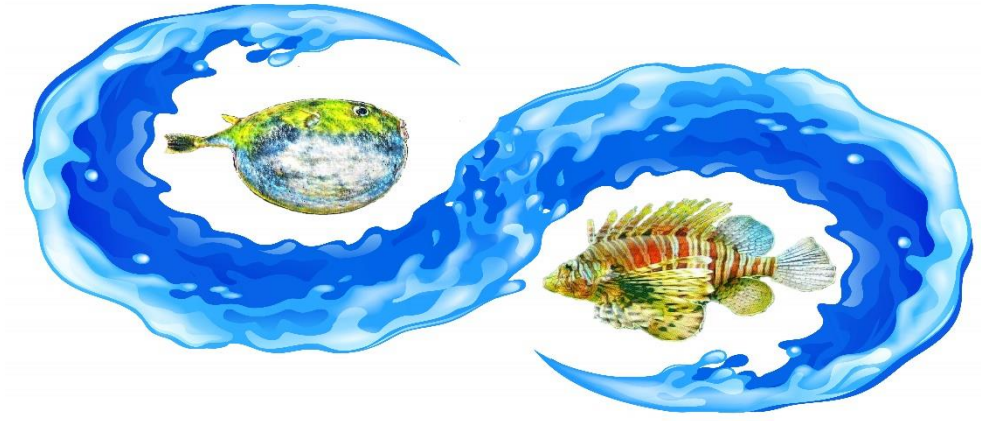


2th International Symposium on Pufferfish/Lionfish
20-22 May 2022, Turkey

Abstract and Proceeding Book

Edited by

Cemal Turan



2th International Symposium on Pufferfish/Lionfish
20-22 May 2022, Turkey

ABSTRACT AND PROCEEDING BOOK OF 2TH INTERNATIONAL SYMPOSIUM ON PUFFERFISH/LIONFISH

20-22 MAY 2022

ISKENDERUN-TÜRKİYE

ISSN: 2458-8989

Year: 2022

Citation: Turan, C. (Eds) 2022. Abstract and Proceeding Book of 2th International Symposium on Pufferfish/Lionfish. Published by Natural and Engineering Sciences, Iskenderun, Turkey, 20-22 May 2022. 58pp.

Dear Colleagues,

It was a great honour and pleasure to host the 2th International Symposium on Pufferfish/Lionfish held on 20-22 May 2022 in Turkey, which was organized by

- Republic of Turkey Ministry of Agriculture and Forestry General Directorate of Fisheries and Aquaculture,

- General Directorate of Agricultural Research and Policies, Mediterranean Fisheries Research, Production and Training Institute,

- Iskenderun Technical University Marine Science and Technology Faculty,

- Nature and Science Society.

The symposium bought together leading scientists in the domain of interest from around the world. Around a hundred participants from 15 different countries presented oral and poster presentations. We would like to thank all participants for their attendance and contribution to the symposium. This book, which has a unique source for researchers, administrative, NGOs, and fishers interested in pufferfish and lionfish, contains abstracts of the presentations (both oral and poster).

Many thanks to the scientific and organizing committee, and the others worked voluntarily.

Yours sincerely,

Cemal Turan

Chair of the Symposium

Symposium Committees

Honorary Presidents

Dr. Tolga DEPCİ
Rector of Iskenderun Technical University, İskenderun, Turkey

Dr. Mustafa Altuğ ATALAY
General Directorate of Fisheries and Aquaculture, Ankara, Turkey

Symposium Chair

Dr. Cemal Turan
Iskenderun Technical University, İskenderun, Turkey

Scientific Committee

Dr. Adnan Ayaz, Turkey
Dr. Adriana Vella, Malta
Dr. Akın Savaş Toklu, Turkey
Dr. Alan Deidun, Malta
Dr. Altan Lök, Turkey
Dr. Athanasios Exadactylos, Greece
Dr. Aydın Ünlüoğlu, Turkey
Dr. Aylin Ulman, Turkey
Dr. Azza Elganiny, Egypt
Dr. Bayram Öztürk, Turkey
Dr. Caner Enver Özyurt, Turkey
Dr. Cem Dalyan, Turkey
Dr. Daniel Golani, Israel
Dr. Deniz Ayas, Turkey
Dr. Deniz Ergüden, Turkey
Dr. Deniz Yağlıoğlu, Turkey
Dr. Earl Harris Holden, USA
Dr. Enajjar Samira, Tunusia
Dr. Erhan Mutlu, Turkey
Dr. Ernesto Azzurro, Italy
Dr. Fatih Özoğul, Turkey
Dr. Fevzi Bardakçı, Saudi Arabia
Dr. Gökçen Bilge, Turkey

Dr. Halit Filiz, Turkey
Dr. Jakov Dulčić, Croatia
Dr. Jamila Ben Souissi, Tunusia
Dr. Levent Bat, Turkey
Dr. Mahir Kandemir, Turkey
Dr. Moez Shaiek, Tunusia
Dr. Maria Corsini-Foka, Greece
Dr. Manal R. Nader, Lebanon
Dr. Marcelo Vasconcellos, Italy
Dr. Mevlüt Gürlek, Turkey
Dr. Michel Bariche, Lebanon
Dr. Murat Bilecenoğlu, Turkey
Dr. Mustafa Altuğ Atlay, Turkey
Dr. Mümtaz Tıraşın, Turkey
Dr. Nuri Başusta, Turkey
Dr. Okan Akyol, Turkey
Dr. Shoichiro Ishizaki, Japan
Dr. Stefanos Kalogirou, Greece
Dr. Türker Bodur, Turkey
Dr. Vahdet Ünal, Turkey
Dr. Yakup Kutlu, Turkey
Dr. Zafer Tosunoğlu, Turkey
Dr. Zeliha Aka Erdoğan, Turkey

Organizing Committee

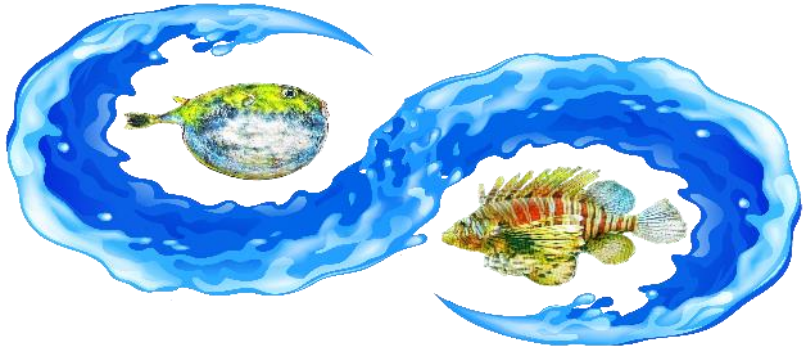
President
Dr. Mustafa Altuğ ATALAY, General Directorate of Fisheries and Aquaculture, Ankara, Turkey
Members
Dr. Cemal TURAN, Iskenderun Technical University, Marine Science and Technology Faculty, İskenerun, Turkey

Dr. Mahir KANYILMAZ, General Directorate of Fisheries and Aquaculture, Ankara, Turkey

Serkan ERKAN, General Directorate of Agricultural Research and Policies, Mediterranean Fisheries Research, Production and Training Institute, Antalya, Turkey

Dr. Yakup KUTLU, Natura and Science Society, Turkey

Contents



2th International Symposium on Pufferfish/Lionfish
20-22 May 2022, Turkey

Abstracts for Oral Presentations

FROM THREATS TO TIMELY MITIGATION MEASURES THROUGH ACCURATE SPECIES IDENTIFICATION: A MEDITERRANEAN PERSPECTIVE

Adriana Vella*, Noel Vella
Conservation Biology Research Group, Department of Biology, University of Malta, Msida, Malta

*Corresponding author: adriana.vella@um.edu.mt

Abstract

The tropicalization of the Mediterranean Sea is favouring the occurrence and spread of non-indigenous species (NIS), especially thermophilic NIS, in the region. Consequently, in the last few decades the Mediterranean Sea has experienced an increasing number of casual records forming established viable populations. These changes call for closer monitoring of coastal habitats and biodiversity towards achieving timely assessment and management, the basis of which relies strongly on the correct identification down to the species level. However, a number of records are identified either to higher taxonomic levels or else the species are misidentified due to lack of regional expertise on specific non-indigenous taxa. This is further exacerbated in taxonomic groups that contain species with overlapping characters. Consequently, a number of records of NIS in the Mediterranean Sea are subject to revisions as new data on species distributions, identification and nomenclature are updated. Such examples include the Diamondback puffer, *Lagocephalus guentheri*, which closely resembles the Half-smooth golden pufferfish, *Lagocephalus spadiceus*, leading to morphological misidentification and incorrect knowledge on the expansion and establishment of the former in the Mediterranean Sea. Thus to minimize these inaccuracies, whenever possible the correct taxonomic identification must rely on multiple tools, where morphological data has to be backed by molecular data, namely DNA barcoding, with comparative analyses considering genetic data from specimens collected from native range of the NIS. The increasing concerns of stakeholders, including fishermen and other sea users, on the presence of alien species and their possible negative impact on the blue economy, call for more collaboration, knowledge sharing and networking between various entities to be able to quickly and correctly identify the alien species, better track and predict expansion patterns, while prioritizing on specific management measures for these invasive species. The research disclosed here has been supported by BioCon_Innovate Research Excellence Grant from the University of Malta awarded to AV and the Biological Conservation Research Foundation–BICREF.

Keywords: DNA barcoding, management measures, Mediterranean Sea, non-indigenous species, species identification

WHAT WE HAVE LEARNED FROM INVASIVE ALIEN SPECIES

Bayram Öztürk
Turkish Marine Research Foundation

*Corresponding author: ozturkb@istanbul.edu.tr

Abstract

The biota of the Mediterranean and the Black Sea has started to change in the last few decades, due to the introduction of alien species as a result of ships' ballast water, lessepsian migration, Atlantic influx, intentional or unintentional introduction as well as climate change. The Black Sea has suffered from the alien jellyfishes *Mnemiopsis leidyi* for many years since the late 1980s, which led to biodiversity loss and decrease in fish catch, mostly of small pelagic species such as anchovy. The Sea of Marmara has been also negatively impacted by the combjelly *M. leidyi*, with the recovery of small pelagic fish species only taking place in recent years. Lessepsian fishes and invertebrates are increasing in the Sea of Marmara but overall impacts are not yet known. The eastern Mediterranean Sea has been invaded by numerous lessepsian species entering through the Suez Canal while others are found in the central and western Mediterranean Sea. A number of fish and invertebrate species originating in the Atlantic have also extended to the eastern part of the Mediterranean Sea. In total, over 900 species are alien species in the Mediterranean and the Black Sea. As a consequence of increasing populations of lessepsian species, the consumption of several of such species has started, which is influencing the local markets, mostly in the eastern Mediterranean region. The new market for alien species is showing an increasing trend. Several invasive alien species have negative impacts on human health, tourism and fisheries, such as puffer fishes and jellyfishes, and need to be particularly monitored. Important impacts on biodiversity are already reported, due to habitat displacement and competition with native species. Disseminating information and raising public awareness, in particular on invasive alien species, are also important tools at a regional level. For the purpose of monitoring and protecting marine biodiversity, regional cooperation on the enforcement of legal measures is essential so as to minimize and reduce the impacts of NIS and invasive alien species both in the Mediterranean and the Black Sea

Keywords: *Lessepsian migration*, Mediterranean Sea, Black Sea

CONTRIBUTION TO PUFFER TOXICITY: TTX ANALYSIS OF THREE PUFFERFISH SPECIES IN THE EASTERN MEDITERRANEAN

Aylin Ulman[1], Hüseyin Tekin[2], Ayhan Ibrahim Aysal[3], Hasan Deniz Akbora[4]*, Burak Ali Çiçek[4]

[1] Mersea Marine Consulting, Fethiye, Turkey, 48300
[2] Encon Laboratory, Cankaya, Ankara, Turkey
[3] Department of Pharmaceutical Chemistry, Faculty of Pharmacy, Gazi University, 06330, Ankara, Turkey
[4] Department of Biological Sciences, Faculty of Arts and Sciences, Eastern Mediterranean University 99628, Famagusta, North Cyprus, Mersin 10 Turkey
*Corresponding author: hasan.deniz@emu.edu.tr

Abstract

The Mediterranean Sea has thirteen pufferfish species in its waters. While none are native to this sea, a few are circumtropical in distribution, and thus are not considered non-native or alien species. Pufferfish generally have a reputation for being toxic, but this varies between species, as many are harmless. To better understand the toxicity of Mediterranean pufferfish species, we examined the toxicity, specifically of the tetrodotoxin (TTX) content of three lesser known pufferfish species (*Sphoeroides pachygaster, Lagocephalus guentheri* and *Lagocephalus suezensis*) to determine if they too pose a threat to human health. The blunthead puffer Sphoeroides pachygaster is a rarely encountered circumtropical species, usually found in deeper waters (between 200-400 m), and tested for the Eastern Mediterranean first time here. *Lagocephalus guentheri*, previously misidentified as *L. spadiceus*, was the first pufferfish to be reported from the Mediterranean in 1950 from Egypt. *L. suezensis* was first reported in 1977 from Lebanon and appears very similar to the highly toxic *L. sceleratus* but reaches a much smaller maximum size, with a brown dorsal background compared to the grey one for *L. sceleratus*. Tissues of these three species were analyzed for TTX content using the LC/MS method. The results revealed *S. pachygaster* and L. guentheri to be non-toxic, while *L. suezensis* is sometimes toxic, and thus should not be consumed

Keywords: *Lagocephalus suezensis*; *Lagocephalus guentheri*; LCMS; Tetraodontidae; aquatoxicology

THE FIRST RECORD OF AGE FINDINGS OF *SPHOEROIDES PACHYGASTER* (MULLER AND TROSCHEL, 1848) IN THE EASTERN MEDITERRANEAN SEA

Merve Karakuş*, İsmail Dal, Coşkun Menderes Aydın

Mediterranean Fisheries Research Production and Training Instıtute

*Corresponding author: merve.karakus@tarimorman.gov.tr

Abstract

The blunthead puffer *Sphoeroides pachygaster* (Muller and Troschel, 1848) is found at depths of between 50-250 m up to 400 m and in all oceans of central and temperate latitudes. It is also widespread in the Mediterranean. It was recorded for the first time from Baleric Islands in 1979, Israel in 1991, the north Aegean Sea in 2003 and Cyprus in 2005 in the Mediterranean Sea. In the Turkey coasts, reported first record from the northern Aegean Sea in 2003, the northern Mediterranean Sea in 2011, additional record from eastern Mediterranean in 2006, new occurrence on northern Aegean Sea in 2017. However, there has been no information on the age pattern of this species in the Eastern Mediterranean region. This study is conducted to first age findings of Sphoeroides pachygaster obtained by trawling from different locations of the Mediterranean coasts of Turkey in March 2022. A total of 5 specimens collected at depths 140-240m. Total length ranged from 19 to 41,8 cm and body weight varied between 10-1405 g for Sphoeroides pachygaster. Age determinations were carried out using vertebrae, and age groups were found to be between 1 and 5. This is the first age findings of *Sphoeroides pachygaster* in the Eastern Mediterranean Sea in Turkish waters.

