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VSEBINA / *INDICE GENERALE / CONTENTS*

BIOTSKA GLOBALIZACIJA
GLOBALIZZAZIONE BIOTICA
BIOTIC GLOBALIZATION

Okan AKYOL, Oğuzhan TAKICAK & Hasan TARUN
A Fugitive Lessepsian Fish in a Sea-Cage Farm in the Aegean Sea: *Stephanolepis diaspros* (Monacanthidae) 1
Ubežni lesepski migrant iz ribogojnice v Egejskem morju: Stephanolepis diaspros *(Monacanthidae)*

Nicola BETTOSO, Lisa FARESI, Valentina TORBOLI & Jose A. CUESTA
Additional Record of the Pea Crab *Pinnotheres bicristatus* (Brachyura: Pinnotheridae) in the Adriatic Sea 7
Dodatni zapis o pojavljanju stražne rakovice vrste Pinnotheres bicristatus *(Brachyura: Pinnotheridae) v Jadranskem morju*

Alan DEIDUN, Sarah BAUMANN, Bruno ZAVA & Maria CORSINI-FOKA
Confirming the Occurrence of the Non-Indigenous *Pteragogus trispilus* (Actinopterygii: Labridae) within Maltese Waters 13
Potrditev pojavljanja tujerodne ustnače vrste Pteragogus trispilus *(Actinopterygii: Labridae) znotraj malteških voda*

Deniz ERGÜDEN, Yusuf Kenan BAYHAN, Sibel ALAGÖZ ERGÜDEN & Deniz AYAS
A New Ichthyological Record and Distributional Update for *Epigonus denticulatus* Dieuzeide, 1950 in Turkish Mediterranean Waters 21
Nov ihtiološki zapis in podatki o razširjenosti rjavega veleokca, Epigonus denticulatus *Dieuzeide, 1950 v turških sredozemskih vodah*

Sara LADOUL, Farid HEMIDA, Christian REYNAUD & Christian CAPAPÉ
On the Occurrence of Cornish Blackfish *Schedophilus medusophagus* (Osteichthyes: Centrolophidae) from the Maghreb Shore (Southwestern Mediterranean Sea) 27
Potrjena prisotnost meduzojeda Schedophilus medusophagus *(Osteichthyes: Centrolophidae) z magrebske obale (jugozahodno Sredozemsko morje)*

Christina MICHAIL & Francesco TIRALONGO
First Occurrence of Ariidae in Cypriot Waters – a Major Contribution to Biodiversity 35
Prvo pojavljanje predstavnikov iz družine Ariidae v ciprskih vodah – velik prispevek k biodiverziteti

SREDOZEMSKE HRUSTANČNICE
SQUALI E RAZZE MEDITERRANEE
MEDITERRANEAN SHARKS AND RAYS

Lovrenc LIPEJ, Riccardo BATTISTELLA, Borut MAVRIČ & Danijel IVAJNŠIČ
An Insight into the Diet of the Bull Ray, *Aetomylaeus bovinus* (Geoffroy Saint-Hilaire, 1817) in the Northern Adriatic Sea 43
Vpogled v prehranjevalne navade kljunatega morskega goloba, Aetomylaeus bovinus *(Geoffroy Saint-Hilaire, 1817) v severnem Jadranu*

Cem ÇEVİK, Deniz ERGÜDEN & Deniz AYAS
A New Capture Record of *Alopias superciliosus* Lowe, 1841 from the Turkish Coast (Northeastern Mediterranean) 55
Nov ulov velikooke morske lisice Alopias superciliosus *Lowe, 1841 iz turške obale (severovzhodno Sredozemlje)*

Cem DALYAN, N. Bikem KESİCİ, Elif YÜCEDAĞ BAKIR, Yunus GÖNÜL & Hakan KABASAKAL
No Longer as Common as its Name: a Review of the Occurrence of *Torpedo torpedo* (Linnaeus, 1758) (Chondrichthyes: Elasmobranchii) in Turkish Waters, with Photographic Evidence 65
Ni več tako pogost kot njegovo ime: pregled pojavljanja okatega električnega skata Torpedo torpedo *(Linnaeus, 1758) (Chondrichthyes: Elasmobranchii) v turških vodah s fotografskimi dokazi*

