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OCCURRENCE AND UNUSUAL ABUNDANCE OF RETICULATED LEATHERJACK *STEPHANOLEPIS DIASPROS* (OSTEICHTHYES: MONACANTHIDAE) FROM THE LAGOON OF BIZERTE (NORTHERN TUNISIA, CENTRAL MEDITERRANEAN SEA)

Moez SHAIEK & Sihem RAFRAFI-NOUIRA

Université de Carthage, Unité de Recherches Exploitation des Milieux aquatiques, Institut Supérieur de Pêche et d'Aquaculture de
Bizerte, BP 15, 7080 Menzel Jemil, Tunisia

Christian CAPAPÉ

Laboratoire d'Ichtyologie, Université de Montpellier, case 104, 34095 Montpellier cedex 5, France
e-mail: capape@univ-montp2.fr

ABSTRACT

*This paper reports some unusual captures of the Lessepsian migrant identified as *Stephanolepis diaspros* Fraser-Brünner, 1940 in the Lagoon of Bizerte, a brackish area located in northeastern Tunisia. It appears that at present a viable population is successfully established in this restricted area due to the fact that the species finds the local environmental conditions adequate for living and reproducing.*

Key words: distribution, expansion range, brackish area, description, colour patterns

PRESENZA E ABBONDANZA INUSUALE DI MONACANTO RETICOLATO *STEPHANOLEPIS DIASPROS* (OSTEICHTHYES: MONACANTHIDAE) NELLA LAGUNA DI BIZERTE (TUNISIA SETTENTRIONALE, MEDITERRANEO CENTRALE)

SINTESI

*L'articolo riporta alcune insolite catture del migrante lessepsiano identificato come monacanto reticolato *Stephanolepis diaspros* Fraser-Brünner, 1940 nella Laguna di Biserta, un'area salmastra situata nel nord-est della Tunisia. Attualmente sembra che una popolazione vitale si sia stabilita con successo in quest'area ristretta, dove la specie probabilmente trova condizioni ambientali locali adeguate per vivere e riprodursi.*

Parole chiave: distribuzione, intervallo di espansione, area salmastra, descrizione, modelli di colore

INTRODUCTION

The reticulated leatherjack *Stephanolepis diaspros* Fraser-Brünnner, 1940 is a Lessepsian migrant *sensu* Por (1948) which entered the Mediterranean Sea through the Suez Canal. Since its first record from the Levant Basin (Steinitz, 1927), the species has successfully invaded the eastern Mediterranean Sea (Golani, 1998; Golani et al., 2017), currently maintaining a viable population in Turkish waters (Taskavak & Bilecenoglu, 2001).

Furtherly, *S. diaspros* migrated toward western Mediterranean areas and reached the Gulf of Gabès, southern Tunisia (Chakroun, 1966), where it found adequate environmental conditions to develop and reproduce in the wild (Zouari-Ktari et al., 2008; Zouari-

Ktari & Bradai, 2011). The first specimen from northern Tunisia was recorded in the Lagoon of Bizerte (Bdioui et al., 2004) and subsequent ones off Tabarka, a city located close to the Algerian border (Ben Amor & Capapé, 2008).

Through routine monitoring regularly and frequently conducted in northern Tunisian waters other *S. diaspros* have been found in the area, mainly in the Lagoon of Bizerte. These new records are presented herein and commented to explain this unusual occurrence of *S. diaspros* as a possible settlement of the species in this lagoon.

MATERIAL AND METHODS

On 7 July 2018, a specimen of *Stephanolepis diaspros* was captured off Bizerte (Fig. 1), a city located in northern Tunisia (37° 17' 40.4" N and 9° 56' 05.0" E), by trammel net on sandy bottom at a depth of 20 m approximately, together with some grey triggerfish *Balistes caprisca* Gmelin, 1789.

