ΑΛΛΑΓΗ ΕΝΔΙΑΙΤΗΜΑΤΟΣ ΤΟΥ ΧΩΡΟΚΑΤΑΚΤΗΤΙΚΟΥ ΑΛΛΟΧΘΟΝΟΥ ΕΙΔΟΥΣ, *LAGOCEPHALUS SCELERATUS*, ΣΕ ΜΙΑ ΠΕΡΙΟΧΗ ΤΟΥ ΝΟΤΙΟΑΝΑΤΟΛΙΚΟΥ ΑΙΓΑΙΟΥ

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Περίληψη

Στην παρούσα εργασία διερευνήθηκε ο οικολογικός και κοινωνικός αντίκτυπος του χωροκατακτητικού αλλόχθονου είδους, *Lagocephalus sceleratus*, στα παράκτια θαλάσσια ενδιαιτήματα της νήσου Ρόδου. Η μελέτη της χρήσης των ενδιαιτημάτων, κατά τα διάφορα στάδια της ζωής του Λαγοκέφαλου, στηρίχθηκε σε εποχικές ποσοτικές δειγματοληψίες και απέδειξε ότι σημαντικότατο για τα πρώτα στάδια ζωής του είναι το αμμώδες ενδιαίτημα. Επίσης, ότι τα μεγαλύτερα άτομα (ολικό μήκος από 29 έως και 64 εκ.) χρησιμοποιούν κυρίως λειμώνες Ποσειδωνίας (*Posidonia oceanica*). Η κατά μήκος κατηγοριοποίηση του Λαγοκέφαλου ανέδειξε τροφική εναλλαγή με την αύξηση του μεγέθους του, η οποία πιθανότατα οφείλεται στην εναλλαγή ενδιαιτήματος. Στα πρώτα στάδια της ζωής του, ο Λαγοκέφαλος ενδιαιτάται σε αμμώδεις πυθμένες, όπου και τρέφεται με διάφορα ασπόνδυλα και μαλάκια, ενώ φτάνοντας μεγαλύτερο μέγεθος τρέφεται κυρίως με οικονομικής σημασίας είδη κεφαλόποδων (π.χ. *Sepia officinalis, Octopus vulgaris*), αλλά και ψάρια. Οι εποχικές διακυμάνσεις του δείκτη φυσικής κατάστασης του Λαγοκέφαλου δε βρέθηκαν να είναι στατιστικά σημαντικές, αλλά οι υψηλές τιμές του σε συνδυασμό με την αφθονία του είδους αποδεικνύουν την κυριαρχία του στα παράκτια συστήματα. Οι κοινωνικές συνέπειες της εγκατάστασης του είδους στα παράκτια θαλάσσια ενδιαιτήματα της περιοχής του ΝΑ Αιγαίου είναι σημαντικές, αφού η κατανάλωση του μπορεί να οδηγήσει στον θάνατο και η αφθονία του έχει δυσμενείς οικονομικές επιπτώσεις στην παράκτια αλιεία. Οι συνδυασμένες οικολογικές, οικονομικές και κοινωνικές επιπτώσεις προφανώς χαρακτηρίζουν τον Λαγοκέφαλο ως μάστιγα στην περιοχή μελέτης.