Deniz ERGÜDEN, Cemal TURAN, Servet Ahmet DOĞDU & Deniz AYAS
Disc Deformity in a Juvenile Female Brown Ray, *Raja miraletus* (Family: Rajidae), from Northeastern Mediterranean (Türkiye) 73
Deformacija diska pri juvenilni samici modropege raže, Raja miraletus *(družina: Rajidae), iz severovzhodnega Sredozemskega morja (Turčija)*

Farid HEMIDA, Christian REYNAUD & Christian CAPAPÉ
On an Old Record of the Smalltooth Sand Tiger Shark *Odontaspis ferox* (Chondrichthyes: Odontaspididae) from the Algerian Coast (Southwestern Mediterranean Sea) 83
O starem zapisu o drobnozobem morskem biku Odontaspis ferox *(Chondrichthyes: Odontaspididae) z alžirske obale (jugozahodno Sredozemsko morje)*

Hakan KABASAKAL, Uğur UZER & F. Saadet KARAKULAK
Plastic Debris-Induced Fin Damage in the Smoothhound, *Mustelus mustelus* 91
Poškodbe plavuti pri navadnem morskem psu, Mustelus mustelus*, zaradi plastičnih odpadkov*

Florane TONDU, Chloé MOSNIER, Sarah FOXONET, Ruben Bao GALLIEN, Mathias POULY, Modan Lou TONIETTO, Lucille VERDON, Janis BROUTIN-RENAUD, Eloïse DEYSSON, Emmanuel BALLIF, Alessandro DE MADDALENA, Hakan KABASAKAL & Nicolas ZIANI
Bite Marks Observed on a Large Female White Shark *Carcharodon carcharias* Off Camargue, France Provide Potential Insights into the Reproduction of the Mediterranean Population 97
Sledovi ugrizov na veliki samici belega morskega volka Carcharodon carcharias *pri Camargu (Francija) kažejo na možno razmnoževanje sredozemske populacije*

MORSKA FAVNA
FAUNA MARINA
MARINE FAUNA

Sihem RAFRAFI-NOUIRA, RIMEL BENMESSAOUD, Mourad CHÉRIF, Christian REYNAUD & Christian CAPAPÉ
Morphological Deformities in a Common Two-Banded Sea Bream, *Diplodus vulgaris* (Osteichthyes: Sparidae), from Northern Tunisian Waters (Central Mediterranean Sea) 109
Morfološke deformacije pri fratru, Diplodus vulgaris *(Osteichthyes: Sparidae), iz severnih tunizijskih vod (osrednje Sredozemsko morje)*

Abdelkarim DERBALI, Aymen HADJ TAIEB & Wassim KAMMOUN
The Current Status of *Polititapes aureus* (Mollusca: Bivalvia) in the Coastal Zone of Sfax, Tunisia (Central Mediterranean) 117
Trenutno stanje vrste Polititapes aureus *(Mollusca: Bivalvia) na obalnem območju Sfaxa v Tuniziji (osrednje Sredozemlje)*

Neža LEBAN & Valentina PITACCO
Current Knowledge on the Distribution of the Poorly Known Echiurid Species *Maxmuelleria gigas* (M. Müller, 1852) in the Slovenian Sea 125
Trenutno poznavanje prostorske razporeditve manj poznane vrste zvezdaša Maxmuelleria gigas *(M. Müller, 1852) v slovenskem morju*

Jan MALEJ, Tjaša KOGOVŠEK, Martin VODOPIVEC, Janja FRANCÉ, Patricija MOZETIČ, Matevž MALEJ & Alenka MALEJ
Long-Term Study of Zooplankton Biomass in the Gulf of Trieste (Adriatic Sea) 133
Dolgoročna študija zooplanktonske biomase v Tržaškem zalivu (Jadransko morje)

Sihem RAFRAFI-NOUIRA, Rimel BENMESSAOUD, Mourad CHÉRIF, Christian REYNAUD & Christian CAPAPÉ
Occurrence of the Longjaw Snake Eel, *Ophisurus serpens* (Ophichthidae), in Tunisian Waters (Central Mediterranean Sea) 145
Pojavljanje zobate jegulje, Ophisurus serpens *(Ophichthidae), iz tunizijskih voda (osrednje Sredozemsko morje)*