Keywords: Blunthead puffer, *Sphoeroides pachygaster*, age estimate, vertebrae, Eastern Mediterranean.

AN IN-DEPTH STUDY ON *LAGOCEPHALUS SCELERATUS* (GMELIN, 1789) BIOLOGY, ECOLOGY, AND CATCHABILITY FROM FINIKE, TURKEY

Hasan Ersonmez[1], Caner Ozyurt[1*], Sinan Mavruk[1], Taner Yildiz[2], Aylin Ulman[3]

[1] Fisheries Faculty, Çukurova University, 01330, Balcali, Adana, TURKEY
[2] Faculty of Aquatic Sciences, Istanbul University, Fatih 34134, Istanbul, TURKEY
[3] Mersea Marine Consulting, 531 Sokak, Fethiye, Muğla, TURKEY

*Corresponding author: cozyurt@cu.edu.tr

Abstract

Seven species of pufferfish are found in Turkish waters, but the silver-cheeked toadfish (*Lagocephalus sceleratus*) is the one of highest concern. It is highly invasive and controls on its populations is needed to mitigate its negative impacts on humans, fishers, the economy, and marine ecosystem health. Despite its numerous negative impacts, relatively few studies have been dedicated to understanding its biology and ecosystem effects. This study thoroughly investigated the biology, diet, and catchability of the *L. sceleratus* stock from Finike, Turkey from March 2017 to March 2018, to understand its habits and effects which can help to manage this invasion. A total of 751 fish were sampled in this study, of which eight were juveniles, 414 males, and 328 females for an M/F ratio of 1.26/1. It becomes sexually mature at three and a half years in age, and Lm_{50} was 41.39 cm for males and 42.08 cm for females. Relative fecundity was RF=415.49 ±16.23 oocytes/g body weight (min.: 348, max.: 423 oocytes/gram). The average fecundity for the sampled female specimen was 937,978 ±98,147 oocytes averaging 42 cm and 1.121 kg. Its spawning season in Finike Bay lasts from April to August, peaking in July. Its diet is mostly comprised of crustaceans in spring, fish in summer, and both crustaceans and fish nearly equally in winter. Cannibalism on other pufferfish was high at 26% of their fish diet, of those species that could be identified, and ingestion of fishing gear parts was found in about 10% of sampled fish. Longlines caught mature fish while trammel nets and handlines caught mostly immature fish. A slight modification of longlines using steel branch lines and a swivel hook resulted in double the CPUE values than standard longlines.

Keywords: Non-indigenous species (NIS), Tetraodontidae, aging, fecundity, feeding

PARENTAL SPECIES IDENTIFICATION OF HYBRID PUFFERFISH AMONG TAKIFUGU GENUS USING MITOCHONDRIA DNA AND MICROSATELLITE MARKER

Haruka Nishikawa, Natsumi Koyama, Shoichiro Ishizaki*
Department of Food Science & Technology, Graduate School of Marine Science and Technology, Tokyo University of Marine Science and Technology

*Corresponding author: ishizak@kaiyodai.ac.jp

Abstract

Pufferfish contain tetrodotoxin and toxicity varies among species. In Japan, the edible species and the portions are described in 'The Guideline for Eating Pufferfish' issued by the Ministry of Health, Labour, and Welfare. In this guideline, species identification is the most important index for ensuring food safety. However, natural hybrid pufferfish individuals have frequently been collected along Japan's coast in recent years. Difficulties with morphological authentication mean that it is necessary to establish new molecular methods to identify parental species of hybrid pufferfish. In this study, we used mitochondria DNA to identify maternal species and to identify paternal species and focused on microsatellite data obtained by previous research about genetic linkage map of *T. rubripes*. We searched for polymorphic locus between *T. rubripes* and *T. porphyreus*. Consequently, a microsatellite marker composed of GCA repeats was found to be useful in distinguishing between two species by the difference of the number of GCA repeats (*T. rubripes* shows 21-44 repeats, *T. porphyreus* shows 5-9 repeats). We also searched the number of GCA repeats on the same locus for other 8 species of *Takifugu* genus. These other 8 species show 5-9 GCA repeats as *T. porphyreus*. Therefore, GCA marker is useful for distinguishing *T. rubripes* from other *Takifugu* species, however this marker is not useful for species identification of *Takifugu* genus except *T. rubripes.* The results suggested that the method combining use of maternal species identification by mitochondrial DNA and the microsatellite marker is applicable to identify hybrids. We need to search other microsatellite loci which shows interspecific polymorphism.

Keywords: hybrid pufferfish, species identification, microsatellite marker, mitochondrial DNA

ESTIMATION OF CPUE AND CPUA OF PUFFERFISH (TETRAODONTIDAE) CAUGHT BY THE BOTTOM TRAWL FISHERY IN THE EASTERN MEDITERRANEAN COASTS

Cemal Turan
Iskenderun Technical University, Faculty of Marine Sciences and Technology, Molecular Ecology and Fisheries Genetics Laboratory, 31220 Iskenderun, Hatay, Turkey

*Corresponding author: cemal.turan@iste.edu.tr

Abstract

For assessing the relative abundance of pufferfish species, catch per unit of effort (CPUE) and catch per unit of area (CPUA) were calculated by using the area swept method in the Mediterranean coasts of Turkey, comprising the Iskenderun Bay, Mersin Bay, and Antalya Bay. The surveys were conducted seasonally in 2018. The average rate of CPUE for *Lagocephalus sceleratus, L. suezensis, L. spadiceus,* and *Torquigener flavimaculosus* caught by the bottom trawl fishery were 2.2, 0.8, 0.5 and 0.2 kg km^{-2}, respectively. The highest CPUE values were in winter (8.0 kg km^{-2}) for *L. sceleratus* and also lowest was in winter (0.08 kg km^{-2}) for *L. spadiceus*. The highest and lowest CPUE values were at the depth of 20-50 m (2.7 kg km^{-2}) for *L. sceleratus* and 50-80 m (0.08 kg km^{-2}) for *T. flavimaculosus*, respectively. In relation to trawled ground structure, the highest CPUE values (3.5 kg km^{-2}) were found at the sandy bottom for *L. sceleratus*, and the lowest one (0.01 kg km^{-2}) was at the hardy-ground for *T. flavimaculosus.* The average annual CPUA of pufferfish species at the Iskenderun, Mersin, and Antalya bays was estimated as 15.6, 28.4, and 6.81 kg, respectively, with a mean value of 17.3 kg km^{-2}. In seasonal distribution, the maximum value was found to be 124.0 kg in winter at the Mersin Bay; whereas the lowest one was at the Iskenderun Bay with 1.2 kg in autumn. In multiple correspondence analyses, *L. sceleratus* showed great positive contribution to CPUA and CPUA data with no ecological effect. However, *T. flavimaculosus* revealed a high negative contribution in catch numbers with depth and precipitation effects.

Keywords: Pufferfish, bottom trawl, CPUE, CPUA, Mediterranean coast of Turkey

ECONOMIC POTENTIAL OF PUFFERFISH FOR DIFFERENT SECTORS

Servet Ahmet Doğdu [1*], Cemal Turan[2], Mahir Kanyılmaz[3], Azza Elganiny[4]

[1]Iskenderun Technical University, Maritime Vocational School of Higher Education, Underwater Technologies, Iskenderun, Hatay, Turkey
[2]Molecular Ecology and Fisheries Genetics Laboratory, Department of Marine Sciences, Faculty of Marine Sciences and Technologies, Iskenderun Technical University, Iskenderun, Hatay, Turkey
[3]General Directorate of Fisheries and Aquaculture, Ankara, Turkey
[4]National Institute of Oceanography and Fisheries, B.O. Box 182, Suez, Egypt

*Corresponding author: servet.dogdu@iste.edu.tr

Abstract

Pufferfishes are commonly found in tropical and subtropical marine waters and include 28 genera and approximately 184 species all over the world in marine waters within the Tetraodontidae family. The Tetraodontidae family is famous for the occurrence of the powerful marine paralytic toxins in their body called Tetrodotoxin. For this reason, they have no commercial value except for a few types consumed in Eastern countries. In Turkish marine waters, pufferfish belonging to the Tetraodontidae family represented by 7 species, *Lagocephalus lagocephalus*, *L. sceleratus*, *L. suezensis*, *L. guentheri*, *Sphoeroides pachygaster*, *Torquigener flavimaculosus* and *Tylerius spinosissimus*. They were reported as invasive alien species in Turkish Marine Waters. Marine species present a rich source of natural source compounds, such as collagen, gelatin, and hydroxyapatite, which are the most abundant valuable products, which can be an alternative source for pharmaceutical and biomedical applications. Alternative management actions are important to mitigate the negative effects stemming from the potential future invasion of pufferfish. Therefore, this review focused on how pufferfish can be brought into the economy.

Keywords: Pufferfish species, ecomomic potential, natural source, tetraondontidae

THE PROCESSING AND EVALUATION OF PUFFERFISH

Ecem Özer*, Berna Kılınç
Faculty of Fisheries, Fish Processing Technology Department, Ege University, 35100 Bornova-Izmir, Turkey

*Corresponding author: ozerecem@gmail.com

Abstract

Nowadays, the increase in sea temperatures due to the increase in global warming affects the habitats of the species. Pufferfish belong to the family Tetradontidae and occur in tropical and subtropical environments. Due to global warming, puffer fish pass through the Suez Canal to the Mediterranean and spread easily. Pufferfish species have a bad effects on both the ecosystem and fisheries. The absence of an upper predator of this fish in our seas causes its rapid reproduction. For such reasons, it spreads rapidly and harms the environment. Pufferfish have strong jaws and sharp teeth. These characteristics cause them to easily break off fishing nets and fishing gear. This situation may negatively affect small-scale and amateur fishing. So, it is very important to evaluate this fish. Being a poisonous species like a pufferfish poses a risk in terms of consumption. Worldwide consumption is made only in Japan. In order to be consumed, it must be prepared by specially trained and certified people. Otherwise this fish can be dangerous after consuming, causing a death. As a result; the education is necessary to be given to people for processing and consumption of this specie. The use of the poison of puffer fish in the pharmaceutical industry and the use of its skin in both the textile and leather industries should be encouraged. The skin of the puffer fish can be processed so planned to be used in the production of accessory, wallets and bags. In this review, the processing and evaluation of pufferfish will be discussed.

Keywords: Pufferfish, processing, evaluation, global warming.

PUFFERFISH VERSUS LIONFISH: RISK COMPARISON AMONG TURKISH SEAFOOD MARKET

Merve Kaplan[1*], Seda Yıldırım [2]
[1] Canakkale Onsekiz Mart University, Fishing, And Seafood Processing Technology, Canakkale, Turkey
[2] Tekirdag Namık Kemal University, Business Administration, Tekirdag, Turkey

*Corresponding author: mervekaplan843@gmail.com

Abstract

Invasive alien fish (species) have been expanding among the Mediterranean Sea for a long time. Mediterranean countries have to fight against these invasive alien fish to keep native marine biodiversity. Puffer fish and lionfish are accepted as the biggest invasive marine species in the Mediterranean Sea due to their huge population and great spread over several Mediterranean countries. As being a Mediterranean country, Turkey has been under attacked of puffer and lion fish invasion. While the invasion of puffer fish and lion fish is continuing, policy makers try to reduce and end the population of these species. Fishery sector and seafood market are all important economic values in the context of food security and economic development in Turkey. In this context, this study aims to explore the influence of puffer fish and lion fish on blue economy and seafood market in Turkey by comparing these invasive alien fish based on their features. Based on qualitative research approach, this study will review recent studies and news on puffer fish and lion fish. Then, selected studies and news will be analyzed by content analysis to provide risk comparison table. With the help of tables, this study will provide a brief framework for the influence of puffer fish and lionfish on Turkish seafood market. As a result, it is thought to give a practical implications and contribution for the related literature.