HABITAT SHIFT OF THE INVASIVE AND PEST PUFFERFISH, *LAGOCEPHALUS SCELERATUS*, IN AN AREA OF THE SOUTH-EASTERN AEGEAN SEA

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Abstract

In this study, the ecological and societal impact of the non-indigenous pest pufferfish *Lagocephalus sceleratus* in coastal habitats of an area of the Aegean Sea was investigated. Seasonal quantitative sampling in two common coastal habitats was used to investigate habitat-use during different life-stages. Sandy areas were found to be highly important for the early life stages of *L. sceleratus*. In contrast, *Posidonia oceanica* habitats were mainly preferred by larger (> 29 cm) individuals with a maximum recorded size of 64 cm. *Lagocephalus sceleratus* was found to be an invertebrate and fish feeder while size classification revealed a tendency for an ontogenetic diet shift with increased size. Ontogenetic diet shift was most probably attributed to shift in habitat use with increased size. During early life stages *L. sceleratus* inhabits sandy bottoms where it feeds on various invertebrates and mollusca while when reaching larger size it feeds on economically important cephalopod species (e.g. *Sepia officinalis* and *Octopus vulgaris*). The social impacts were obvious since consumption of this tetrodotoxin containing pufferefish can be lethal. Seasonal variations in the condition of *L. sceleratus* did not show any significance and the high conditional values together with high densities, signifies its dominance on the coastal fish community. Combined ecological, economical and social effects clearly classify *L. sceleratus* a pest in the area.

Keywords: non-indigenous, pufferfish, impact, Mediterranean Sea.

1. Introduction

The recent man-made opening of geographical barriers, combined with climate change and increased sea water temperatures, are shuffling the geographical distributions of plant and animal species (Parmesan & Yohe 2003), enhancing the spread and success of species into new

environments. The acceleration and magnitude of this phenomenon is well illustrated in Mediterranean Sea systems (Galil *et al.*, 2007) and especially in fish communities (Quignard and Tomasini, 2000; Lasram and Mouillot, 2008).

The Mediterranean Sea is considered to be one of the main hotspots of marine bioinvasions on earth with increasing rates of introductions being reported (Rilov and Galil, 2009; Zenetos, 2010). Since the opening of the Suez Canal, in 1869, the coastal ecosystems of the eastern Mediterranean Sea have been subject to the establishment of non-indigenous species (NIS), predominantly of Indo-Pacific origin. Concerning fish, 80 species have already been reported in the eastern Mediterranean Sea (Golani, 2010), and the immigration via the shallow Suez Canal explains the dominance of coastal fish species. The rate of fish immigration has increased in recent decades and is predicted to have profound ecological and societal impacts. Until now, research focus has been on the origin of invaders, the mode of transport and including biotic and abiotic descriptions of the invaded areas (Corsini-Foka and Economidis, 2007; Corsini-Foka, 2010). The limited information on ecological and societal consequences attributed to the establishment of NIS, signifies the importance of studying such processes.

Puffers are marine fish species that are distributed in tropical and subtropical areas of the Atlantic, Indian and Pacific Ocean. Puffers include 121 species within the Tetraodontidae family among which six are found in the eastern Mediterranean. The family name, literally meaning four teeth in greek, refers to their fused jaw teeth which are very sharp. Some puffers contain the strongest paralytic toxin known today, tetrodotoxin (Sabrah *et al.*, 2006). European legislation (854/2004/EC) states that toxic fish of the Tetraodontidae family should not enter the European markets.

Lagocephalus sceleratus received considerable public attention shortly after its first report in 2003 from Gökova bay in the south-eastern coasts of the Aegean Sea due to the presence of tetrodotoxin (Akyol *et al.*, 2005). The distribution of *L. sceleratus* is currently limited to the eastern Mediterranean Sea and showed a rapid spread. In a global perspective, occasional accidental poisonings have lead to numerous human deaths, the majority of which have been documented in southeastern Asia, including Malaysia, Taiwan, Hong Kong, and Korea (Kan *et al.*, 1987; Yang *et al.*, 1996). In the eastern Mediterranean, 13 cases of tetrodotoxin poisoning have been reported (Bentur *et al.*, 2008). The high numbers of *L. sceleratus* that have been caught by coastal fishermen in the eastern Mediterranean has initiated major national efforts to alert fishermen and the public about the toxicity of this fish. These efforts have included setting up posters warning the public about the lethal effects if consumed, but also that small individuals could easily be misidentified with other small commercial edible species such as *Spicara smaris*, *Boops boops* and *Atherina hepsetus* (Kalogirou pers. obs.). *Lagocephalus sceleratus* has been considered an economical pest by fishermen since it is considered to affect the local fish market in three ways; deterring customers from buying fish, introducing additional work to discard toxic fish and reducing local stocks of commercial squids and octopus through predation. The most important aspect from a societal point of view is undoubtedly the risks involved with consuming the fish, due to its toxicity. Studies from the Mediterranean Sea show that there is a significant positive correlation between toxicity levels and size of fish (Katikou *et al.*, 2009). According to the results of Katikou et al. (2009) individuals smaller than 16 cm in length do not possess toxicity levels that could be lethal. This reduces the risks in connection with misidentification since commercial *S. smaris*, *B. boops* and *A. hepsetus* rarely exceed this size.