FLORA
FLORA
FLORA

Martina ORLANDO-BONACA, Artur BONACA, Diego BONACA & Ana ROTTER
Seagrasses: a Promising Source of Bioactive Compounds for Human Health Applications 153
Morske cvetnice: obetaven vir bioaktivnih spojin za uporabo v zdravstvu

OCENE IN POROČILA
RECENSIONI E RELAZIONI
REVIEWS AND REPORTS

Shin-ichi Uye
Book review: Mirrors of the Sea: When Science and Art Meet. 30 Years of the Unesco Intergovernmental Oceanographic Commission in Slovenia 167

Kazalo k slikam na ovitku 169
Index to images on the cover 169

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MORPHOLOGICAL DEFORMITIES IN A COMMON TWO-BANDED SEA BREAM, *DIPLODUS VULGARIS* (OSTEICHTHYES: SPARIDAE), FROM NORTHERN TUNISIAN WATERS (CENTRAL MEDITERRANEAN SEA)

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ABSTRACT

In a sample of common two-banded sea bream, Diplodus vulgaris*, collected from the northern coast of Tunisia, one specimen displayed abnormal morphology. This individual presented a prominently developed upper margin, arched into a hump, a pointed upper head profile, and a strongly curved lateral line. X-ray imaging revealed abnormal curvatures in the vertebral column, such as hyperkyphosis and lordosis. A length-weight relationship analysis based on 49 normal specimens and the abnormal specimen showed a slightly negative allometry, suggesting that such specimens are capable of living alongside normal population in the wild.*

Key words: *Diplodus vulgaris*, hyperkyphosis, lordosis, environmental pollution, length-weight

DEFORMAZIONI MORFOLOGICHE IN SARAGO COMUNE, *DIPLODUS VULGARIS* (OSTEICHTHYES: SPARIDAE), PROVENIENTE DALLE ACQUE DELLA TUNISIA SETTENTRIONALE (MEDITERRANEO CENTRALE)

SINTESI

In un campione di sarago comune, Diplodus vulgaris*, pescato lungo la costa settentrionale della Tunisia, un esemplare presentava una morfologia anomala. Questo pesce esibiva un margine superiore molto sviluppato, arcuato in una gobba, un profilo superiore della testa appuntito e una linea laterale fortemente incurvata. Le immagini radiografiche hanno rivelato curvature anomale della colonna vertebrale, come ipercifosi e lordosi. Un'analisi del rapporto lunghezza-peso basata su 49 esemplari normali e sull'esemplare anormale ha mostrato un'allometria leggermente negativa, suggerendo che questi esemplari sono in grado di vivere insieme alla popolazione normale in natura.*

Parole chiave: *Diplodus vulgaris*, ipercifosi, lordosi, inquinamento ambientale, lunghezza-peso

INTRODUCTION

The common two-banded sea bream *Diplodus vulgaris* (E. Geoffroy Saint-Hilaire, 1817) inhabits the eastern Atlantic from Brittany and the Bay of Biscay to northern Spain and Portugal (Quéro *et al*., 2003). South of the Strait of Gibraltar, the species is widely distributed from the coast of Morocco to Angola and South Africa, including the archipelagos of Madeira (Wirtz *et al*., 2008), the Canary Islands (Bauchot & Hureau, 1990), and Cape Verde (Wirtz *et al*., 2013). *D. vulgaris* is caught throughout the Mediterranean Sea and has also been recorded in the Black Sea, off the Bulgarian coast (Bauchot & Hureau, 1986).

D. vulgaris is one of the 21 sparid species of commercial value that are commonly caught along the entire Tunisian coast. It is is particularly abundant in the Gulf of Gabès, where it has been the subject of several studies (Bradaï, 2000; Hadj Taïeb, 2012). The species is also found in northern areas such as the Gulf of Tunis, where its age structure and growth rates have been studied by Mouine *et al*. (2010).

Investigations conducted in northern Tunisia over the two decades since 2000 – initially focused on elasmobranch species (El Kamel et *al*., 2009a,b) and later encompassing all fish species (Rafrafi-Nouira, 2016) – led to the collection of multiple *D. vulgaris* specimens. One individual among them displayed morphological deformities involving both external (body shape, lateral line) and internal anatomical features.