The Lagoon of Bizerte is a brackish water body located in northeastern Tunisia, between 37° 8' and 37° 14' N, and between 9° 46' and 9° 56' E. It appears as an ellipse, 11 km wide and 13 km long, connected to the Mediterranean Sea by an artificial navigation channel with a maximum depth of 12 m, which facilitates the invasion of the area by *S. diaspros*. The average and maximum depths of the lagoon are 7 m and 12 m, respectively, the bottoms sandy, muddy and detritic and in places covered by seagrass meadows (Zaouali, 1974). At least 15 teleost and 8 elasmobranch species have been recorded in the Lagoon of Bizerte, an area with two landing sites, commercially exploited by artisanal craft fisheries (Harzallah, 2003; El Kamel et al., 2009).

A total of 32 specimens of *S. diaspros* were collected with the assistance of local fishermen working in the area and aware of the fishing grounds. This participative monitoring method combined with interviews of fishermen is known as local ecological knowledge (LEK). It constitutes complementary support and a source of information increasing and improving the reliability and therefore the quality of our data, following the protocols of Azzurro et al. (2011) and CIESM (2018).

All fresh specimens were measured to the nearest millimetre and weighed to the nearest gram. The Shapiro-Wilk test for normality of the sample was performed, with $P < 0.05$. The chi-square test was used to determine the significance ($P < 0.05$). The relation between total length (TL) and total body weight (TBW) was used as a complement to feeding studies following Froese et al. (2011), to assess if *Stephanolepis diaspros* is able to develop in its new habitat. This LWR is $TBW = aTL^b$, and was converted into its linear regression, expressed in decimal logarithmic coordinates and correlations were assessed by least-squares regression ($\log TBW = \log a + b \log TL$). Significance of constant b differences

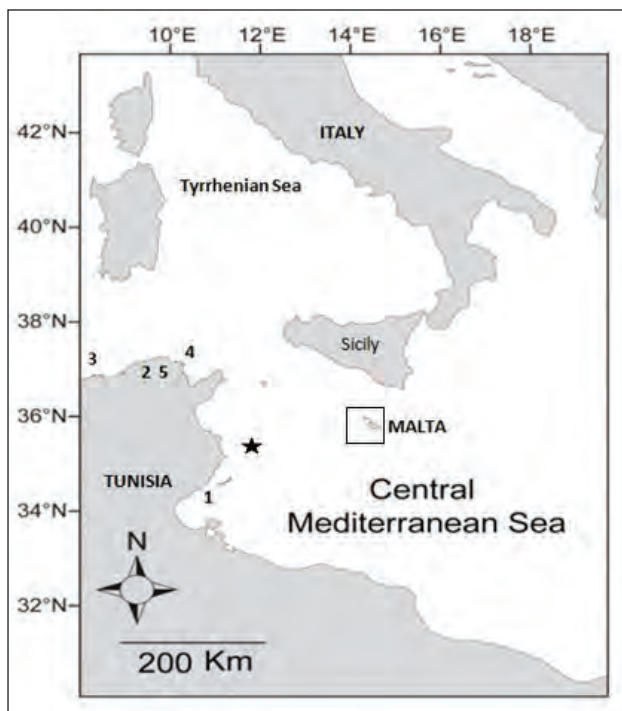


Fig. 1: Capture sites of *Stephanolepis diaspros* in the central Mediterranean Sea. 1. Gulf of Gabès (Chakroun, 1966). 2. Lagoon of Bizerte (Bdioui et al., 2004). 3. Off Tabarka (Ben Amor & Capapé, 2008). 4. Off Bizerte (this study). 5. Lagoon of Bizerte (this study). The black star and square indicate the captures of the species in the waters surrounding the Island of Lampedusa and the Islands of Malta, respectively (Deidun et al., 2015). Sl. 1: Lokalitete, kjer so bili ujeti primerki vrste *Stephanolepis diaspros* v osrednjem Sredozemskem morju. 1. Gabeški zaliv (Chakroun, 1966). 2. Laguna pri Bizerti (Bdioui et al., 2004). 3. Pri Tabarki (Ben Amor & Capapé, 2008). 4. Pri Bizerti (ta študija). 5. Laguna pri Bizerti (ta študija). Črna zvezdica in kvadrat prikazujeta lokaliteta ulova v vodah okoli otoka Lampedusa in Malte (Deidun et al., 2015).