Lagocephalus sceleratus has been ranked among the 100 ‘worst’ Invasive Alien Species (IAS) in the Mediterranean Sea with profound social and ecological impacts due to presence of tetrodotoxin being a source of food poisoning (Streftaris and Zenetos, 2006). Social impacts are obvious due to

toxicity but lack of quantitative data does not support ecological impacts. In the area under study, *L. sceleratus* has become well established since the species was first reported in 2005 (Kalogirou *et al.*, 2010), but to my knowledge, little is known concerning the ecology of the fish.

The aim of this study was to investigate the establishment status of *Lagocephalus sceleratus* in coastal habitats where commercial fishing is carried out. By quantitatively studying size distribution and habitats used during the life cycle the investigation focused on identifying potential ontogenetic habitat shifts. In addition, investigation of feeding habits aimed to assess possible interactions in the food web and to discuss its potential impact on commercial fisheries.

2. Materials and methods

2.1 STUDY AREA

This study was performed in coastal habitats of Rhodes Island, located in the straddle between the Aegean and Levantine Sea in the eastern Mediterranean Sea. There is approximately 700 km of open waters between Rhodes and the Suez Canal, but the studied coastal habitats are similar to those along the coasts between the two areas.

The investigation was carried out at four locations, 1: 36°, 24´ 47 N; 28°, 05´ 53 S, 2: 36°, 25´ 20 N; 28°, 11´ 50 S, 3: 36°, 20´ 50 N; 28°, 12´ 37 S and 4: 36°, 08´ 40 N; 28°, 05´ 10 around Rhodes Island during the years 2008-2009, two representing *Posidonia oceanica* meadows, and two sandy habitats (Fig. 1). In order to study temporal variations in the occurrence of *Lagocephalus sceleratus* in the two habitats daylight samples were taken on four occasions over a year; December 2008 representing autumn and March, May and August 2009 representing winter, spring and summer respectively. Mean surface water temperature in the study area ranges between 16 °C and 18 °C in winter, 21 °C and 23 °C in autumn and spring respectively, reaching 28 °C in summer. Salinity is relatively constant throughout the year and range between 39.3 and 39.7.

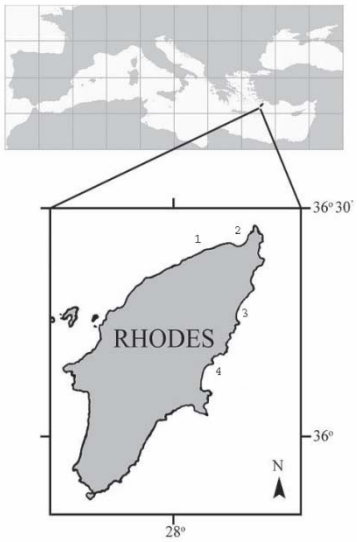

Fig. 1 Map of Rhodes Island with sampling locations of *Lagocephalus sceleratus*. 1 (36°, 24´ 47 N; 28°, 05´ 53 S), 2 (36°, 25´ 20 N; 28°, 11´ 50 S), 3 (36°, 20´ 50 N; 28°, 12´ 37 S), 4 (36°, 08´ 40 N; 28°, 05´ 10)