Keywords: Invasive alien fish, pufferfish, lionfish, seafood market, risk comparison

THE BIOLOGY AND ECOLOGY OF THE INVASIVE SILVER-CHEEKED TOADFISH (*LAGOCEPHALUS SCELERATUS*), WITH EMPHASIS ON THE EASTERN MEDITERRANEAN

Aylin Ulman[1*], Taner Yildiz[2], Nazli Demirel[3], Ozgur Canak[2], Emre Yemişken[4], Daniel Pauly[5]

[1] Mersea Marine Consulting, 531 Sokak, Apt 4/1, Fethiye 48300, Turkey
[2] Faculty of Aquatic Sciences, Istanbul University, Fatih, Istanbul 34134, Turkey
[3] Institute of Marine Sciences and Management, Istanbul University, Fatih, Istanbul, 34134 Turkey
[4] Faculty of Sciences, Biology Department, Istanbul University, Fatih, Istanbul 34134, Turkey
[5] Sea Around Us, Institute for the Oceans and Fisheries, University of British Columbia, 2202 Main Mall, Vancouver, BC V6T 1Z4, Canada

*Corresponding author: uaylin@hotmail.com

Abstract

Invasive species pose threats to either human health or inflict ecological and/or economic damage. The silver-cheeked toadfish (*Lagocephalus sceleratus*), a Lessepsian species, is one of the most harmful species in the Mediterranean Sea, because of its potent neurotoxin, impacts on marine biodiversity, and the increased costs and labor they inflict on fishers. Since the catch and consumption of this pufferfish is prohibited by almost all countries bordering the Mediterranean, they have now expanded into the entire Mediterranean and Black Sea. We performed a comprehensive study of L. sceleratus covering ecological aspects, growth, reproduction, diet and trophic level based on samples from southwestern coasts of Turkey. The estimated growth parameters were L_∞ = 88.7 cm, K = 0.27 year^{-1}, C = 0.6 and WP = 0.1. Their sexratio was M/F = 1:0.69. Lagocephalus sceleratus appears to be a batch spawner with discontinuous oocyte recruitment and has different spawning seasons in the Eastern Mediterranean which seem to be based on temperature cues which get shorter in duration as one moves north from the Suez. We also report their first positive ecological trait, that they are controlling some other invasive species through their diets, such as lionfish, Red Sea goatfish, rabbitfish and longspine sea urchins, in addition to controlling themselves through cannibalism, which appears to be density-dependent. They are indeed a top predator in the region with a trophic level of 4.1. We suggest that targeted fishing using improved gear-types to reduce fishing gear damages are initiated, and that finding commercial markets for pufferfish could help to naturally fund ongoing control efforts.

Keywords: Cannibalism, growth, Invasive Alien Species (IAS), pufferfish, reproduction, Tetraodontidae

MONITORING DNA DAMAGE IN SUEZ PUFFERFISH (*LAGOCEPHALUS SUEZENSIS*) FROM THE NORTHEASTERN MEDITERRANEAN

Ayşegül Ergenler[1*], Funda Turan[1], Fevzi Bardakcı[2]

[1] Faculty of Marine Science and Technology, University of Iskenderun Technical, 31200, Iskenderun, Hatay, Turkey
[2]Department of Biology, Laboratory of General Biology, University of Ha'il, Ha'il, Saudi Arabia

*Corresponding author: aergenler@gmail.com

Abstract

Industrial effluents, agricultural runoff, and municipal wastewaters contain unknown substances and complex mixtures that are released into the environment and can lead to contamination of surface and subsurface waters. Such activities have endangered the existence of ecosystems and their inhabitants. Changes in genome caused by genotoxic agents led to mutations and pose a burden to the populations of fish species. In the present study, we have used the alkaline Comet assay to detect the genotoxicity in Suez pufferfish (*Lagocephalus suezensis)* sampled from two different gulfs (Iskenderun and Mersin Bay), Northeastern Mediterranean. At the end of study, the Damage frequency (%), Arbitrary unit and Genetic damage index (%) were evaluated in gill and liver cells of *L. suezensis* by Comet assay. The DNA damages at gill and liver cells of *L. suezensis* in the present study were observed with a higher level of DNA damage in gill cells compared to liver cells in both the Iskenderun and Mersin bays. The highest level of DNA damage (55.01±1.02%), arbitrary unit (143.01±7.21) and Genetic damage index (1.43±0.07 %) were found at gill cells of *L. suezensis* from Mersin Bay. Statistically significant differences were found between DNA damage, arbitrary unit and genetic damage index values of the two locations ($p < 0.001$). In conclusion, this study indicates that the Comet assay gives sensitive results in monitoring the pollution, especially the pollution of gulf, and thus it might be used as standard method in regularly monitoring pollution of coastal ecosystem.

Keywords: *Lagocephalus suezensis*, DNA damage, Comet assay, Iskenderun Bay, Mersin Bay

EFFECTS OF PUFFERFISHES ON SMALL-SCALE FISHERIES IN THE ISKENDERUN BAY

Deniz Ergüden*, Ferhat Kabaklı
Iskenderun Technical University, Marine Sciences and Technology Faculty, TR 31220 Iskenderun/Hatay

*Corresponding author: deniz.ergüden@iste.edu.tr

Abstract

So far, there are 7 different pufferfish species recorded in the Mediterranean coasts of Turkey, 4 of these species are *Lagocephalus guentheri* Miranda Ribeiro, 1915, *Lagocephalus sceleratus* (Gmelin, 1789), *Lagocephalus suezensis* Clark & Gohar, 1953 and *Torquigener flavimaculosus* Hardy & Randall, 1983 are widely caught by local fishermen in Iskenderun Bay. In the answers given to the questions asked to the fishermen fishing in the region (in three different shelters), the fishermen stated that they suffered the most damage from the *Lagocephalus sceleratus* species. Besides, in the interviews with the fishermen, they stated that they caught pufferfish up to 3 times the fish they caught under normal conditions, pufferfishes attacked the caught fish and were fed in regions where the high abundance of economically important fishes, therefore, considerably decreased the rate of commercial fish catches. Moreover, the fishermen emphasized that the fish species that decreased due to the increase in pufferfish in the region were sea bass, common dentex, barracuda, red mullet, surmullet, and sardine species. Besides, in the present study, important information about the economic and socio-economic effects of pufferfish and their control methods has been given to the nets and fish caught in the nets of the fishermen in the region who make a living with different fishing methods.

Keywords: Pufferfishes, fisheries, socio-economic effects, Iskenderun Bay, Turkey

MICROPLASTIC ABUNDANCE IN THE GASTROINTESTINAL TRACTS OF *LAGOCEPHALUS SUEZENSIS* FROM THE ISKENDERUN BAY

Nebil Yücel*, Ece Kılıç, Cemal Turan
[1]Iskenderun Technical University, Faculty of Marine Science and Technology, Hatay, Türkiye

*Corresponding author: nebil.yucel@iste.edu.tr

Abstract

Since the establishment of the Marine Strategy Framework, microplastic pollution and its potential impact on marine biota have been a controversial issue. This study was conducted to evaluate the bioindicator potential of invasive *Lagocephalus suezensis* to monitor microplastic pollution in marine environments. For this purpose, gastrointestinal tracts (GIT) of 33 individuals sampled in December 2021 from northeastern Mediterranean were examined. Microplastic abundance in the GIT was detected as 1.6±2.9 item/individuals in total samples and 2.5±3.2 item/individuals in positive samples with a detection rate of 64%. The majority of samples were fiber in shape, black in color and less than 1000 µm in size. The results obtained from this study prove the reality of microplastic pollution in the study area and suggest that further studies are needed to undertake the necessary legislation to control microplastic pollution.

Keywords: Microplastic pollution, pufferfish, northeastern Mediterranean

PUFFERFISH AND LIONFISH CASES IN TURKIYE AND THE TURKISH REPUBLIC OF NORTHERN CYPRUS

Mevlüt Gürlek[1*], Erhan Akbora[2]

[1] Molecular Ecology and Fisheries Genetic Laboratory, Marine Science and Technology Faculty, Iskenderun Technical University, Iskenderun, Türkiye

[2] Amateur Sport Fishing Association, the Turkish Republic of Northern Cyprus (SF-AB)

*Corresponding author: mevlut.gurlek@iste.edu.tr

Abstract

The majority of the poisonous marine fish species in Turkish and the Turkish Republic of Northern Cyprus marine waters entered via the Suez Canal. The spread of pufferfish species poses several risk factors and has implications for human health, biodiversity, and fisheries. Tetrodotoxin, found in pufferfish, is one of the most toxic poisons found in nature. Symptoms generally occur 10-45 minutes after eating the pufferfish poison and begin with numbness and tingling around the mouth, salivation, nausea, and vomiting. These symptoms progress to respiratory failure leading to paralysis, unconsciousness, and death. Venomous characteristics of Pterois spp. can cause some allergic reactions in humans. The stings cause excruciating pain and marked inflammation, with local erythema, edema, heat, paleness and cyanosis. In this study, the poisoning cases and clinical effects of pufferfish and lionfish in Turkey and the Turkish Republic of Northern Cyprus were discussed.

Keywords: Poisonous**,** clinical effects, venom, human health

OCCURRENCE OF NATIVE PARASITE *NEROCILA BIVITTATA* (RISSO, 1816) PARASITIC ON ALIEN LIONFISH PTEROIS MILES (BENNETT, 1828) FROM AEGEAN SEA AND MEDITERRANEAN SEA

Alper Yanar[1*], Cemal Turan[1], Servet Ahmet Doğdu[2]

[1] Department of Marine Sciences, Faculty of Marine Sciences and Technologies, Iskenderun Technical University, Iskenderun, Hatay, Turkey

[2] Department of Underwater Technologies, Maritime Vocational School, Iskenderun Technical University, Iskenderun, Hatay, Turkey

*Corresponding author e-mail: alper.yanar@iste.edu.tr

Abstract

Since 2014, an invasive alien fish species, lionfish *Pterois miles* (Bennett, 1828) has been started to distribute in the Turkish Mediterranean Sea coasts and spread to the Aegean Sea. In the present study, a Cymothoid fish parasite, *Nerocila bivittata* (Risso, 1816) was reported from the pectoral fin of *P. miles* caught from the northeastern Mediterranean (Iskenderun Bay) and the southern Aegean Sea (Bodrum, Turkey). Also this study is the first record of *N. bivittata* on lionfish *P. miles* caught from Iskenderun Bay. Key diagnostic characters of *N. bivittata*, some morphological differences observed between the newly collected material of *N. bivittata* and its previous descriptions, and some newly observed additional characters were presented.

Keywords: Lionfish, cymothoid isopod, Iskenderun and Bodrum coasts

LESSONS FROM THE WESTERN ATLANTIC LIONFISH INVASION TO INFORM MANAGEMENT IN THE MEDITERRANEAN

Aylin Ulman[1*], Fadilah Z. Ali[2], Holden E. Harris[3], Mohammad Adel[4], Sara A. A. Al Mabruk[5], Michel Bariche[6], Allison C. Candelmo[7], Jennifer K. Chapman[8], Burak Ali Cicek[9,10], Kaylin R. Clements[11], Alexander Q. Fogg[12], Stacy Frank[13,14], Stephen R. Gittings[15], Stephanie J. Green[16], Jason M. HallSpencer[17,18], Jim Hart[13,14], Summer Huber[7], Philip E. Karp[19], Fabian C. Kyne[8], Demetris Kletou[20,21], Lauryn Magno[7], Shevy B. S. Rothman[22], Jennifer N. Solomon[11], Nir Stern[23], Taner Yildiz[24]

[1] Mersea Marine Consulting, Fethiye, Turkey, [2] Gulf and Caribbean Fisheries Institute, Marathon, FL, United States, [3] Nature Coast Biological Station, Institute of Food and Agriculture Sciences, University of Florida, Gainesville/Cedar Key, FL, United States, [4] Unaffiliated, Alexandria, Egypt, [5] Department of General Nursing Technology, Higher Institute of Science and Technology, Cyrene, Libya, [6] Biology Department, American University in Beirut, Beirut, Lebanon, [7] Reef Environmental Education Foundation (REEF), Key Largo, FL, United States, [8] Blue Ventures, Corozal, Belize, [9] Department of Biological Sciences, Faculty of Arts and Sciences, Eastern Mediterranean University, Famagusta, Cyprus, [10] Underwater Research and Imaging Center, Eastern Mediterranean University, Famagusta, Cyprus, [11] Department of Human Dimensions of Natural Resources, Colorado State University, Fort Collins, CO, United States, [12] Okaloosa County Board of County Commissioners, Destin - Fort Walton Beach, FL, United States, [13] Lionfish University, New York, NY, United States, [14] Lionfish University, Asheville, NC, United States, [15] National Oceanic & Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD, United States, [16] Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada, [17] Department of Biological and Marine Sciences, University of Plymouth, Plymouth, United Kingdom, [18] University of Tsukuba, Shizuoka, Japan, [19] Unaffiliated, Scottsdale, AZ, United States, [20] Marine & Environmental Research (MER) Lab, Limassol, Cyprus, [21] Frederick University, Limassol, Cyprus, [22] Steinhardt Museum of Natural History, Tel Aviv University,Tel Aviv, Israel, [23] National Institute of Oceanography, Israel Oceanographic and Limnological Research, Haifa, Israel, [24] Faculty of Aquatic Sciences, Istanbul University, Istanbul, Turkey
*Corresponding author e-mail: uaylin@hotmail.com

Abstract

Major invasions of Indo-Pacific lionfish (Pterois volitans and P. miles) are underway in the Western Atlantic Ocean and the Mediterranean Sea. While the establishment of lionfish in the Western Atlantic is perhaps the most well-studied marine fish invasion to date, the rapidly expanding invasion in the Mediterranean is more recent and has received less attention. Here we review and synthesize successes and failures from two decades of lionfish management in the Western Atlantic to give policy recommendations for their management in the Mediterranean. Two failed approaches that were attempted multiple times in the Western Atlantic and that we advise against are (1) feeding lionfish to native fish to promote predation and (2) implementing bounty programs to incentivize lionfish harvest. Broadly, the most important management lessons that we recommend include (1) conducting routine removals by spearfishing with scuba, which can effectively suppress local abundances of lionfish; (2) encouraging the development of recreational and commercial lionfish fisheries, which can promote long-term, sustainable lionfish population control; and, (3) engaging local communities and resource users (e.g., with lionfish removal tournaments), which can concurrently achieve multiple objectives of promoting lionfish removals, market-development, research, and public education. Managers in the Western Atlantic often needed to adapt current conservation policies to enable lionfish removals in areas where spearfishing with scuba was otherwise prohibited for conservation purposes. The risk of abusing these policies was mitigated through the use of gear restrictions, diver trainings, and through participatory approaches that integrated scuba divers and stakeholder organizations in lionfish research and management. Our review of policies and practices in the Mediterranean Sea found that many of our recommended lionfish management approaches are not being done and indicate potential opportunities to implement these. We expect and fully recommend that work continues towards multinational cooperation to facilitate regional coordination of research, control, and management efforts with respect to the Mediterranean lionfish invasion. As with other major biological invasions, lionfish are unconstrained by political borders and their control will require rapid and strategic management approaches with broad cooperation among and between governments and stakeholders.