was assessed to the hypothesis of isometric growth if $b = 3$, positive allometry if $b > 3$, negative isometry if $b < 3$ (Pauly, 1983). A comparison of means was carried out using ANOVA. These two latter tests were performed using the STAT VIEW 5.0 logistic model.

Morphometric measurements and meristic counts were recorded, following Ben Amor & Capapé (2008), in the specimen caught off Bizerte and three specimens from the Lagoon of Bizerte (see Table 1). These four specimens were fixed in 10% buffered formaldehyde and preserved in 75% ethanol. One specimen was deposited in the Ichthyological Collection of the Faculté des Sciences de Bizerte, under the catalogue number FSB-Ste-dia-01, and the other 3 in the Ichthyological Collection of the Institut de Pêche et d'Aquaculture de Menzel Jemil under catalogue numbers ISPAB-Ste-dia-01, ISPAB-Ste-dia-02 and ISPAB-Ste-dia-03, respectively.

RESULTS AND DISCUSSION

The occurrence of *Stephanolepis diaspros* in those Tunisian regions where the species was previously unknown or rare could result from hydrobiological changes, especially temperature rise, which has affected Tunisian waters and the entire Mediterranean Sea for several decades (Francour et al., 1994; Ben Raïs Lasram

& Mouillot, 2009). Such occurrence in restricted areas is not a fortuitous event, it confirms the opinion of Ounifi-Ben Amor et al. (2019), who noted that Tunisian lagoons are hotspots for intrusion of non-indigenous species.

All specimens were identified as *Stephanolepis diaspros* in complete agreement with Tortonese (1967, 1986), Golani et al. (2017), Dulčić & Pallaoro (2003) and Bdioui et al. (2004). The specimen from off Bizerte displayed a brown to green-grey colour, with posterior dark areas and sinuous grey lines on the sides, dark bands non visible in caudal (Fig. 2). The specimens from the Lagoon of Bizerte exhibited a diversity of colour patterns and the phenomenon of polychromatism cannot be totally ruled out (Fig. 3). These colour differences suggest that the specimens caught off the northern coast of Tunisia could be *S. hispidus* (Linnaeus, 1766) according to Ben Amor & Capapé (2008). However, a new revision of the genus *Stephanolepis* Gill, 1862 is needed prior to drawing any definite conclusions; *S. hispidus* and *S. diaspros* are well separated geographically, the former occurs in the Atlantic Ocean and the latter in the eastern Mediterranean (Tortonese, 1986).

At present, *S. diaspros* occurs throughout the central Mediterranean Sea, and a viable population is successfully established in the Gulf of Gabès, southern Tunisia (Zouari-Ktari & Bradaï, 2011). The species is continuing its migration toward northern areas, as corroborated by