2.2 SAMPLING

The Danish- or boat-seine method was used to sample *Lagocephalus sceleratus*, from a local commercial fishing boat. The procedure is to set out the start warp with an anchor and a buoy near the shore. The boat heads away from the shore and forms a triangle back to the start warp while the net is set parallel to the shore at 35 m depth. This method enables sampling each habitat from 5 to 35 m in depth. The mesh size of the gear decreases from the outer end of the wing towards the centre with the sequence 500, 180, 32-34, 12, and 11 mm, with minimum mesh size of 5-8 mm at its codend. For further details see Kalogirou *et al.* (2010). Three samples with the seine were randomly deployed on each location and sampling occasion, covering a total area of 0.12 km² (0.04 km² per seining). The total time elapsing from deployment of the start line with an anchor to the time the seine was taken onboard was *c.* 35 min.

All samples were placed in labeled plastic bags and immediately stored in a freezer at -17°C, to prevent further digestion of the prey items.

2.3 FEEDING ECOLOGY

A total of 290 *Lagocephalus sceleratus* individuals were analyzed. Each specimen was thawed, measured (total length: TL accuracy of 0.1 cm) and wet weighed (accuracy 0.01 g).

Identification of prey items was generally limited to higher taxonomic levels since the beak-like jaws of *Lagocephalus sceleratus* crush food items to the extent that prey could rarely be identified to species. However, cephalopod beaks found in the stomachs could easily be identified to species level according to Clarke (1986). Due to differences in level of taxonomic classification, prey items were arranged into three major groups as Mollusca, Crustacea and Fish for the presentation of diets.

It was possible to describe percentage frequency of occurrence of each prey taxa of *Lagocephalus sceleratus*, even though no quantitative measurements of prey numbers or biomass could be estimated in the diet. Additionally, to investigate ontogenetic diet shift with increased fish size, *L. sceleratus* individuals were categorized into seven size classes accordingly: 0-10, class 1; 10.1-20, class 2; 20.1-30, class 3; 30.1-40, class 4; 40.1-50, class 5; 50.1-60, class 6 and 60.1-70 to class 7.

2.4 LENGTH-WEIGHT RELATIONSHIPS AND CONDITION OF FISH

The length-weight relationship was calculated for each season following the equation:
$W=aTL^b$,

where W is the wet weight (g), *a* the intercept of the relationship, TL the standard length (cm), and *b* the slope. In addition, *a* and *b* values, given from the length-weight relationship, are used to estimate the condition of the fish. Length-weight relationships are important in fisheries biology because they allow estimation on the average weight of the fish at a given length, by establishing a mathematical relation between these two.

Seasonal variations in the condition of *Lagocephalus sceleratus* was calculated according to Le Cren (1951) and recommendations given by Froese (2006) following the equation:

$K_{rel}= W/aTL^b$,

where K_{rel} is the relative condition factor, W the total weight (g), TL the total length (cm) and *a* and *b* a term resulting from the length-weight relationship. Tukey's honest significant difference test (HSD) was used to test for seasonality in condition factor.

3. Results

3.1 HABITAT PREFERENCE

In total, higher densities of *Lagocephalus sceleratus* occurred on sandy habitats (168 individuals) compared to *Posidonia oceanica* meadows (122 individuals). During sampling in summer, juvenile fish with a length of five to six cm was caught on sandy bottoms, whereas larger individuals (30 to 40 cm) were found in *P. oceanica* meadows (Fig. 2a). In autumn, the density of fish increased on sandy bottoms and fish size varied between 5 and 32 cm (Fig. 2b). At this time, two size classes (9 to 33 cm and 42 to 62 cm) of *L. sceleratus* occurred in the *P. oceanica* habitat (Fig. 2b). Later in the season, during winter and spring, *L. sceleratus* were only found on sandy bottoms and fish size ranged from 15 to 27 cm (Fig. 2c, d).