Keywords: Fisheries management, invasive species, marine policy, Mediterranean Sea, *Pterois sp.*

THE DYNAMICS OF MAXIMUM LENGTHS FOR THE INVASIVE SILVER-CHEEKED TOADFISH (*LAGOCEPHALUS SCELERATUS*) IN THE EASTERN MEDITERRANEAN SEA

Aylin Ulman[1], Stefanos Kalogirou[2*], Daniel Pauly[3]
[1] Mersea Marine Consulting, Tuzla Mah., Fethiye 48300, Muğla, Turkey
[2] Laboratory of Applied Hydrobiology, Department of Animal Science, School of Animal Sciences, Agricultural University of Athens, Iera odos 75, 11855 Athens, Greece
[3] Sea Around Us, Institute for the Oceans and Fisheries, University of British Columbia, 2202 Main Mall, Vancouver, BC V6T 1Z4, Canada

*Corresponding author: stefanos.kalogirou@aua.gr

Abstract

The Eastern Mediterranean Sea is the most invaded sea on the planet, with 666 non-indigenous species now recorded in the region. However, not all of these become successful in their new environments. Success here is defined by wide geographical spread, increased abundances, and larger maximum sizes than their native range. The silver-cheeked toadfish *Lagocephalus sceleratus* (Gmelin 1789) was first recorded in the Mediterranean Sea in 2003. It has now spread to all corners of the basin and is increasingly abundant in the Eastern Mediterranean Sea where it reaches monstrous sizes compared to the maximum sizes reported from its native range. This contribution presents three well-documented new weight records from the Dodecanese Islands, Greece: one specimen weighing 8.5 kg from 2012, and two specimens weighing 8 and 9 kg, respectively, from 2021. The latter is also confirmed with other well-documented larger-size records, along with a physiological hypothesis suggesting how such large sizes are reached

Keywords: Length records, top predator, Tetraodontidae, extreme value theory, oxygen supply

DNA DAMAGE INDUCED BY METAL POLLUTION IN LIONFISH, *PTEROIS MILES* FROM ISKENDERUN BAY, NORTH-EASTERN MEDITERRANEAN

Ayşegül Ergenler[1*], Funda Turan[1]
[1] Faculty of Marine Science and Technology, University of Iskenderun Technical, 31200, Iskenderun, Hatay, Turkey

*Corresponding author: aergenler@gmail.com

Abstract

Trace metal pollution in marine waters and its impact on marine ecosystems is a dynamic process. Metal exposures may induce toxiogenetic damage and carcinogenesis in aquatic organism. Fish are ideal indicators of heavy metal contamination and detection genotoxic parameters in aquatic systems because they occupy different trophic levels and are of different sizes and ages. In the present study was examined DNA damage in P. miles induced by metal pollution. At the end of study, the damage frequency (%), arbitrary unit and genetic damage index (%) were evaluated in gill and liver cells of lionfish by Comet assay. Pearson's chi-squared test was also used to determine the relationship between trace metal and DNA damage. In this study, Cr, Hg, Fe and Zn in water column were only exceed the permissible limit set by TEG (2016) according to criterion continuous concentrations. The highest level of DNA damage (53.667±3.512%), arbitrary unit (117.00±5.201) and genetic damage index (1.170±0.052 %) were found at gill cells of *P. miles*. Moreover, Pearson correlation analysis detected a positive relationship between Co and Fe in sea water and DNA damage levels in in *P. miles*. Consequently, this study firstly exposed genotoxic damage of *P. miles* due to metal pollution in Iskenderun Bay.

Keywords: Genotoxic effect, Metal pollution, Lionfish, Comet Assay.

EVALUATION OF THE MEAT, FIN SPINES AND VENOM OF LIONFISH

Berna Kılınç, Ecem Özer*
[1] Faculty of Fisheries, Fish Processing Technology Department, Ege University, 35100 Bornova-Izmir, Turkey

*Corresponding author: ozerecem@gmail.com

Abstract

Nowadays, with the increasing of global warming, sea temperatures are also increasing. The increase in sea temperatures causes some species called invasive fish species to migrate to the different regions by expanding their habitats. The lionfish (*Pterois* spp.) started to migrate to the seas of Turkey via the Suez channel with the increasing temperatures. Lionfish, Indo-pacific origin; It is a poisonous fish that lives in the coral reefs of the Red Sea, the Indian Ocean and the Western Pacific Ocean. However, this invasive lionfish species are also spreading in the seas of Turkey day by day. There is poison in the fin spines of lionfish. So, When this fish is alive, as a result of the contact of the poison of lionfish with people, it can cause burning, sweating, respiratory distress and even death. But, the venom becomes inactive after the fish died. Lionfish are fed with small fish and fish of economic value. In addition, less predators that feed on lionfish grow and reproduce faster than other fish. For this reason, it poses a threat both economically and ecologically. Therefore, the spreading of this lionfish species in the seas of Turkey should also be prevented. Lionfish are considered as an invasive species and the catching of this fish species are encouraged in some countries. There is no poison in the meat of lionfish. After the spines are cleaned, they can be offered for consumption like other fish species. For this reason, after catching, the consumption of the meat of this invasive species should be increased in Turkey. The increasing of the consumption of the lionfish meat in Turkey should be encouraged by developing various fish products from lionfish meat. In this review, not only the evaluation and consumption of lionfish will be discussed, but also the evaluation of fin spines and venom will be rewieved.

Keywords: Lionfish, processing, evaluation, consumption, global warming.

LIONFISH SPECIES CLASSIFICATION, MORPHOMETRY, BIOMETRIC POINTS, LANDMARK, BIOLOGICAL MEASUREMENT METHODS

Yakup Kutlu[1*], Cemal Turan[2]

[1] Department of Computer Engineering, Faculty of Engineering, Iskenderun Technical University, Hatay, Turkey

[2] Molecular Ecology and Fisheries Genetics Laboratory, Department of Marine Sciences, Faculty of Marine Sciences and Technologies, Iskenderun Technical University, Iskenderun, Hatay, Turkey

*Corresponding author: yakup.kutlu@iste.edu.tr

Abstract

Species of lionfish are very similar to each other and are difficult to recognize. The aim of this study is to create a lionfish classification model. Classification purposes are based on biometric points of the fishes. This application consists of three main phases, data acquisition, feature extraction and classification. In the first phase, fish image was collected. Unfortunately, in eastern Mediterranean Sea (Gulf of Iskenderun) there is not more species. In our study therefore only two lion fish species could be collected. After obtained data features extracted using morphometry by BioMorph and classified with high accuracy.

Keywords: Lionfish, classification, morphometry, landmark.

SHOULD WE CONSUME LIONFISH FROM A NUTRITIONAL PERSPECTIVE?

Ayşe Özyılmaz[1*], Servet Ahmet Doğdu[2]

[1] Iskenderun Technical University, Faculty of Marine Science and Technology, Department of Marine Technologies, Iskenderun/Hatay, Türkiye

[2] Iskenderun Technical University, Maritime Vocational School of Higher Education, Underwater Technologies, Iskenderun, Hatay, Türkiye

*Corresponding author: ayse.ozyilmaz@iste.edu.tr

Abstract

Native to the Indo-Pacific and belonging to the Scorpaenidae family, the lionfish has become an invasive fish species throughout the Mediterranean. *Pterois miles*, Bennett 1828 and *Pterois volitans*, Linnaeus, 1785 are the two fish species a total of 10 valid species of the genus *Pterois* all around the world. *P. miles* is the invasive fish species in the Mediterranean, however, the existence of the other lionfish species *P. volitans* is relatively new in the Mediterranean. On the other hand, they have been a major problem in another part of the world e.g., Parque Nacional Arrecife Alacranes in the Gulf of Mexico, Bahamian Archipelago. Many studies have been conducted on the abundance of lionfish and how to prevent their further spread. In some of the previous studies, the nutritional values of lionfish as a consumable food source were revealed. This study aims to emphasize the nutritional aspect of lionfish by reviewing the research on this subject. The proximate composition, fatty acid profiles, micro, and macro element contents of the edible part of lionfish (*P. miles* and *P. volitans*) was investigated from the previously published papers. The results showed that the dominant fatty acid in saturated fatty acids (SFA) was C16:0 followed by C18:0. The average levels of monounsaturated fatty acid (MUFA) were lower than polyunsaturated fatty acids (PUFA). The amounts of eicosapentaenoic acid (EPA, C20:5n3) and docosahexaenoic acid (DHA, C22:6n3) in PUFA were in the range of 3.21-5.79 and 18.77-30.03, respectively. Studies have shown that lionfish is a rich source of omega 3 fatty acids; however, these results need to be supported by further investigations on this subject.

Keywords: Lionfish, *Pterois miles*, *Pterois volitans*, fatty acid profiles, invasive

FOOD COMPOSITION AND DIETARY OVERLAP OF THE *PTEROIS VOLITANS* AND *PTEROIS MILES* IN ISKENDERUN BAY

Burçin Demirci[1], Sefa Ayhan Demirhan[2*]
[1]Ministry of Agriculture and Foresty, District Directorate of Agriculture and Forestry
[2]Iskenderun Technical University, Faculty of Marine Sciences and Technology

[*]Corresponding author: sayhan.demirhan@iste.edu.tr

Abstract

The food composition and dietary overlap of the *Pterois volitans* and *Pterois miles* were studied in the Iskenderun Bay. The main prey groups found in the stomachs of the *P. volitans* and *P. miles* were fishes and crustaceans. The study has shown that the Niche overlap-Pianka's index of these species was 83.2%. Most of stomach contents for both species were not identified. Fish and shrimps were found in the stomachs contents for both species freqently. However reef parts, moss residuals, molluscs shell parts and crab parts were found in the stomachs content for both species rarely. *Chloropthalmus agassizi, Uranoscopus scaber, Helicolenus dactylopterius* and Serranidae, Sparidae, Scorpaenidae members were identified stomach contents of *P. volitans*. Similarly *Chloropthalmus agassizi* were identified stomach contents of *P. miles*. Conspicuously, juvenile lionfish and body parts (dorsal fin and spines) were found 4 specimens stomachs of *P. miles*.

Keywords: Food composition, *Pterois volitans*, *Pterois miles*, Iskenderun Bay

POTENTIAL USAGE OF LIONFISHES (*PTEROIS SPP*) IN BIOMEDICAL AND BIOINSPIRED APPLICATIONS

Ali Uyan*
Izmir Katip Celebi University, Faculty of Fisheries, Molecular Ecology and Genetics Laboratory, Cigli, Izmir, TURKEY.

*Corresponding author: ali.uyan@yahoo.com

Abstract

Lionfishes are recognized as invasive and predatory species in the world. The genus *Pterois* belongs to the Scorpaenidae family has 10 confirmed species. Among them, two species *Pterois miles* and *P. volitans* were reported as non-indigenous species in Turkish marine waters. Although dorsal, pelvic, and anal fins of lionfish have venom-releasing spines which can have systemic effects such as severe pain, fever, vomiting, and dizziness, there are no reports of death by lionfish in the literature anyway. After careful removal of the venomous spines, lionfish meat is suitable for human consumption. The bioactivity of homogenates obtained from the venomous spines of lionfish has been the subject of various research since the 1950s. Until now, it has been proven that the venomous spines of the lionfish contain anticancer, antiviral, anti-inflammatory, anticoagulant, antioxidant, and antibacterial compounds and can be used in biomedical applications as a natural resource of marine origin. Moreover, the spine shape of lionfish has provided inspiration that can be useful in designing reusable syringe needles and sterilizable plungers, thereby reducing biomedical waste and sharps disposal costs. Additionally, the fins and spines of lionfish, which are typically removed and discarded, are used to make jewelry. This review, therefore, focused on evaluating alternative management actions to bring these invasive fish into the economy and control their populations, owing to both their use in biomedical fields and their suitability for bioinspiration.

Keywords: Lionfish, venom, spine, bioactivity, bioinspiration

MICROPLASTIC OCCURRENCE IN THE GASTROINTESTINAL TRACTS OF *PTEROIS MILES* FROM NORTHEASTERN MEDITERRANEAN SEA

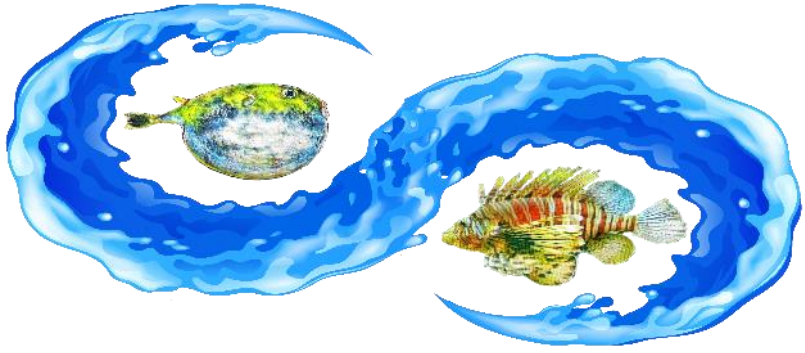
Ece Kılıç*, Nebil Yücel, Cemal Turan
Iskenderun Technical University, Faculty of Marine Science and Technology, Hatay, Turkey

*Corresponding author: ece.kilic@iste.edu.tr

Abstract

Nowadays, the majority of marine debris consists of microplastic particles. For that reason, microplastic pollution in marine environments and its potential impacts on marine animals has been extensively studied. This study has been developed to investigate the bioindicator potential of *Pterois miles* (Bennett, 1828) for the monitoring of microplastic pollution. 21 individuals were sampled from Iskenderun Bay, Northeastern Mediterranean Sea on April 2022, and their gastrointestinal tracts (GIT) was examined for microplastic occurrence. Mean microplastic abundance was found as 2.06±1.88 particles/individual in positive samples and 1.47±1.83 particles/individual in total samples. The microplastic detection rate was estimated as 71%. In terms of color, black (55%), blue (32%), red (10%) and brown (3%) microplastic particles were detected. Among all, majority of the extracted particles were fiber in shape (93%) and followed by fragments (7%). The high frequency of detection and microplastic abundance estimated in this study showed that this specie could be used to monitor microplastic pollution in marine environments.