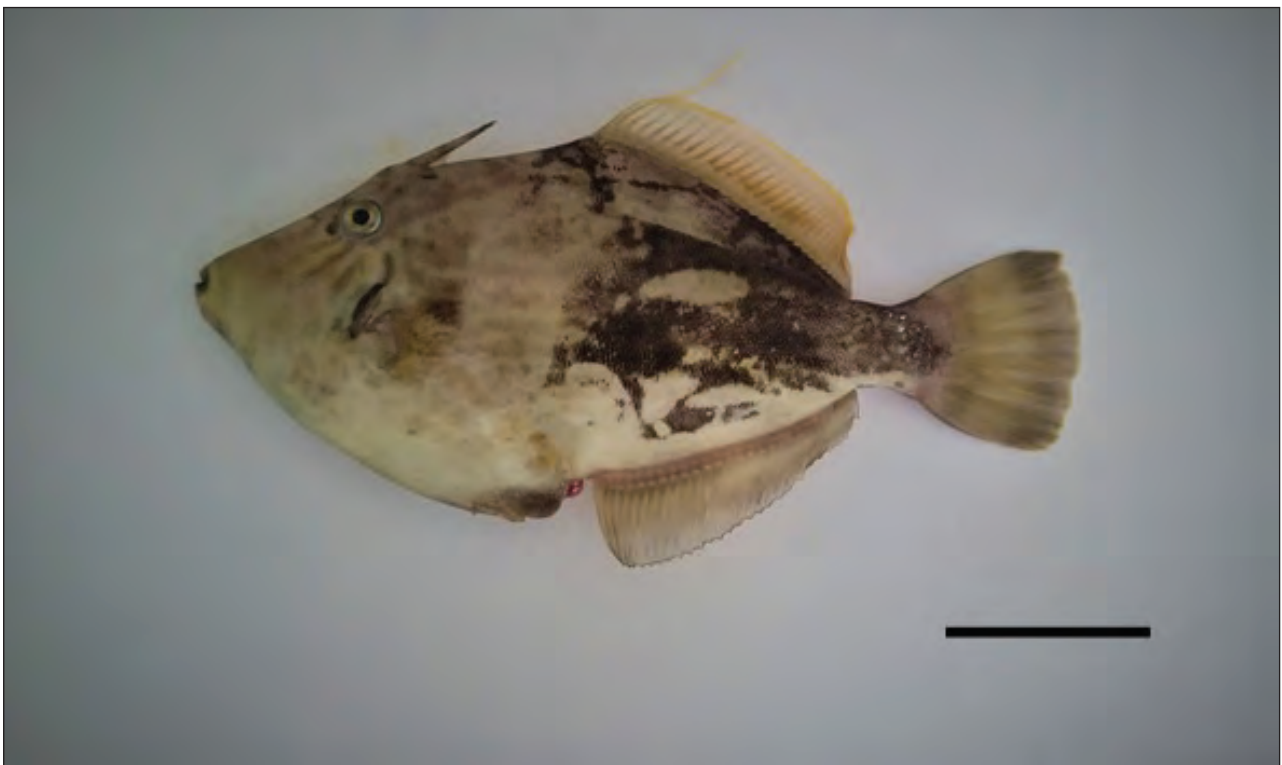


Fig. 2: The specimen of *Stephanolepis diaspros* captured off Bizerte (ref. FSB-Ste-dia-01), scale bar = 50 mm.
Sl. 2: Primerek vrste *Stephanolepis diaspros* ujet pri Bizerti (ref. FSB-Ste-dia-01), merilo = 50 mm.

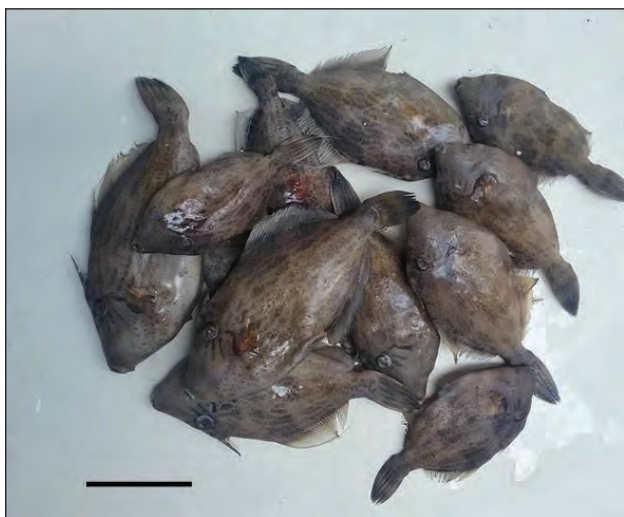


Fig. 3: The lot of specimens of *Stephanolepis diaspros* collected in the Lagoon of Bizerte, scale bar = 80 mm.
Sl. 3: Številni primerki vrste *Stephanolepis diaspros*, ujeti v laguni pri Bizerti, merilo = 80 mm.