Comprehensive published scientific references on abnormalities in teleost species document no recorded cases of morphological anomalies in *D. vulgaris* (see Dawson, 1964, 1966, 1971; Dawson & Heal 1971; Dulčić & Soldo, 2005; Jawad *et al*., 2010; Jawad & Ibrahim, 2018). This paper describes an abnormal specimen and suggests potential causes of similar abnormalities observed in other teleost species.

MATERIAL AND METHODS

Between 2016 and 2023, a total of 50 specimens of *D. vulgaris* were collected, along with other sparid and labrid species (Fig. 1), using commercial gill-nets with a 26 mm stretched mesh size, on sandy substrates off Ras Jebel, northern Tunisia (37°14′57.53″ N, 10°11′52.85″ E). Three fresh specimens – including one abnormal and two normal ones – were measured for total length (TL) to the nearest centimetre and total body weight (TBW) to the nearest decigram. Morphometric measurements and meristic counts were performed following Tortonese (1975), Bauchot & Hureau (1986), and Quéro *et al*. (2003), with the results summarised in Table 1. The three specimens were then fixed in 10% buffered formalin, preserved in 75%

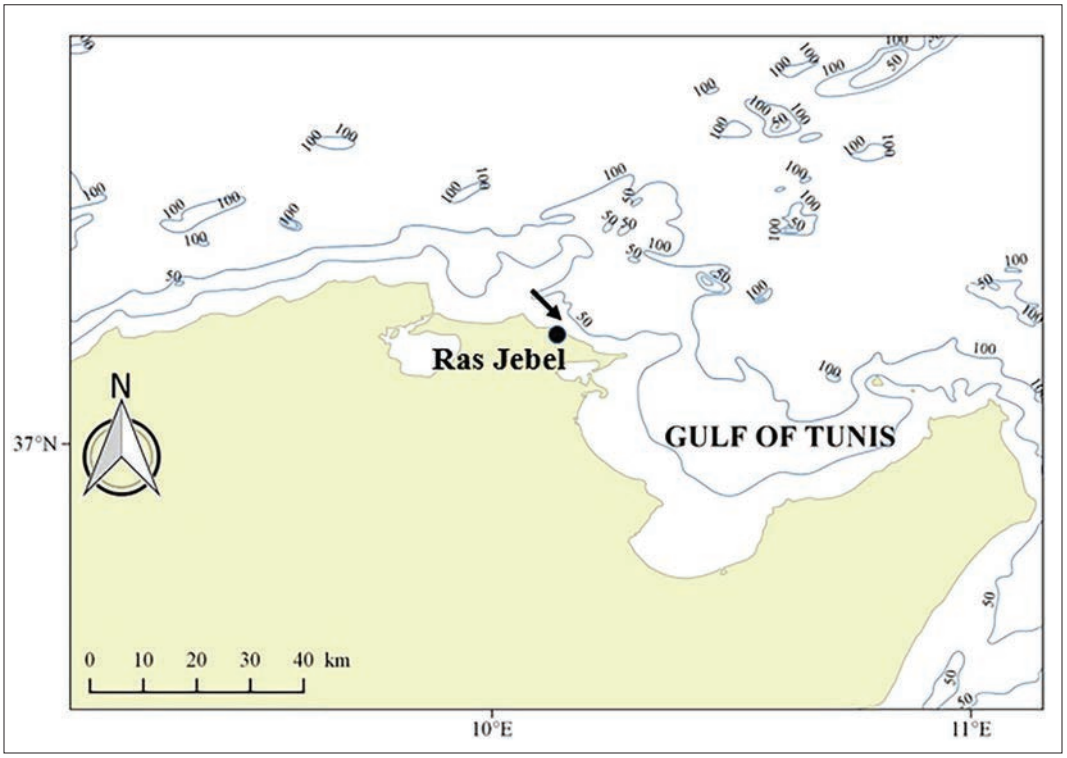

Fig. 1: Map of northern Tunisia indicating the capture sites of *D. vulgaris* ***(black arrow).***
Sl. 1: Zemljevid severne Tunizije z označeno lokaliteto ulova vrste *D. vulgaris* ***(črna puščica).***