Keywords: Plastic Debris, Iskenderun Bay, Red Lion Fish, Microplastic Pollution



2th International Symposium on Pufferfish/Lionfish
20-22 May 2022, Turkey

Abstracts for Poster Presentations

THE MEDICAL USAGE OF TETRODOTOXIN OBTAINED FROM PUFFERFISH IN TURKISH MARINE WATERS

İdil Selen Sangün[1*], Mustafa Kemal Sangün[2]
[1]İzmir University of Economics, Faculty of Engineering, Department of Genetics and Bioengineering, İzmir, Turkey
[2] Mustafa Kemal University, Faculty of Science and Arts, Department of Chemistry, 31024, Hatay, Turkey

∗Corresponding author: sangunselen@gmail.com

Abstract

The eight species of pufferfish from Tetraondontidae family *Lagocephalus lagocephalus, L. sceleratus, L. spadiceus, L. suezensis, L. guentheri, Sphoeroides pachygaster, Torquigener flavimaculosus and Tylerius spinosissimus* are found in Turkish marine waters. The Tetrodotoxin (TTX) (molecular formula $C_{11}H_{17}N_3O_8$) is found in pufferfish which is a potent blocker of voltage-dependent sodium channels in motor nerves. It causes skeletal muscle paralysis and death. The toxin is mainly present in the gonads, liver, intestines, and skin of pufferfish. Its appearance in an organism depends on the presence of toxin-synthesizing bacteria, including *Pseudoalteromonas haloplanktis tetraodonis*, marine bacteria belonging to the genus Vibrio, especially *V. alginolyticus*. These bacteria are most frequently and abundantly found in toxic marine animals and are more capable than other bacteria of producing tetrodotoxin. This study is reviewing the applications and usage of the tetraodotoxin obtained from the pufferfish, which is commonly found in Turkish marine waters, for new insights for further research.

Keywords: Tetrodotoxin, pufferfish, usage, medicine.

THE POTENTIAL THREAT OF PUFFERFISH TO BIVALVE MOLLUSKS

Sinem Uğur*, Selçuk Yiğitkurt, Ali Kırtık, Yaşar Durmaz
Ege University, Aquaculture Department of Fisheries Faculty, 35100 Izmir-Turkey

*Corresponding author: sinemugur41@gmail.com

Abstracts

The pufferfish are species of the Tetraodontidae family that contains a neurotoxin poison called Tetrodotoxin (TTX) and Saxitoxin (STX). They are undesirable invasive species as they cause human deaths if consumed as well as they damage fisheries and fishing gear. They live in freshwater, marine, and estuarine environments in tropical and temperate regions. The Mediterranean has come under pressure from some invasive species such as pufferfish through the Suez Canal, the Strait of Gibraltar, the ship's ballast water, and accidental discharge. It has become one of the centers where invasive species are increasing day by day. There are pufferfish species (*Ephippion guttiferum, Lagocephalus lagocephalus, Lagocephalus sceleratus, Lagocephalus spadiceus, Lagocephalus suezensis, Lagocephalus guentheri, Sphoeroides pachygaster, Sphoeroides cutaneus, Sphoeroides marmoratus, Sphoeroides spengleri, Torguigener flavimaculasus, Tylerius spinosissimus*) that have populations in the Mediterranean so far. In general, pufferfish's food preferences include crabs, gastropods, crustaceans, prawns, squid, fish, and bivalves. Although the feeding habits differ according to the species and seasons, in some species of pufferfish, nearly 70% of the stomach contents are determined as bivalves, while this rate is found to be 0.1% in some. In particular, the exact determination of the prey pressure of pufferfish on bivalves is important in terms of possible damage to mussels and other bivalve farms. As a conclusion, experimental studies should be carried out immediately and necessary precautions should be taken to determine this hunting pressure.

Keywords: Pufferfish, potential threat, bivalve, mollusks

Proceeding Articles

ECONOMIC POTENTIAL OF PUFFERFISH FOR DIFFERENT SECTORS

Servet Ahmet Doğdu[1*], Cemal Turan[2], Mahir Kanyılmaz[3], Azza Elganiny[4]

[1]Iskenderun Technical University, Maritime Vocational School of Higher Education, Underwater Technologies, Iskenderun, Hatay, Turkey
[2]Molecular Ecology and Fisheries Genetics Laboratory, Department of Marine Sciences, Faculty of Marine Sciences and Technologies, Iskenderun Technical University, Iskenderun, Hatay, Turkey
[3]General Directorate of Fisheries and Aquaculture, Ankara, Turkey
[4]National Institute of Oceanography and Fisheries, B.O. Box 182, Suez, Egypt
*Corresponding author e-mail: servet.dogdu@iste.edu.tr

Abstract

Pufferfishes are commonly found in tropical and subtropical marine waters and include 28 genera and approximately 184 species all over the world in marine waters within the Tetraodontidae family. The Tetraodontidae family is famous for the occurrence of the powerful marine paralytic toxins in their body called Tetrodotoxin. For this reason, they have no commercial value except for a few types consumed in Eastern countries. In Turkish marine waters, pufferfish belonging to the Tetraodontidae family represented by 7 species, *Lagocephalus lagocephalus*, *L. sceleratus*, *L. suezensis*, *L. guentheri*, *Sphoeroides pachygaster*, *Torquigener flavimaculosus* and *Tylerius spinosissimus*. They were reported as invasive alien species in Turkish Marine Waters. Marine species present a rich source of natural source compounds, such as collagen, gelatin, and hydroxyapatite, which are the most abundant valuable products, which can be an alternative source for pharmaceutical and biomedical applications. Alternative management actions are important to mitigate the negative effects stemming from the potential future invasion of pufferfish. Therefore, this review focused on how pufferfish can be brought into the economy.

Keywords: Pufferfish species, economic potential, natural source, tetraondontidae

Introduction

The opening of the Suez Canal in November 1869 connected the tropical Red Sea with the Mediterranean, known for its primarily temperate fauna, dramatically affecting both marine commerce and the biodiversity of the Mediterranean (Erguden et al., 2007; Turan et al., 2016; Doğdu et al., 2016; Stamouli et al., 2017; Turan et al., 2020). Pufferfishes are marine fish species that are distributed in tropical and subtropical areas of the Atlantic, Indian and Pacific Ocean. Puffers include 28 genera and approximately 184 species all over the world in marine waters within the Tetraodontidae family, among which at least ten are found in the eastern Mediterranean (Farrag et al., 2016). In Turkish marine waters, the family of the Tetraodontidae represented by 7 species, *Lagocephalus lagocephalus*, *L. sceleratus*, *L. suezensis*, *L. guentheri*, *Sphoeroides pachygaster*, *Torquigener flavimaculosus* and *Tylerius spinosissimus* (Figure 1) (Turan et al., 2018). These lessepsian invasive species have established large populations along the coasts of many countries of the eastern basin such as Israel, Lebanon, Turkey, Cyprus and Greece, while still rapidly expanding westwards along the coasts of Egypt, Libya, and along the entire Tunisian coastline (Soussi et al. 2014). Apart from several large species used for human consumption as delicious food in a few countries, particularly in China, Korea, Japan and Taiwan (Turan et al. 2017), most pufferfish species have no commercial value.

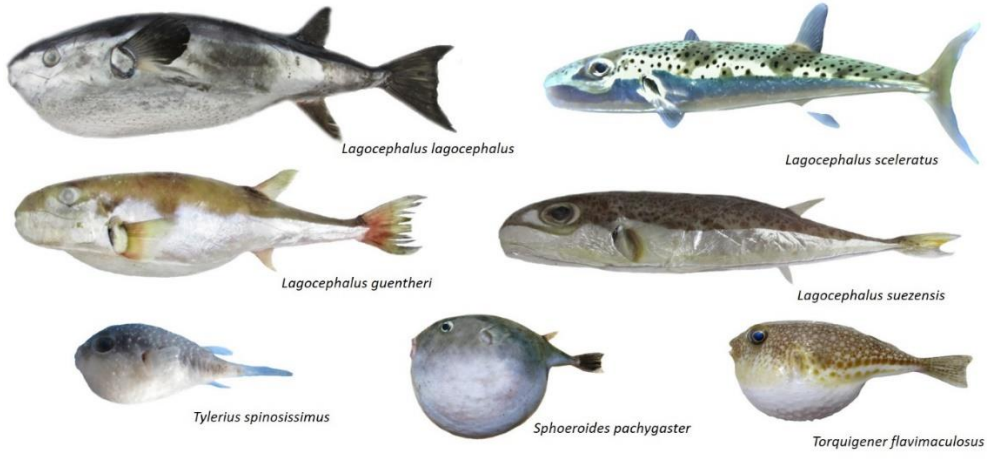


Figure 1. Pufferfish species in Turkish Marine Waters

Pufferfishes are the worst invasive fish species that have negative impacts on public health, biodiversity, and fishery (Zenetos et al. 2012; Otero et al. 2013; Farrag et al. 2016; Ragkousis et al. 2020; Doğdu et al. 2021a). This is a very dangerous fish to human health since it is toxic to eat due to having lethal tetrodotoxin (TTX) (Ayas et al., 2019; Doğdu et al. 2019; Kosker et al., 2019; Akbora et al., 2020). Moreover, it has negative impacts

on biodiversity due to being untargeted and also creates problems for fishermen that damage passive fishing gear and fish entangled in the fishing gear, causing economic losses (Turan, 2010; Ünal et al. 2015; Farrag et al. 2016). Besides, the family is renowned for the occurrence of a powerful toxin in their skin and organs called tetrodotoxin (TTX) (Doğdu and Turan, 2021). Tetrodotoxin is a very potent neurotoxin and one of the strongest marine paralytic toxins (El-Sayed et al., 2003; Sato et al., 2008).

Marine species present a rich source of natural source compounds, such as collagen, gelatin, and hydroxyapatite, which are the most abundant valuable products, which can be an alternative source for pharmaceutical and biomedical applications. Alternative management actions are important to mitigate the negative effects stemming from the potential future invasion of pufferfish. Therefore, this review focused on how pufferfish can be brought into the economy.

Collagen and Gelatin

Collagen is one of the most useful biomaterials because it has a wide-ranging of industrial applications (Schmidt et al., 2016). That is a major essential protein in the connective tissue of animal skin and bone and composes about 30% of the total proteins (Ogawa et al., 2003; Li et al., 2013). It is used as a vehicle for drugs, proteins, and genes, as well as a substitute for human skin, blood vessels and ligaments (Gómez-Guillén et al., 2011). Gelatin is a partially hydrolyzed form of collagen, and mostly it has been used as a potential agent in the food and packaging industry. Fish gelatins are normally produced through acid extraction methods reported properties typically known for the similar gelatin group. Film-forming applications of gelatin, which is derived by partial hydrolysis of collagen, in the pharmaceutical and food industries, include microencapsulation of ingredients and the manufacture of tablet and capsule coatings (Jeevithan et al., 2013).

Several studies have been done to date. For instance; Nagai et al. (2002) extracted collagen from the skin of ocellate pufferfish *Takifugu rubripes.* They collected a Type I collagen and results showed that ocellate pufferfish skin has the potential as an alternative source of collagen for use in various fields. Chen et al. (2019) extracted Type I collagen from the skin of *Takifugu flavidus* using the electrodialysis method. As they reported *T. flavidus* collagen could serve as an alternative source of collagen to meet the increasing demand from consumers. Iswariya et al. (2018) ısolation and characterization of collagen from the skin of *Lagocephalus inermis.* They obtained Type I collagen and results showed that *L. inermis* skin collagen useful product recovery was achieved from the underutilized puffer fish, which may serve as an alternative source for mammalian collagen, as well as the management of natural wastes or ecological problems. Doğdu et al.

(2019) extracted and characterization of collagen and gelatin from the skin of *Lagocephalus sceleratus.* They obtained a high yield of Type I collagen (Figure 2). They reported that pufferfish skin can be an alternative and important source of collagen. All previous studies show that pufferfish skin collagen is a natural alternative source for cow and pig leather collagen since it has no economic value and is very abundant in marine waters.

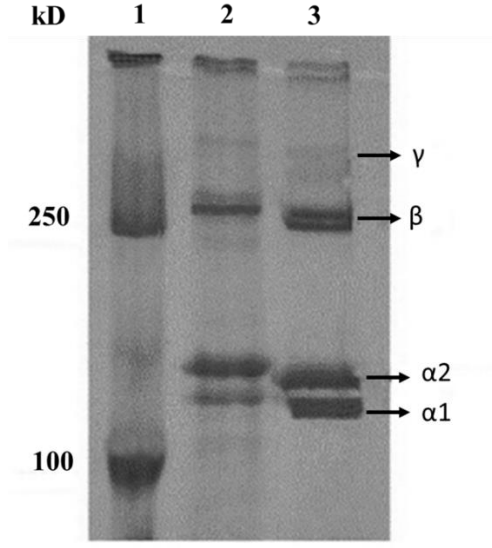


Figure 2. SDS-PAGE gel image of the obtained collagen from *L. sceleratus* skin (1: Molecular weight marker, 2: Sigma Type-1 collagen, 3: Collagen from *L. sceleratus* skin) (Doğdu, 2021)

Hydroxyapatite

Biomaterials are resources with unique properties that make them an accurate instrument for local contact with living tissues (Srivastava et al., 2015). Biomaterials should have specific features such as biocompatibility, serializability, functionality, and manufacturability (Ehrlich et al., 2010). The marine organism is getting favoured to obtain biomaterials for biomedical applications (Antoniac et al., 2016; Lim et al., 2019). Bioceramic materials have found widespread application in the fields of bone tissue, biomedical, dentistry and medicine with their adaptability and functionality (Lee et al., 2013; Mojahedian et al., 2016). Biologically originated ceramic materials are much more preferred which makes them proper for intimate contact with living tissues (Williams, 2009; Srivastava et al., 2015). Essentially, Hydroxyapatite (HA) from bones or biomass in which the main element is calcium in its chemical structure can be synthesized to use in biomedical applications (Doğdu et al., 2021a). HA and calcium phosphate ceramic materials are commonly applied as implant materials because they have

perfect bioactivity, osteoconductivity and osteoinductivity (Best et al., 2008; Venkatesan et al., 2015). HA has been used in dental treatment, having better metabolic activity and a sincerer response to the environment rather than the synthetic one. It is used as a filling material, replacing missing or damaged teeth tissues and also to support tissue regeneration and to stay healthy teeth tissue (Williams, 2009).