the single specimen reported from the Lagoon of Bizerte by Bdioui et al. (2004) and now by the 32 specimens included in this study. Some of the latter were collected off the city of Tabarka close to the Algerian border (Ben Amor & Capapé, 2008) and one specimen was captured off Bizerte (this study). Additionally, findings of the species in waters surrounding the Island of Lampedusa, close to the Tunisian coast, and the Islands of Malta confirm such hypothesis (Deidun et al., 2015).

Some fishermen working in the Lagoon of Bizerte were interviewed to provide further substantiating information about the captures of *S. diaspros* in the area. These captures occurred in May, June and, to a smaller extent, July. The fishermen would find 4–6, maximum 8 specimens per fishing trip and the captures occurred throughout the lagoon, so apparently there was no preferential site (Fig. 4). *S. diaspros* has a low economic value in the area, so the collected specimens were not auctioned and sold at landing sites, rather consumed by the fishermen themselves and their families. The abundance of captures in the Lagoon of Bizerte is a recent phenomenon – just two years ago, *S. diaspros*

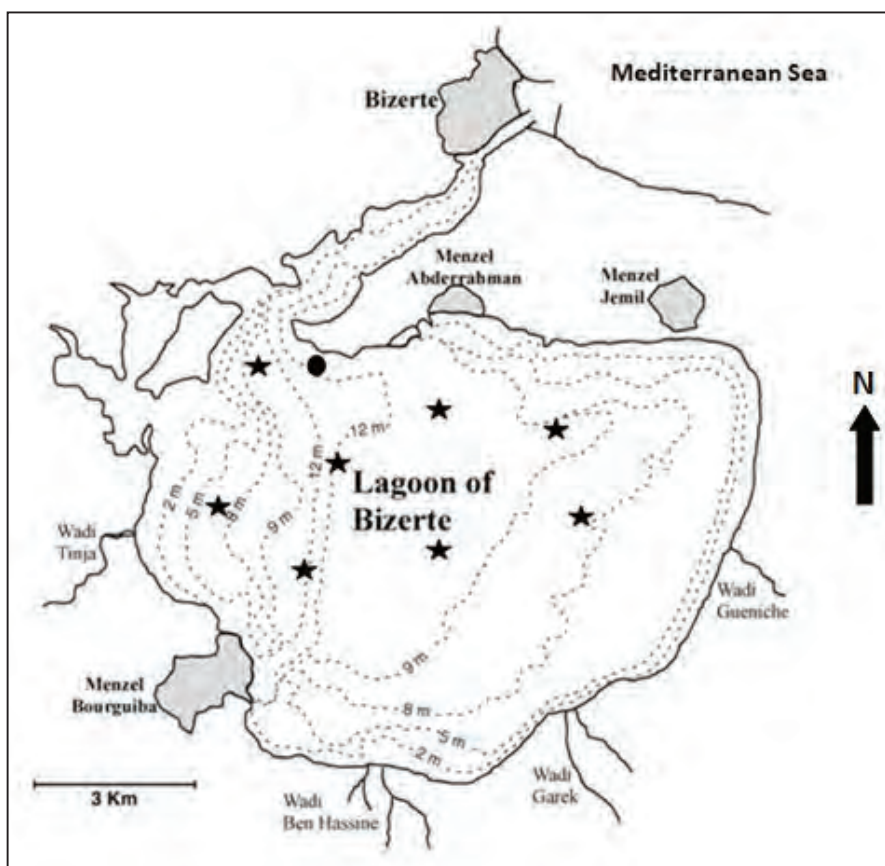


Fig. 4: Map of the Lagoon of Bizerte indicating the capture sites of *Stephanolepis diaspros*: black disc (Bdioui et al., 2004), black stars (this study).