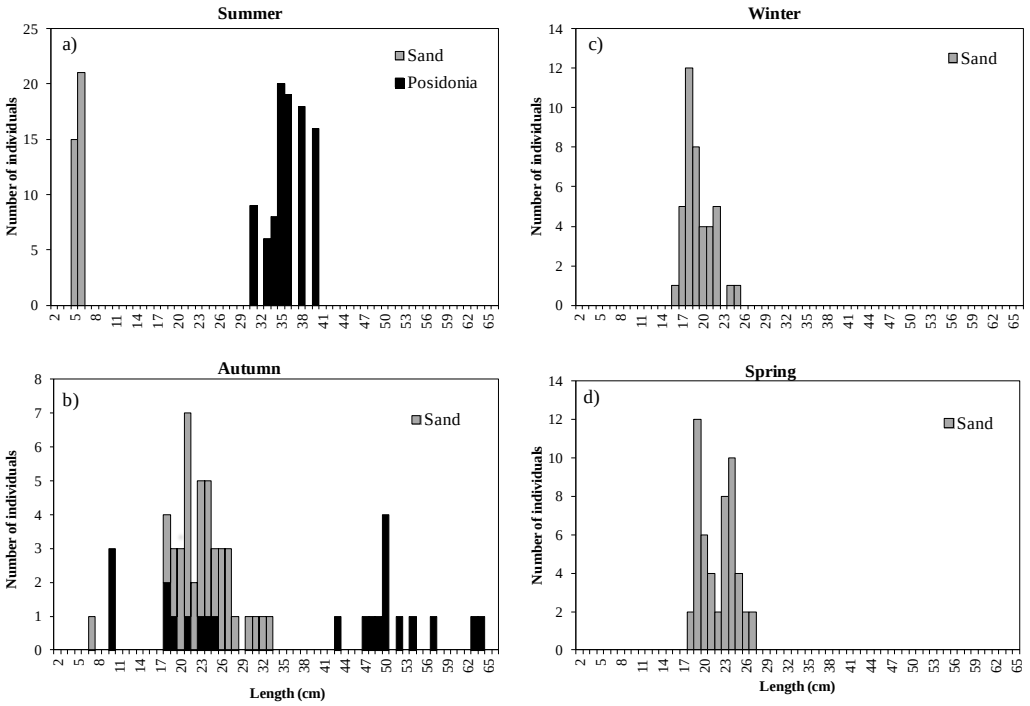

Fig. 2 Length and number of *Lagocephalus sceleratus* individuals found over *Posidonia oceanica* and sandy habitats in summer (a), autumn (b), winter (c) and spring (d).

3.2 FEEDING ECOLOGY

Out of 290 individuals examined, 59 (20.3 %) had empty stomachs, among which 41 (69 %) in winter and 18 (31 %) in autumn. The diet of *Lagocephalus sceleratus* consisted of various prey species within the taxa of mollusca, crustacea and fish, classifying it as an invertebrate and fish feeder. With increased body size, *L. sceleratus* was shown to shift its diet to molluscivore dominated feeding (Fig. 3). According to size classification none of the individuals found during this study exceeded size class 7 (64 cm).

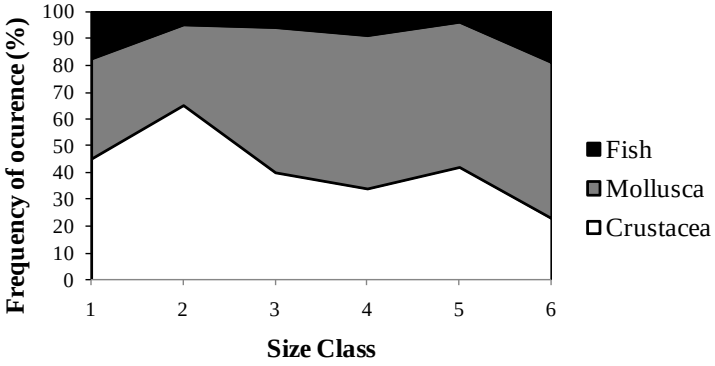

Fig. 3 Frequency of occurrence for each prey taxa (Fish, Crustacea and Mollusca) in the diet of *Lagocephalus sceleratus* related to size-classes.