Doğdu et al. (2021a) extracted HA from the teeth of Silver-cheeked toadfish (*Lagocephalus sceleratus*). They reported a Ca/P molar ratio of 1.32 and the presence of carbonate and phosphate ions in oval and plate-shaped particles. They were reported to supply a natural, original and alternative product for the production of fillers, implants, bone powder, and dentures for biomedical and other industrial purposes since it has no economic value and is very abundant in the world marine waters (Figure 3). Also, their invention has been registered by the Turkish Patent and Trademark Office (Patent no: 2019/10617B). This innovation was the first patent for pufferfish teeth using the dental industry.

Figure 3. Application of HA to the human teeth (A) The external appearance of teeth of L. sceleratus, B) Powdered teeth, C) The final form of the filled teeth) (Doğdu et al., 2021a)

Metal Accumulation Indicator

Heavy metal input into the environment is caused by natural events and anthropogenic effects (Moiseenko and Kudryavtseva, 2001). Heavy metals are distributed in aquatic ecosystems in different chemical forms according to their weight and participation. Since metal involvement is more anthropogenic, monitoring its changing effect is inevitable for environmental health (Duruibe et al., 2007). Some of the heavy metals are essential for the animal, and others are never needed for life which has a toxic effect on a certain concentration following accumulation that causes metabolic and physiological changes and mortality (Duruibe et al., 2007). Fish are used as a bioindicator in pollution monitoring studies to be an important protein source in human consumption and to reflect the state of the environment and food chain in aquatic ecosystems.

Doğdu et al. (2021b) studied for the first time revealed that dentin tissue can be used as an indicator for toxicology studies that metal accumulations in dentin were determined in parallel with other examined tissues of pufferfish species. The results of these study, they reported dentin tissue of pufferfish contributes to time-dependent monitoring studies because of the protection due to its stable structure. Also reported, the mineral phase of dentin tissue displays a chelation effect for heavy metals.

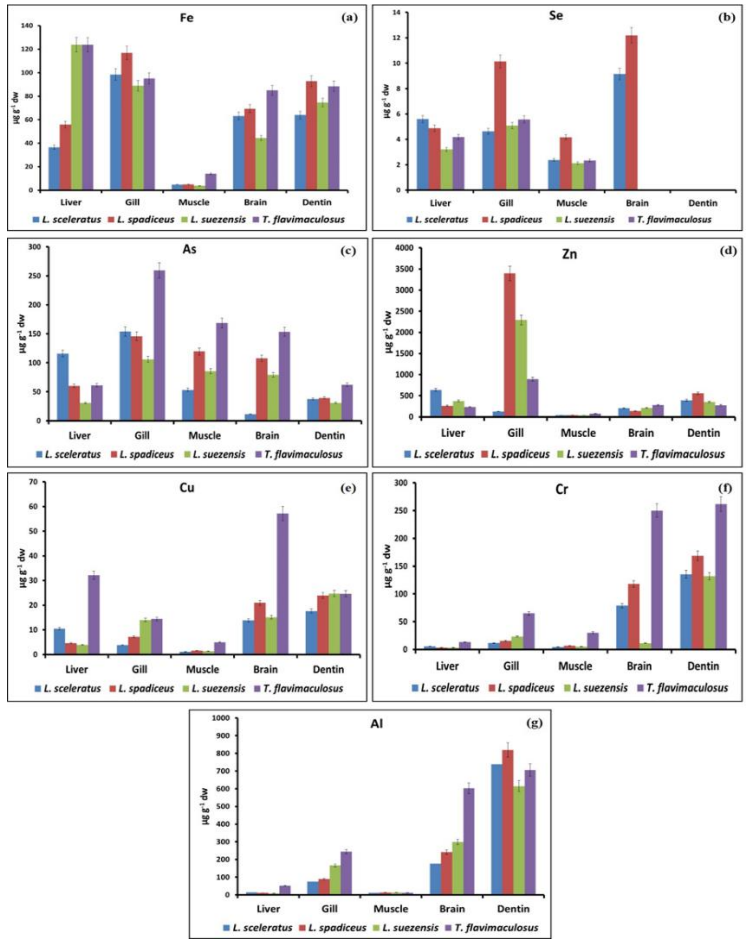


Figure 4. Comparison of metal analyses results according to metals (a; Iron, b; Selenium, c; Arsenic, d; Zinc, e; Copper, f; Chrome, g; Aluminum) (Doğdu et al., 2021b)

Tetrodotoxin

Tetrodotoxin (TTX) is a strong marine toxin. It has been found in pufferfish and other marine organisms (Kosker et al., 2016; 2018; 2019). There haven't known antidote for TTX, which is a powerful sodium channel inhibitor

(Hwang and Noguchi, 2007). The presence of TTXs in potentially edible aquatic organisms, especially pufferfish, has been long documented. Pufferfish species are the most notorious TTX source.

Firstly, Dr Yoshizumi Tahara isolated the poison from the aqueous extract of the ovaries of globefish in 1894. After that, he confirmed that globefish contains only one toxic substance and named it tetrodotoxin due to the name of the family of Tetraodontidae in 1909 (Suehiro, 1994; Lago et al., 2015). Although TTX is a strong poison, it is also used as a medicine in the health sector today. There are several examples of potent natural toxins being used as drugs in human medicine. The most therapeutic use of TTX is the treatment of certain pains (Hagen et al., 2008; Nieto et al., 2012; Bane et al., 2014). The research tries to make use of TTX in cancer pain treatment (Berde et al., 2011; Newman and Cragg, 2014).

Accessories

Another important economic sector for pufferfish is the accessory sector. pufferfish inflates like a balloon, its skin has a very flexible and robust structure (Kaplan et al., 2022). Especially in the fashion industry, puffer fish skin has begun to be used (Figure 5) (Uzun and Kadınkız, 2022). Accessories such as bags and key chains have been obtained from successfully tanned leathers (Figure 6) (Anonymous, 2022).

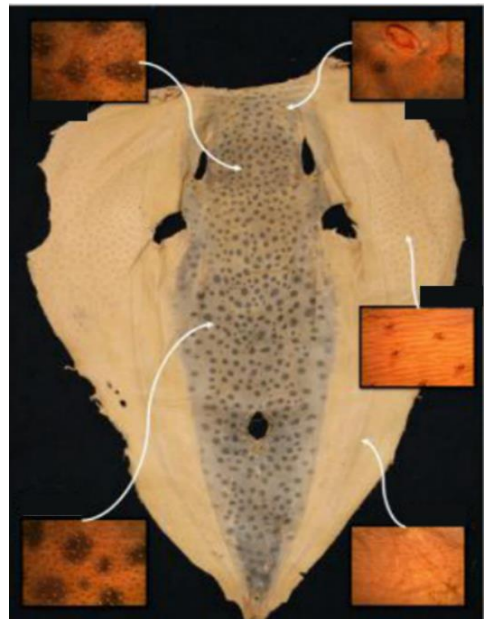


Figure 5. The general structure of *Lagocephalus sceleratus* skin (Uzun & Kadınkız, 2022)

Figure 6. Accessories have been obtained from successfully tanned leathers from *L. sceleratus* (a: key chains, b: bags) (Anonymous, 2022)

In conclusion, the fact that pufferfish species are not consumed by humans and the scarcity of predatory species cause the number of pufferfish to increase and become dominant in the Mediterranean Sea ecosystem. With the previous studies carried out, it was revealed in which areas and how the species would be used, and it was aimed to bring the products to the economy by obtaining them. This and similar studies show that the most reliable way to combat invasive alien species is to bring these species into the economy. Unfortunately, there is a limited management study against this species in our country. Increasing the use of biomaterial sources obtained from pufferfish in drug discovery studies with new perspectives and being inspired in the development of various products can be an effective strategy in preventing its spread by giving commercial importance to this species. Consequently, a collaboration between disciplines would be beneficial for developing biomedical and pharma applications and preventing their invasions.

References

Akbora, H. D., Kunter, İ., Erçetin, T., Elagöz, A. M., & Çiçek, B. A. (2020). Determination of tetrodotoxin (TTX) levels in various tissues of the silver cheeked puffer fish (*Lagocephalus sceleratus* (Gmelin, 1789)) in Northern Cyprus Sea (Eastern Mediterranean). *Toxicon*, 175, 1-6. https://doi.org/10.1016/j.toxicon.2019.12.002.

Anonymous, 2022. Balon balığı çantadan sonra aksesuar da oldu. Lider Gazetesi, https://www.lidergazete.com/balon-baligi-cantadan-sonra-aksesuar-da-oldu-h152181.htm. (Access: September, 2022)

Antoniac, I. V., Albu, M. G., Antoniac, A., Rusu, L. C., & Ghica, M. V. (2016). Collagen–bioceramic smart composites. In *Handbook of Bioceramics and Biocomposites* (pp. 301-324). Springer, Cham. https://doi.org/10.1007/978-3-319-12460-5_18.

Ayas, D., Gürlek, M., Çiftçi, N., Doğdu, S. A., Akbora, H. D., Moez, S., & Turan, C. (2019, December). Length-weight relationships of pufferfish species (Tetraodontidae Bonaparte, 1832) from Mersin Bay, Northeastern Mediterranean Sea. In *Proceeding of Next Generation Biometry Workshop and Course*. Published by *Natural and Engineering Sciences* (pp. 18-25).

Bane, V., Lehane, M., Dikshit, M., O'Riordan, A., & Furey, A. (2014). Tetrodotoxin: Chemistry, toxicity, source, distribution and detection. *Toxins*, 6(2), 693-755. https://doi.org/10.3390/toxins6020693.

Berde, C. B., Athiraman, U., Yahalom, B., Zurakowski, D., Corfas, G., & Bognet, C. (2011). Tetrodotoxin-bupivacaine-epinephrine combinations for prolonged local anesthesia. *Marine Drugs*, 9(12), 2717-2728. https://doi.org/10.3390/md9122717.

Best, S. M., Porter, A. E., Thian, E. S., & Huang, J. (2008). Bioceramics: Past, present and for the future. *Journal of the European Ceramic Society*, 28(7), 1319-1327. https://10.1016/j.jeurceramsoc.2007.12.001.

Chen, J., Li, M., Yi, R., Bai, K., Wang, G., Tan, R., ... & Xu, N. (2019). Electrodialysis extraction of pufferfish skin (*Takifugu flavidus*): A promising source of collagen. *Marine drugs*, 17(1), 25. https://doi.org/10.3390/md17010025.

Doğdu, S. A. (2021). İstilacı deniz türlerinden biyomateryal eldesi ve biyomedikal endüstrisindeki potansiyel kullanımı. (In Turkish). PhD Thesis from the Iskenderun Technical University.

Doğdu, S. A., & Turan, C. (2021). Authentication and traceability of pufferfish species using DNA sequencing. *Pakistan Journal of Marine Sciences*, 30(1), 1-11.

Doğdu, S. A., Uyan, A., Uygur, N., Gürlek, M., Ergüden, D., & Turan, C. (2016). First record of the Indo-Pacific striped eel catfish, *Plotosus lineatus* (Thunberg, 1787) from Turkish marine waters. *Natural and Engineering Sciences*, 1(2), 25-32. https://doi.org/10.28978/nesciences.286245.

Doğdu, S. A., Turan, C., & Ayas, D. (2019). Isolation and characterization of collagen and gelatin from skin of silver cheeked pufferfish *Lagocephalus sceleratus* for pharmaceutical and biomedical applications. *Natural and Engineering Sciences*, 308-314. https://doi.org/10.28978/nesciences.661099.

Doğdu, S. A., Turan, C., Depci, T., & Ayas, D. (2021a). Natural hydroxyapatite obtained from pufferfish teeth for potential dental application. *Journal of Ceramic Processing Research*, 22(3), 356-361. https://doi.org/10.36410/jcpr.2021.22.3.356.

Doğdu, S. A., Çiftçi, N., Ayas, D., & Turan, C. (2021b). Potential Usage of Pufferfish Dentin as a Metal Accumulation Indicator. *Journal of Water Chemistry and Technology*, 43(3), 269-275. https://doi.org/10.3103/S1063455X21030061.

Duruibe, J. O., Ogwuegbu, M. O. C., & Egwurugwu, J. N. (2007). Heavy metal pollution and human biotoxic effects. *International Journal of Physical Sciences*, 2(5), 112-118.

Ehrlich, H. (2013). Biomimetic potential of chitin-based composite biomaterials of poriferan origin. In *Biomimetic Biomaterials* (pp. 46-66). Woodhead Publishing. https://10.1533/9780857098887.1.46.

El-Sayed, M., Yacout, G. A., El-Samra, M., Ali, A., & Kotb, S. M. (2003). Toxicity of the Red Sea pufferfish *Pleuranacanthus sceleratus* "El-Karad". *Ecotoxicology and Environmental Safety*, 56(3), 367-372. https://doi.org/10.1016/S0147-6513(02)00142-2.

Erguden, D., Gurlek, M., & Turan, C. (2017). First occurrence of the oceanic puffer, *Lagocephalus lagocephalus* (Linnaeus, 1758) in Iskenderun Bay, north-eastern Mediterranean, Turkey. *Journal of Applied Ichthyology*, 33(4), 801-803. https://doi.org/10.1111/jai.13363.

Farrag, M., El-Haweet, A. A., & Moustafa, M. A. (2016). Occurrence of puffer fishes (Tetraodontidae) in the eastern Mediterranean, Egyptian coast-filling in the gap. *BioInvasions Record*, 5(1). https://doi.org/10.3391/bir.2016.5.1.09.

Gómez-Guillén, M. C., Giménez, B., López-Caballero, M. A., & Montero, M. P. (2011). Functional and bioactive properties of collagen and gelatin from alternative sources: A review. *Food hydrocolloids*, 25(8), 1813-1827. https://doi.org/10.1016/j.foodhyd.2011.02.007.