Sl. 4: Zemljevid lagune pri Bizerti z označenimi lokalitetami, kjer so bili ujeti primerki vrste: črni krogec (Bdioui et al., 2004), črne zvezdice (ta študija).

was still unknown to the local fishermen and often misidentified as the grey triggerfish *B. capriscus*.

The specimen of *S. diaspros* caught off Bizerte measured 215 mm in TL and its total body weight was 186 g. The TL of the 32 specimens collected in the Lagoon of Bizerte ranged between 96 mm and 235 mm, their TBW between 14 g and 235 g. Zouari-Ktari & Bradaï (2011) noted that the Tunisian specimens sampled in the Gulf of Gabès reached the first sexual maturity at about 80 mm in females and 110 mm in males, thus we assume that our specimens were probably adults. Additionally, Zouari-Ktari *et al.* (2008) noted that specimens from the same area fed on benthic organisms and phyto-benthos, and the large diversity of prey species found in the stomach contents indicated that *S. diaspros* is omnivorous and opportunistic. Availability and accessibility of similar prey species and the presence of large seagrass meadows (Zaouali, 1974) could explain the successful settlement of *S. diaspros* in this brackish area. This may be confirmed by the LWR ($\log \text{TBW} = -4.73 + 3.01 \log \text{TL}$; $r = 0.98$; $n = 32$), a slightly positive allometry indicating that *S. diaspros* found sufficient resources locally to live in the area (Fig. 5).

Information provided by the fishermen working in this area (LEK) showed that other species with a diet similar to that of *S. diaspros*, such as the grey triggerfish *Balistes capriscus* or the salema *Sarpa salpa* (Linnaeus, 1758), are rarely captured. There was a single capture of the Lessepsian migrant dusky spinefoot *Siganus luridus* (Rüppell, 1829) in the lagoon (Ounifi-Ben Amor *et al.*, 2016), but with no new records following. However, the pressure of interspecific and/or intraspecific competition for food among these omnivorous teleost species cannot be totally ruled out. Therefore, regular

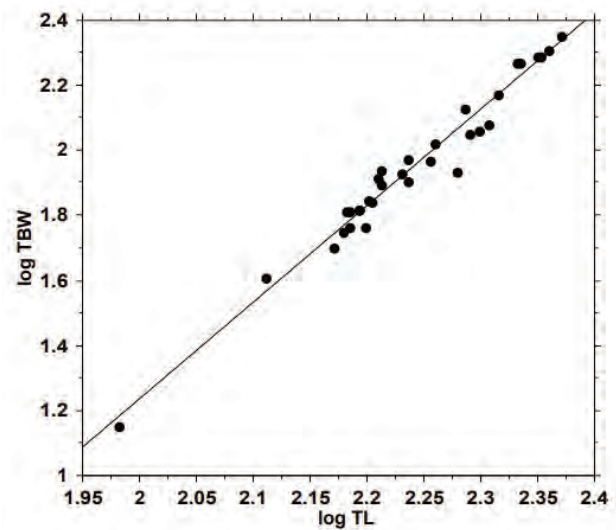


Fig. 5: The size (TL) versus total body weight (TBW) relationship in the specimens collected in the Lagoon of Bizerte (this study) expressed in logarithmic coordinates.

Sl. 5: Razmerje med velikostjo (TL) in celotno telesno težo (TBW) pri primerkih ujetih v laguni Bizerte (ta študija), izraženo v logaritmičnih koordinatah.

monitoring of *S. diaspros* should be carried out to assess the role of the species in its new environment. To reach this goal, further captures of the species are necessary for studying, in particular, its reproductive biology, diet and feeding habits.

Tab. 1: Morphometric measurements, meristic counts and total body weight recorded in the specimens of *Stephanolepis diaspros* collected off Bizerte (ref. FSB-Ste-dia-01) and in the Lagoon of Bizerte (ISPAB-Ste-dia-01, ISPAB-Ste-dia-02 and ISPAB-Ste-dia-03).