The two most frequent classes of Mollusca found in the stomachs of *Lagocephalus sceleratus* were Gastropoda and Cephalopoda. Among Gastropoda, the genus *Nassarius* and the family Dentaliidae were identified and among Cephalopoda, *Sepia officinalis* and *Octopus vulgaris*.

Among Crustacea, *Calappa granulata* was the only species identified to a lower level of classification.

An indication of the prey fish families found in the stomachs of *L. sceleratus* were Synodontidae, Trachinidae, Syngnathidae and Tetraodontidae. Stomach content analyses show a high tendency for it to be an invertebrate and fish feeder, if feeding guild classification specify that invertebrates and fish together add up to 90% of the total diet (Kalogirou *et al.*, 2012)

3.3 LENGTH-WEIGHT RELATIONSHIP AND CONDITION OF FISH

The overall length-weight relationship for *Lagocephalus sceleratus* showed a good fit to the exponential curve with R^2 value exceeding 0.99. The value of *a* was 0.0164 and 2.8932 for *b* (Fig. 4).

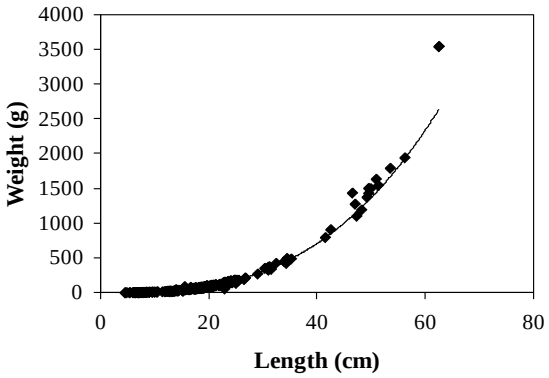

Fig. 4 Length-weight relationship for 290 individuals of *Lagocephalus sceleratus* around the coasts of Rhodes Island

Lagocephalus sceleratus was found to have a similar average condition close to 1 throughout the year with no significant difference among any of the seasons (Tukey's HSD; $P < 0.05$; Fig. 5).

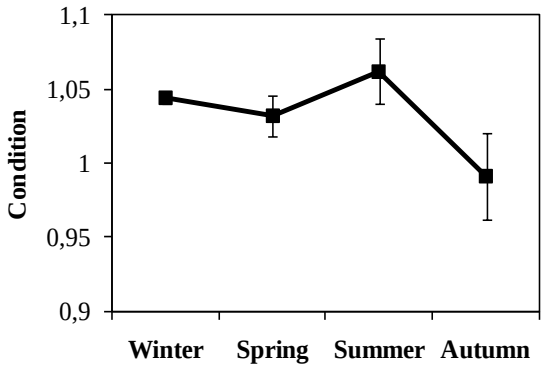

Fig. 5 Mean ± S.E. of relative condition factor for *Lagocephalus sceleratus*

4. Discussion

In this study, status of establishment of the most invasive fish species, *Lagocephalus sceleratus*, five years after it was first reported from the studied area was investigated. Quantitative sampling allowed measurements on population size-structure of *L. sceleratus* in two important coastal habitats. Together with information on feeding habits important life-cycle characteristics are provided for this species in its new environment.

In sandy habitats, *Lagocephalus sceleratus* were present throughout the year and most of the specimens did not exceed size class 3 (30 cm) (Fig. 2). Larger fish (size classes 3 to 6) were mainly found to inhabit *Posidonia oceanica* meadows (Fig. 2). This reveals that with increasing body size, *L. sceleratus* shift habitat. According to the results of this study, habitat shift from sand