Hagen, N. A., du Souich, P., Lapointe, B., Ong-Lam, M., Dubuc, B., Walde, D., ... & Canadian Tetrodotoxin Study Group. (2008). Tetrodotoxin for moderate to severe cancer pain: a randomized, double blind, parallel design multicenter study. *Journal of Pain and Symptom Management*, 35(4), 420-429. https://doi.org/10.1016/j.jpainsymman.2007.05.011.

Hwang, D. F., & Noguchi, T. (2007). Tetrodotoxin poisoning. *Advances in Food and Nutrition Research*, 52, 141-236. https://doi.org/10.1016/j.jpainsymman.2007.05.011.

Iswariya, S., Velswamy, P., & Uma, T. S. (2018). Isolation and characterization of biocompatible collagen from the skin of puffer fish (*Lagocephalus inermis*). *Journal of Polymers and the Environment*, 26(5), 2086-2095. https://doi.org/10.1007/s10924-017-1107-1.

Jeevithan, E., Qingbo, Z., Bao, B., & Wu, W. (2013). Biomedical and pharmaceutical application of fish collagen and gelatin: a review. *Journal of Nutritional Therapeutics*, 2(4), 218-227. https://doi.org/10.6000/1929-5634.2013.02.04.6.

Kaplan, M., Yildirim, S., & Yildirim, D. C. (2022). Pufferfish versus lionfish: comparing risks for Turkish marine economics. *Marine Economics and Management*, 5(2), 173-187.

Kosker, A. R., Özogul, F., Durmus, M., Ucar, Y., Ayas, D., Regenstein, J. M., & Özogul, Y. (2016). Tetrodotoxin levels in pufferfish (Lagocephalus sceleratus) caught in the Northeastern Mediterranean Sea. *Food Chemistry*, 210, 332-337. https://doi.org/10.1016/j.foodchem.2016.04.122.

Kosker, A. R., Özogul, F., Durmus, M., Ucar, Y., Ayas, D., Šimat, V., & Özogul, Y. (2018). First report on TTX levels of the yellow spotted pufferfish (*Torquigener flavimaculosus*) in the Mediterranean Sea. *Toxicon*, 148, 101-106. https:// /10.1016/j.toxicon.2018.04.018.

Kosker, A. R., Özogul, F., Ayas, D., Durmus, M., Ucar, Y., Regenstein, J. M., & Özogul, Y. (2019). Tetrodotoxin levels of three pufferfish species (*Lagocephalus sp.*) caught in the North-Eastern Mediterranean sea. *Chemosphere*, 219, 95-99. https://doi.org/10.1016/j.chemosphere.2018.12.010.

Lago, J., Rodríguez, L. P., Blanco, L., Vieites, J. M., & Cabado, A. G. (2015). Tetrodotoxin, an extremely potent marine neurotoxin: Distribution, toxicity, origin and therapeutical uses. *Marine Drugs*, 13(10), 6384-6406. https://doi.org/10.3390/md13106384.

Lee, J. C., Hou, M. F., Huang, H. W., Chang, F. R., Yeh, C. C., Tang, J. Y., & Chang, H. W. (2013). Marine algal natural products with anti-oxidative, anti-inflammatory, and anti-cancer properties. *Cancer Cell International*, 13(1), 1-7. https://doi.org/10.1186/1475-2867-13-55.

Lim, Y. S., Ok, Y. J., Hwang, S. Y., Kwak, J. Y., & Yoon, S. (2019). Marine collagen as a promising biomaterial for biomedical applications. *Marine drugs*, 17(8), 467. https://doi.org/10.3390/md17080467.

Moiseenko, T. I., & Kudryavtseva, L. P. (2001). Trace metal accumulation and fish pathologies in areas affected by mining and metallurgical enterprises in the Kola Region, Russia. *Environmental Pollution*, 114(2), 285-297. https://doi.org/10.1016/S0269-7491(00)00197-4.

Mojahedian, M., Fahimipour, F., Larsen, K. L., Kalantar, M., Bastami, F., & Omatali, N. (2016). Ethanol-based sol-gel synthesis of nano-crystalline hydroxyapatite with different calcium phosphorus ratios (Ca/P). *Journal of Ceramic Processing Research*, 17(11), 1138-1142.

Nagai, T., Araki, Y., & Suzuki, N. (2002). Collagen of the skin of ocellate puffer fish (*Takifugu rubripes*). *Food chemistry*, 78(2), 173-177. https://doi.org/10.1016/S0308-8146(01)00396-X.

Newman, D. J., & Cragg, G. M. (2014). Marine-sourced anti-cancer and cancer pain control agents in clinical and late preclinical development. *Marine Drugs*, 12(1), 255-278. https://doi.org/10.3390/md12010255.

Nieto, F. R., Cobos, E. J., Tejada, M. Á., Sánchez-Fernández, C., González-Cano, R., & Cendán, C. M. (2012). Tetrodotoxin (TTX) as a therapeutic agent for pain. *Marine Drugs*, 10(2), 281-305. https://doi.org/10.3390/md10020281.

Ogawa, M., Moody, M. W., Portier, R. J., Bell, J., Schexnayder, M. A., & Losso, J. N. (2003). Biochemical properties of black drum and sheepshead seabream skin collagen. *Journal of Agricultural and food Chemistry*, 51(27), 8088-8092. https://doi.org/10.1021/jf034350r.

Otero, P., Rodríguez, P., Botana, A. M., Alfonso, A., & Botana, L. M. (2013). Analysis of natural toxins. In Liquid Chromatography (pp. 411-430). Elsevier. https://doi.org/10.1016/B978-0-12-415806-1.00015-2.

Ragkousis, M., Abdelali, N., Azzurro, E., Badreddine, A., Bariche, M., Bitar, G., ... & Zenetos, A. (2020). New alien Mediterranean biodiversity records (October 2020). *Mediterranean Marine Science*, 21(3), 631-652. https://dx.doi.org/10.12681/mms.23674.

Sato, K. I., Akai, S., Shoji, H., Sugita, N., Yoshida, S., Nagai, Y., ... & Yoshimura, J. (2008). Stereoselective and efficient total synthesis of

optically active tetrodotoxin from D-glucose. *The Journal of Organic Chemistry*, 73(4), 1234-1242. https://doi.org/10.1021/jo701655v.

Schmidt, M. M., Dornelles, R. C. P., Mello, R. O., Kubota, E. H., Mazutti, M. A., Kempka, A. P., & Demiate, I. M. (2016). Collagen extraction process. *International Food Research Journal*, 23(3), 913.

Souissi, J. B., Rifi, M., Ghanem, R., Ghozzi, L., Boughedir, W., & Azzurro, E. (2014). *Lagocephalus sceleratus* (Gmelin, 1789) expands through the African coasts towards the Western Mediterranean Sea: a call for awareness. *Management of Biological Invasions,* 5(4), 357-362.

Srivastava, A., Srivastava, A., Srivastava, A., & Chandra, P. (2015). Marine biomaterials in therapeutics and diagnostic. In *Springer handbook of marine biotechnology* (pp. 1247-1263). Springer, Berlin, Heidelberg.

Stamouli, C., Akel, E. H. K., Azzurro, E., Bakiu, R., Bas, A. A., Bitar, G., Boyaci, Y., Cakalli, M., Corsini-Foka, M., Crocetta, F., Dragičević, B., Dulčić, J., Durucan, F., Zrelli, R. E., Erguden, D., Filiz, H., Giardina, F., Giovos, I., Gönülal, O., Hemida, F., Kassar, A., Kondylatos, G., Macali, A., Mancini, E., Ovalis, P., Paladini De Mendoza, F., Pavičič, M., Rabaoui, L., Rizkalla, S., Tiralongo, F., Turan, C., Vrdoljak, D., Yapici, S., & Zenetos, A. (2018). New Mediterranean Biodiversity Records (December 2017). *Mediterranean Marine Science*, 18(3), 534–556. Https://doi.org/10.12681/Mms.15823.

Suehiro, M. (1994). Historical review on chemical and medical studies of globefish toxin before World War II. *Yakushigaku zasshi*, 29(3), 428-434.

Turan, C. (2010). Status and trend of Lessepsian species in marine waters of Turkey. *FAO-EastMed Technical Document*, 4, 109-118.

Turan, C., Ergüden, D., Uygur, N., Gürlek, M., Erdoğan, Z., Sönmez, B., Uyan, A., Karan, S., & Doğdu, S. A. (2015). First record of the Indian Ocean twospot cardinalfish, *Cheilodipterus novemstriatus* (Actinopterygii: Perciformes: Apogonidae), from Turkish marine waters. *Acta Ichthyologica et Piscatoria*, 45, 319-322. https://doi.org/ 10.3750/AIP2015.45.3.12.

Turan, C., Ergüden, D., Gürlek, M. (2016). Climate change and biodiversity effects in Turkish Seas. *Natural and Engineering Sciences*, 1(2), 15-24. https://doi.org/10.28978/nesciences.286240.

Turan, C., Gürlek, M., Ergüden, D., Uyan, A., Karan, S., & Doğdu, S. A. (2017). Assessing DNA Barcodes for Identification of Pufferfish Species (Tetraodontidae) in Turkish Marine Waters. *Natural and Engineering Sciences*, 2(3), 55-66. https://doi.org/10.28978/nesciences.369538.

Turan, C., Gürlek, M., Başusta, N., Uyan, A., Doğdu, S. A., & Karan, S. (2018). A checklist of the non-indigenous fishes in Turkish marine waters. *Natural and Engineering Sciences*, 3(3), 333-358. https://doi.org/10.28978/nesciences.468995.

Turan, C., Uyan, A., Gürlek, M., & Doğdu, S. A. (2020). DNA barcodes for identifications of two lionfish species *Pterois miles* (Bennett, 1828) and *Pterois volitans* (Linnaeus, 1758) in The Mediterranean. *Fishtaxa*, 16, 29-36.

Uzun, M., and Kadınkız, N. (2022). Potential Industrial Applications of Invasive Alien Species in the Fashion Industry: Technical Case Study on Pufferish. *Denizel Istilaci Yabanci Türlerin Etkileri Bilimsel Konferansı*. Abstract Book, pp 60-61.

Ünal, V., Göncüoğlu, H., Durgun, D., Tosunoğlu, Z., Deval, C., & Turan, C. (2015). Silver-cheeked toadfish, *Lagocephalus sceleratus* (Actinopterygii: Tetraodontiformes: Tetraodontidae), causes a substantial economic losses in the Turkish Mediterranean coast: A call for decision makers. *Acta Ichthyologica et Piscatoria*, 45(3), 231-237. https://doi.org/10.3750/AIP2015.45.3.02.

Venkatesan, J., & Kim, S. K. (2015). Marine biomaterials. In Springer Handbook of Marine Biotechnology (pp. 1195-1215). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-53971-8_53.

Williams, D. F. (2009). On the nature of biomaterials. *Biomaterials*, 30(30), 5897-5909. https://doi.org/10.1016/j.biomaterials.2009.07.027.

Zenetos, A., Gofas, S., Morri, C., Rosso, A., Violanti, D., Raso, J. G., ... & Verlaque, M. (2012). Alien species in the Mediterranean Sea by 2012. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part 2. Introduction trends and pathways. *Mediterranean Marine Science*, 13(2), 328-352. http://dx.doi.org/10.12681/mms.327.

MICROPLASTIC ABUNDANCE IN THE GASTROINTESTINAL TRACTS OF SUEZ PUFFERFISH *LAGOCEPHALUS SUEZENSIS* FROM THE ISKENDERUN BAY

Nebil Yücel[1*], Ece Kiliç[1], Cemal Turan[2]

[1]Iskenderun Technical University, Faculty of Marine Science and Technology, Hatay, Turkey
[2]Molecular Ecology and Fisheries Genetics Laboratory, Department of Marine Sciences, Faculty of Marine Sciences and Technologies, Iskenderun Technical University, Iskenderun, Hatay, Turkey

*Corresponding author e-mail: nebil.yucel@iste.edu.tr

Abstract

Since the establishment of the Marine Strategy Framework, microplastic pollution and its potential impact on marine biota have been a controversial issue. This study was conducted to evaluate the bioindicator potential of invasive *Lagocephalus suezensis* to monitor microplastic pollution in marine environments. For this purpose, gastrointestinal tracts (GIT) of 33 individuals sampled in December 2021 from northeastern Mediterranean Sea were examined. Microplastic abundance in the GIT was detected as 1.6±2.9 item/individuals in total samples and 2.5±3.2 item/individuals in positive samples with a detection rate of 64%. The majority of samples were fiber in shape, black in color and less than 1000 µm in size. The results obtained from this study prove the reality of microplastic pollution in the study area and suggest that further studies are needed to undertake the necessary legislation to control microplastic pollution.

Keywords: Microplastic pollution, pufferfish, northeastern Mediterranean

Introduction

As parallel the global increase in the plastic production and usage, the amount of plastic waste accumulated in the marine environments have been increasing. Plastics found in the marine litter divided into five size classes as megaplastics, macroplastics, mesoplastics, microplastics and nanoplastics. Of all, microplastics and nanoplastics took the attention; since they have significant environmental concerns due to high bioavailability, toxicity, detection and clean up difficulty.

Microplastic particles which are less than 5 mm in size were sometimes fragmenting from larger plastic particles; whereas, sometimes

directly produced within this range such as microbeads in cosmetic products. These tiny plastic particles interact with the marine biota which might severe damage in digestive tract, deterioration in hormonal structure, alteration in animal behavior (Karbalaei et al., 2020; Rios-Fuster et al., 2021).

For that reasons, many research has been focused on the microplastic content in the marine ecosystems. Till date, many aquatic animals was employed as bioindicator organisms for microplastic monitoring such as anemone (Morais et al., 2020), mussel (Li et al., 2019), crustacean (Patria et al., 2020), fish (Kılıç & Yücel, 2022).

There has been increasing number of alien species in Turkish marine waters (Turan et al., 2016; Turan et al., 2018). Pufferfishes are marine fish species belong to the Tetraodontidae family (Farrag et al., 2016), and represented by 7 species in Turkish marine waters (Turan et al., 2018; Doğdu & Turan, 2021; Turan et al, 2017). The natural range of Suez pufferfish *Lagocephalus sceleratus* has dramatically increased in the last decade and has spread along the coast of the Aegean Sea and Marmara Seas (Turan et al., 2018). However, there has been no study on microplastic pollution in pufferfish species.