Tab. 1: Morfometrične meritve, meristična štetja in celotna masa telesa primerkov afriškega kostoroga, ujetih pri Bizerti (ref. FSB-Ste-dia-01) in v laguni pri Bizerti (ISPAB-Ste-dia-01, ISPAB-Ste-dia-02 in ISPAB-Ste-dia-03).

References	FSB-Ste-dia-01		ISPAB-Ste-dia-01		ISPAB-Ste-dia-02		ISPAB-Ste-dia-03	
Measurements	mm	% TL	mm	% TL	mm	% TL	mm	% TL
Total length (TL)	215	100	235	100	180	100	160	100
Standard length (SL)	185	86.05	200	85.11	150.00	83.33	137	85.63
Head length	55	25.58	56.96	24.24	43.85	24.36	40.02	25.01
First predorsal length	48.66	22.63	56.98	24.25	43.45	24.14	36.07	22.54
Second predorsal length	94.52	43.96	100.5	42.77	80.47	44.71	74.59	46.62
Preal length	97.51	45.35	108.68	46.25	86.85	48.25	78.05	48.78
Prepectoral length	49.49	23.02	52.5	22.34	44.38	24.66	40.15	25.09
First dorsal fin length	13.57	6.31	14.31	6.09	12.50	6.94	12.58	7.86
Second dorsal fin length	73.43	34.15	74.64	31.76	57.04	31.69	52.86	33.04
Anal fin length	65.84	30.62	69.59	29.61	54.58	30.32	47.02	29.39
Pectoral fin length	9.36	4.35	11.62	4.94	8.40	4.67	7.56	4.73
Caudal fin length	24.29	11.30	25.83	10.99	20.58	11.43	16.43	10.27
Maximal body length	85.55	39.79	87.89	37.40	70.44	39.13	65.67	41.04
Eye diameter	11.44	5.32	14.2	6.04	10.63	5.91	9.59	5.99
Interorbital length	12.39	5.76	14.41	6.13	11.44	6.36	9.67	6.04
Preorbital length	35.68	16.60	39.6	16.85	32.62	18.12	25.62	16.01
Postorbital length	6.12	2.85	9.29	3.95	7.21	4.01	6.74	4.21
Meristic counts								
First dorsal fin rays	I		I		I		I	
Second dorsal fin rays	31		31		31		31	
Anal fin rays	31		31		31		31	
Pectoral fin rays	13		13		13		13	
Caudal fin rays	12		12		12		12	
Total body mass (gram)	186		225		93		70	

POJAVLJANJE IN NENAVADNA ŠTEVILČNOST AFRIŠKEGA KOSTOROGA,
STEPHANOLEPIS DIASPROS (OSTEICHTHYES: MONACANTHIDAE) IZ LAGUNE PRI
BIZERTI (SEVERNA TUNIZIJA, OSREDNJE SREDOZEMSKO MORJE)

Moez SHAIEK & Sihem RAFRAFI-NOUIRA

Université de Carthage, Unité de Recherches Exploitation des Milieux aquatiques, Institut Supérieur de Pêche et d'Aquaculture de
Bizerte, BP 15, 7080 Menzel Jemil, Tunisia

Christian CAPAPÉ

Laboratoire d'Ichtyologie, Université de Montpellier, case 104, 34095 Montpellier cedex 5, France
e-mail: capape@univ-montp2.fr

POVZETEK

Avtorji poročajo o nenavadnih ulovih ribje lesepske selivke vrste *Stephanolepis diaspros* Fraser-Brünnner, 1940 v laguni pri Bizerti, brakičnem okolju v severovzhodni Tuniziji. Kaže, da se je v tem omejenem okolju zaradi ugodnih življenjskih razmer za preživetje in razmnoževanje vzpostavila viabilna populacija te vrste.

Ključne besede: razširjenost, širjenje areala, brakično okolje, opis, barvni vzorci

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