to seagrass meadows is related to shift in feeding preferences with increased body size. In the Gulf of Suez, Sabrah *et al.* (2006) showed that *L. sceleratus* reach maturity during the third year of life at a size of 42-43 cm (size class 5). Higher densities of *L. sceleratus* were generally found in sandy habitats (168 individuals) compared to *P. oceanica* meadows (122 individuals) due to high concentrations of small-sized individuals in this habitat during summer. On sandy bottoms, size range of *L. sceleratus* individuals during summer were predominantly five to six cm in length, suggesting that the fish recruit into this habitat. In the autumn, density of fish increased on sandy bottoms and mean fish size of 22 cm show that small individuals are highly affiliated to sandy bottoms. The few small-sized specimens (9 to 26 cm) caught during the same season in *P. oceanica* meadows were likely attributed to a patchy seagrass habitat interrupted by sand. During the autumn, few adult *L. sceleratus* individuals (42 to 62 cm) were present in the *P. oceanica* habitat, indicating that this species might be in the process of further ontogentic shift to deeper or other coastal habitats. Later in the season, during winter and spring, *L. sceleratus* were only found on sandy bottoms where fish size ranged from 15 to 27 cm further signifying the importance of this habitat for the early life stages of *L. sceleratus*. In an earlier study *Lagocephalus sceleratus* was classified a seagrass resident with intermediate affinity to *Posidonia oceanica* habitats of the same area (Kalogirou *et al.*, 2010). This study extends the knowledge of habitats used during the life cycle by revealing habitat shift from sand to *P. oceanica* habitats with increased size. Habitat shift was shown to occur when *L. sceleratus* reach approximately 27-32 cm.
All the above underline that *Lagocephalus sceleratus* is well established in the area but the lack of larger (> 65 cm) individuals from the data could be attributed to the recent establishment of *L. sceleratus* in the area (only for 5 years) or to further habitat shift and deeper grounds. Long-line fishery indicates that larger individuals reaching 78 cm in length are caught over rocky bottoms (pers. obs.).

Even though several authors have mentioned that *Lagocephalus sceleratus* feeds on benthic invertebrates (Golani *et al.*, 2006) this study extends the knowledge on feeding preferences by revealing it as an invertebrate and fish feeder. This study suggests a diet shift with increased body size (to a molluscivore feeding), possibly explaining habitat shift due to changed prey availability or preferences. It is commonly believed that *L. sceleratus* rapid expansion might have affected commercial squid and octopus populations negatively. It is, however, difficult to quantify the predation impact of puffer fish due to the lack of quantitative studies on local invertebrate communities and extended state of digestion of prey items.

Lagocephalus sceleratus was for the first time reported in the Mediterranean Sea in 2003 off Akayka, Gökova Bay in Turkey (Akyol *et al.*, 2005). It has since then showed a rapid expansion throughout the eastern Mediterranean Sea reaching the northern most parts of the Aegean Sea, but has to date not been observed in the western Mediterranean and has not reached Italy (Golani, 2010). Nevertheless, the rapid expansion indicates that the species is well adapted in its new environment. *Lagocephalus sceleratus* was generally found to be in a good condition in the area under study with low seasonal fluctuations. Even though the condition factor used during this study is believed to be a good indicator of the physiological state of the species, it is to be mentioned that condition is also related to other factors such as reproductive period and fat storage. The α (0.0164) and β (2.8932) values given from the length-weight relationship during this study corresponds to values given by Sabrah (2006) from a conspecific population in Attaka fishing harbour of the Suez Canal revealing similar growth rates.

Lagocephalus sceleratus possess one of the strongest paralytic toxin known today, tetrodotoxin (Sabrah *et al.*, 2006) and has been regarded as one of the "worst alien fish" of the Mediterranean Sea (Streftaris and Zenetos, 2006); harmful to human health, fishing gears