Therefore, this study aimes to evaluate the microplastic pollution level of highly urbanized Iskenderun Bay by examining the microplastic abundance in the gastrointestinal tract of *Lagocephalus suezensis.*

Material and Methods

Sampling

Individuals of *Lagocephalus suezensis* (n:33) were purchased from local fisherman. Samples were caught from Iskenderun Bay, northeastern Mediterranean Sea (NE Med) on December 2021. Selected samples were recently caught and free of any morphological deformation. Before transportation to laboratory, samples were wrapped with tin foil and placed in an ice bag. In the laboratory, weight (to the nearest 0.1 g) and total length (to the nearest 0.5 cm) of each specimen were recorded before further analysis (Table 1).

Table 1. Measurements of of *Lagocephalus suezensis* speciment.

Species	# of fish	Habitat	Feed on	Total length (cm)	Weight (g)	GIT weight (g)
Lagocephalus suezensis	33	Demersal	Molluscs, shrimps, crabs, fish, squids, and cuttlefish	15.2±1.2	47.6±10.8	1.7±0.5

Microplastic Extraction

Microplastic (MP) extraction was carried in accordance with Kılıç and Yücel (2022). Briefly, gastrointestinal tracts (GIT) from the upper part of the oesophagus to the anal opening were dissected, weighted and placed in a glass beaker which was covered with tin foil. Then, 20 mL of 30% H_2O_2 per gram of tissue was added to degradate organic material. Next, solution was filtered with the use of 50 µm pore size filters and filters were placed into sterile petri dishes until microscopic examination. Filters were examined under Olympus SZX7 microscope with an attached Olympus DP 20 digital camera. Observed particles were exposed to a hot needle to check whether or not it is plastic in nature (Hanke et al., 2013). Color, type, number of MPs, and size of detected MP were recorded.

Contamination Prevention

First of all, specimens, dissection equipment and laboratory surfaces were cleaned with pure water before dissection. Laboratory personnel always wore nitrile gloves and cotton lab coats during analysis. Before use, filters were controlled under the microscope for the existence of MPs. To control existence of contamination, wet filters in three replicates were placed into petri dishes during the digestion and microscopic examination procedures. Blank filters were examined for the microplastic presence at the microscope. No plastic was observed at the blank filters.

Results and Discussion

Until now, many studies used fish to monitor microplastic pollution (Cheung et al., 2018; Anastasopoulou et al., 2018; Garcia-Garin et al., 2019; Kılıç & Yücel, 2022; Kılıç et al., 2022). However, microplastic occurrence in the GIT of *Lagocephalus suezensis* have not been reported, and this study will provide first data regarding its suitability in microplastic monitoring.

In this study, 33 individuals were analyzed in terms of MPs occurrence in the GIT and total of 54 MPs were extracted from 21 specimens. MPs detection rate (64%) in the GIT of *Lagocephalus suezensis* was higher than the majority of the previous studies employing fish from similar habitat and location. In increasing order, previous studies reported the MPs ingestion as 9% in *Merlangius merlangus* from Black Sea (Aytan et al., 2022), 41% in *Saurida undosquamis* from NE Med (Güven et al., 2017), 50% in *Pagellus erytrinus* from Croatian Sea (Med) (Anastasopoulou et al., 2018), 58% in 28 different fish from NE Med (Güven et al., 2017), 66% in *Mullus barbatus* from Iskenderun Bay (Kılıç & Yücel, 2022), 80% in *Solea solea* from Adriatic Sea (Pellini et al., 2018), 90% in *Saurida undosquamis* from İskenderun Bay, NE Med Sea (Kılıç & Yücel, 2022).

Number of MPs extracted from the GIT of *Lagocephalus suezensis* were varied from 0 to 16 items individual^{-1} with an average of 1.6±2.9 MPs individual^{-1} which is coherent to previous studies conducted in Mediterranean Sea (Table 2) (Güven et al., 2017; Pellini et al. 2018; Anastasopoulou et al. 2018; Bottari et al. 2021; Sayed et al. 2021; Aytan et al. 2022; Kılıç & Yücel, 2022).

Fiber shaped particles were constituted the majority of extracted MPs from the GIT of *Lagocephalus suezensis* (Figure 1) similar to the previous studies (Güven et al., 2017; Abbasi et al., 2018; Anastasopoulou et al., 2018; Sayed et al., 2021; Kılıç & Yücel 2022). This consition indicate the impact of anthropogenic influences in the study; since, fiber shaped particles were linked with anthropogenic influences (Alomar et al., 2016).

MPs extracted from the GIT were classified by color as black (65%), blue (20%), white (11%), and red (4%) (Figure 1). Dominance of black and blue particles were also reported in other studies conducted in Mediterranean Sea (Güven et al., 2017; Abbasi et al., 2018; Anastasopoulou et al., 2019; Sayed et al., 2021; Kılıç & Yücel, 2022).

In terms of size, most of the extracted particles were belonging to 0.5-1 mm size class (31%) and followed by 1-2 mm (24%) and 2-3 mm (13%) size classes (Figure 1). In this study, mean length of the extracted MPs was found as 1.7±1.7 mm (Table 2).

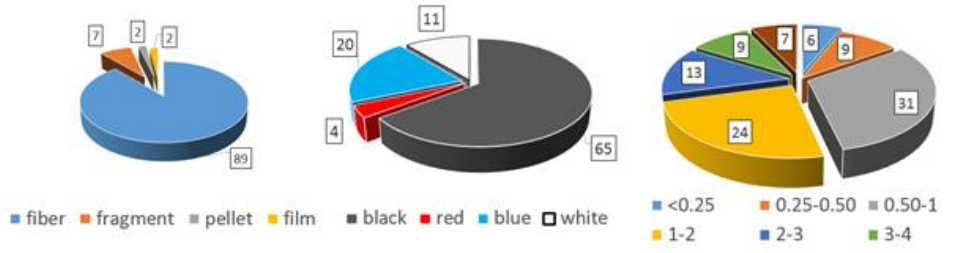


Figure 1. Characterization of extracted MPs by shape, color and size, respectively

Table 2. Number of MPs extracted from the gastrointestinal tract of *Lagocephalus suezensis*

Species	n	Fiber	Fragment	Pellet	Film	Mean number of MPs per fish		Frequency of occurrence (%)
						All samples	Positive samples	
Lagocephalus suezensis	33	48	4	1	1	1.64±2.89	2.45±3.26	64

In conclusion, this study was the first study evaluating the MPs occurrence in the GIT of *Lagocephalus suezensis*. Considering bio-ecology of this species together with high MPs occurrence and high MPs abundance observed in this study, it is concluded that Lagocephalus suezensis could be effectively used as a bioindicator for microplastic pollution in the marine environments. Results revealed that MPs occurrence in the Mediterranean Sea is a series problem which needs to control with legislations.

References

Abbasi, S., Soltani, N., Keshavarzi, B., Moore, F., Turner, A., & Hassanaghaei, M. (2018). Microplastics in different tissues of fish and prawn from the Musa Estuary, Persian Gulf. *Chemosphere*, *205*, 80-87. https://doi.org/10.1016/j.chemosphere.2018.04.076.

Alomar, C., Estarellas, F., Deudero, S. (2016). Microplastics in the Mediterranean Sea: deposition in coastal shallow sediments, spatial variation and preferential grain size. *Mar. Environ. Res*. 115, 1–10. https://doi.org/10.1016/j.marenvres.2016.01.005.

Anastasopoulou, A., Virˇsek, M.K., Varezi´c, D.B., Digka, N., Fortibuoni, T., Koren, ˇS.,Mandi´c, M., Mytilineou, C., Pesic, A., Ronchi, F., ˇSilji´c, J., Torre, M., Tsangaris, C.,Tutman, P., 2018. Assessment on marine litter ingested by fish in the Adriatic and NE Ionian Sea macro-region (Mediterranean). *Marine Pollution Bulletin.* 133, 841–851. https://doi.org/10.1016/j.marpolbul.2018.06.050.

Aytan, U., Esensoy, F. B., Senturk, Y., Arifoğlu, E., Karaoğlu, K., Ceylan, Y., & Valente, A. (2021). Plastic occurrence in commercial fish species of the Black Sea. *Turkish Journal of Fisheries and Aquatic Sciences*, *22*(12). https://doi.org/10.4194/TRJFAS20504.

Bottari, T., Mancuso, M., Pedà, C., De Domenico, F., Laface, F., Schirinzi, G. F., Battaglia, P., Consoli, P., Spano, N., Greco, S., Romeo, T. (2022). Microplastics in the bogue, Boops boops: A snapshot of the past from the southern Tyrrhenian Sea. *Journal of hazardous materials*, *424*, 127669. https://doi.org/10.1016/j.jhazmat.2021.127669.

Cheung, L. T., Lui, C. Y., & Fok, L. (2018). Microplastic contamination of wild and captive flathead grey mullet (*Mugil cephalus*). *International journal of Environmental Research and Public Health*, *15*(4), 597. https://doi.org/10.3390/ijerph15040597.

Doğdu, S. A., & Turan, C. (2021). Authentication and traceability of pufferfish species using DNA sequencing. *Pakistan Journal of Marine Sciences*, 30(1), 1-11.

Garcia-Garin, O., Vighi, M., Aguilar, A., Tsangaris, C., Digka, N., Kaberi, H., & Borrell, A. (2019). Boops boops as a bioindicator of microplastic pollution along the Spanish Catalan coast. *Marine Pollution Bulletin*, *149*, 110648. https://doi.org/10.1016/j.marpolbul.2019.110648

Güven, O., Gökdağ, K., Jovanović, B., & Kıdeyş, A. E. (2017). Microplastic litter composition of the Turkish territorial waters of the Mediterranean Sea, and its occurrence in the gastrointestinal tract of fish. *Environmental Pollution*, *223*, 286-294. https://doi.org/10.1016/j.envpol.2017.01.025

Karbalaei, S., Hanachi, P., Rafiee, G., Seifori, P., & Walker, T. R., 2021. Toxicity of polystyrene microplastics on juvenile *Oncorhynchus mykiss* (rainbow trout) after individual and combined exposure with chlorpyrifos. *Journal of Hazardous Materials*, *403*, 123980. https://doi.org/10.1016/j.jhazmat.2020.123980.

Kılıç, E., & Yücel, N. (2022). Microplastic occurrence in the gastrointestinal tract and gill of bioindicator fish species in the northeastern Mediterranean. *Marine Pollution Bulletin, 177*, 113556. https://doi.org/10.1016/j.marpol.

Kılıç, E., Yücel, N., & Turan, C. Microplastic Occurrence in the Gastrointestinal Tracts of *Pterois miles* (Bennett, 1828) from northeastern Mediterranean Sea. *Natural and Engineering Sciences*, 7(2), 200-213. https://doi.org/10.28978/nesciences.1159300.

Li, J., Lusher, A. L., Rotchell, J. M., Deudero, S., Turra, A., Bråte, I. L. N., sun, C., Hossain, S., Li, Q., Kolandhasamy, P., & Shi, H. (2019). Using mussel as a global bioindicator of coastal microplastic pollution. *Environmental pollution, 244*, 522-533. https://doi.org/10.1016/j.envpol.2018.10.032

Morais, L. M. S., Sarti, F., Chelazzi, D., Cincinelli, A., Giarrizzo, T., & Martinelli Filho, J. E. (2020). The sea anemone *Bunodosoma cangicum* as a potential biomonitor for microplastics contamination on the Brazilian Amazon coast. *Environmental Pollution, 265*, 114817. https://doi.org/10.1016/j.envpol.2020.114817

Patria, M. P., Santoso, C. A., & Tsabita, N. (2020). Microplastic Ingestion by Periwinkle Snail *Littoraria scabra* and Mangrove Crab *Metopograpsus quadridentata* in Pramuka Island, Jakarta Bay, Indonesia. *Sains Malaysiana, 49*(9), 2151-2158. http://dx.doi.org/10.17576/jsm-2020-4909-13.

Pellini, G., Gomiero, A., Fortibuoni, T., Ferrà, C., Grati, F., Tassetti, A. N., ... & Scarcella, G. (2018). Characterization of microplastic litter in the gastrointestinal tract of *Solea solea* from the Adriatic Sea. *Environmental pollution, 234*, 943-952. https://doi.org/10.1016/j.envpol.2017.12.038.

Rios-Fuster, B., Arechavala-Lopez, P., García-Marcos, K., Alomar, C., Compa, M., Álvarez, E., Julià, M. M., Solomando Martí, A., Sureda, A., & Deudero, S., 2021. Experimental evidence of physiological and behavioral effects of microplastic ingestion in *Sparus aurata*. *Aquatic Toxicology*, *231*(January). https://doi.org/10.1016/j.aquatox.2020.105737.

Sayed, A. E. D. H., Hamed, M., Badrey, A. E., Ismail, R. F., Osman, Y. A., Osman, A. G., & Soliman, H. A. (2021). Microplastic distribution, abundance, and composition in the sediments, water, and fishes of the

Red and Mediterranean seas, Egypt. *Marine Pollution Bulletin*, *173*, 112966. https://doi.org/10.1016/j.marpolbul.2021.112966.

Turan, C., Ergüden, D., Gürlek, M. (2016). Climate change and biodiversity effects in Turkish Seas. Natural and Engineering Sciences, 1(2), 15-24.

Turan, C., Gürlek, M., Ergüden, D., Uyan, A., Karan, S., & Doğdu, S. A. (2017). Assessing DNA Barcodes for Identification of Pufferfish Species (Tetraodontidae) in Turkish Marine Waters. *Natural and Engineering Sciences*, 2(3), 55-66. https://doi.org/10.28978/nesciences.369538.

Turan, C., Gürlek, M., Başusta, N., Uyan, A., Doğdu, S. A., & Karan, S. (2018). A checklist of the non-indigenous fishes in Turkish marine waters. *Natural and Engineering Sciences*, 3(3), 333-358. https://doi.org/10.28978/nesciences.468995.

NESciences
Natural and Engineering Sciences
an International Journal
www.nesciences.com

www.nesciences.com

NATURE and SCIENCE
SOCIETY

www.dogavebilim.com