(Katsanevakis *et al.*, 2009) and biodiversity (Bilecenoglu, 2010). As mentioned earlier, European legislation (Regulation 854/2004/EC) declares that poisonous fish of the family Tetraodontidae are prohibited from European markets. In Turkey, *L. sceleratus* is considered the most common pufferfish in terms of biomass (Bilecenoglu *et al.*, 2006) while in south-eastern Aegean Sea, Rhodes, *L. sceleratus* was found to rank among the 10 most dominant fish species in terms of biomass in *Posidonia oceanica* habitats (Kalogirou *et al.*, 2010). This undoubtedly shows its high abilities in rapidly colonizing and establishing populations in new areas. Its large size was considered the main reason for this species to be marketed in some fishing ports and there are several cases of poisonings (Bentur *et al.*, 2008; Bilecenoglu, 2010; Golani, 2010). Both Turkish (Bilecenoglu, 2010), Greek and Cypriot (EastMed, 2010) ministries of Agriculture has recently banned fishing and marketing of *L. sceleratus*. Complaints by local fishermen in newspapers have been mentioned from Turkey (Bilecenoglu, 2010), Cyprus, and Greece (Kalogirou, pers. obs.). Complaints by fishermen included destruction of gill nets due to entangling or predation on already captured fish, reduction of local commercial catches of *Sepia officinalis* and *Octopus vulgaris*, cut-off of long-line hooks and the worrying of fish consumers due to warnings by national authorities in difficulties of separating small-sized individuals of *L. sceleratus* from other commercial important fishes of the same size (*Spicara smaris*, *Atherina hepsetus* and *Boops boops*) (Katikou *et al.*, 2009). As an indication of the economical impact from Fethiye Bay of Turkey, five minutes of recreational fishing resulted in 3 broken fishing lines, ten missing hooks and a capture of one *L. sceleratus* weighing 1 kg (Bilecenoglu, 2010). Bilecenoglu's observations correspond to the results of this study where 52 long-line hooks were found in 33 stomachs thus confirming its pest status for commercial long-line fishermen. In economical terms, the time consumed to clean the gear from discarded fish is also considered as negative even though this measurement was not considered in this study. Adaption of long- and handline fisheries, included fishing on deeper grounds (>60 m) where *L. sceleratus* was considered to be absent and the reconstruction of fishing lines with steel lines prohibiting removal of hooks.

The potential effects following the introduction of the NIS *Lagocephalus sceleratus* are hard to predict, but fundamental knowledge on life-cycle characteristics are important to understand environmental responses. An invading species might sometimes reach a peak in density and then decline, a development often referred to as "boom and bust" (Reise *et al.*, 2006). This dynamic leads to the significant reduction in the invading species population. When a NIS becomes established in an area where its preferred food is under-utilized by indigenous species the resulting population explosion can later be brought into equilibrium with available resources (Wellcome, 1988). Competition, despite strong support (Moulton, 1993), seems the less important factor for most of the examples (Reise *et al.*, 2006). Decline and extinction from a build-up of enemies (predators and pathogens) and lack of sufficient resources to sustain the population may be a more likely explanation for failure of invading animals to establish permanent populations (Reise *et al.*, 2006). The invasive NIS *Fistularia commersonii* (Kalogirou *et al.*, 2007) clearly followed this boom and bust development in the studied area according to personal observations. An obvious example of competitive exclusion/displacement of indigenous species was the introduction of two herbivores. *Siganus rivulatus* Forsskål and *Siganus luridus* Rüppell out-competed the native herbivorous species *Sarpa salpa* (L.) and significantly reduced its abundance (Harmelin-Vivien *et al.*, 2005; Azzurro *et al.*, 2007). Several non-indigenous fish species may have the ability to change the trophic food web by being highly dominant in a habitat or competing for food resources with indigenous inhabitants. The impact of NIS on biodiversity is sometimes referred to as positive due to increased species richness, however others argue the opposite effect may result when NIS can become ecosystem engineers and significantly modify the habitat they invade

(Wallentinus and Nyberg, 2007; Rilov and Galil, 2009). There is no doubt that biodiversity in the Mediterranean Sea is changing but to what extent warm-water species of tomorrow will affect the trophic web and the functioning of marine ecosystems needs continuous monitoring (Bianchi, 2007; Kalogirou *et al.*, 2010). Future investigations will reveal how *Lagocephalus sceleratus* will affect the food web structure and function.

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