Tab. 1: Morphometric measurements (expressed as percentages of standard length, %SL), meristic counts, and total body weight (in grams) recorded from the three *D. vulgaris* ***specimens collected off the northern Tunisian coast: one abnormal specimen (ISPAB-Dipl vul 01) and two normal specimens (ISPAB-Dipl vul 02 and ISPAB-Dipl vul 03).***
Tab. 1: Morfometrične meritve (izražene kot odstotki standardne dolžine, %SL), meristična štetja in skupna telesna teža (v gramih), zabeležene pri treh primerkih vrste *D. vulgaris*, ***zbranih ob severni tunizijski obali: enem nenormalnem vzorcu (ISPAB-Dipl vul 01) in dveh normalnih vzorcih (ISPAB-Dipl vul 02 in ISPAB-Dipl vul 03).***

References	**ISPAB-Dip-vul 01**		**ISPAB-Dip-vul 02**		**ISPAB--Dip-vul 03**	
Condition	**Abnormal**		**Normal**		**Normal**	
Morphometric measurements	mm	%SL	mm	%SL	mm	%SL
Total length	108	131.0	107	120.2	115	129.2
Fork length	91	110.0	98	110.1	98	110.1
Standard length	82	100.0	89	100.0	89	100.0
Head length	31	37.4	26	29.5	28	31.0
Eye diameter	10	12.2	9	10.3	9	10.1
Pre-orbital length	12	14.1	11	11.9	10	11.3
Post-orbital length	11	13.1	11	11.9	11	12.7
Dorsal fin length	43	51.9	40	45.2	46	52.0
Pectoral fin length	9	10.6	6	7.3	7	8.0
Pelvic fin length	8	10.0	7	7.6	7	7.6
Anal fin length	19	23.5	20	22.9	22	25.2
Caudal fin length	12	14.4	9	10.3	10	11.7
Snout length	10	12.7	9	10.3	10	11.4
Body height	51	62.4	40	45.3	43	47.9
Pre-dorsal fin length	39	47.0	38	43.1	38	42.9
Pre-pectoral fin length	32	39.3	29	32.5	30	33.9
Pre-pelvic fin length	37	45.4	38	42.7	39	43.9
Pre-anal fin length	62	75.2	59	66.4	59	66.0
Length of the longest spine of the pectoral fin	36	43.1	30	33.8	43	48.2
Thickness	18	22.0	15	16.4	16	17.7
Meristic counts						
Vertebral number	45		26		26	
Lateral line scales	65		60		60	
Dorsal fin rays	XII+14		XI+14		XI+14	
Pectoral fin rays	15		15		15	
Pelvic fin rays	I+5		I+5		I+5	
Anal fin rays	III+14		III+13		III+13	
Caudal fin rays	20		20		20	
Weight (g)	32.06		21.08		23.93	

formaldehyde, and deposited in the Ichthyological Collection of the Institut Supérieur de Pêche et d'Aquaculture de Bizerte (Tunisia) under catalogue numbers ISPAB-Dipl vul 01 for the abnormal specimen, and ISPAB-Dipl vul 02 and ISPAB-Dipl vul 03 for the two normal specimens. The vertebral column anomalies in the abnormal specimen were identified following descriptions provided by Elie & Girard (2014) and Jawad & Ibrahim (2018), which include scoliosis (lateral curvature), lordosis (ventral curvature), kyphosis (dorsal curvature), and ankylosis (fusion of vertebrae) – conditions reported in many wild and cultured fish species. Additionally, three regions were considered, partially following Louiz *et al.* (2007): the anterior or cephalic region, the intermediate or abdominal region, and the terminal or caudal region.

A *t*-test was performed to compare lateral line scale and vertebral counts between the abnormal *D. vulgaris* specimen and normal conspecifics. The total length (TL) to total body weight (TBW) ratio, analysed in all three specimens, was used as a baseline for assessing whether the abnormal specimen could develop in the wild similarly to normal individuals, following Froese *et al.* (2011). This length-weight relationship (LWR) was modelled as $TBW = aTL^b$ and log-transformed to its linear form: $\log TBW = \log a + b \log TL$. Correlations were estimated via least-squares regression. The scaling coefficient b was tested against the null hypothesis of isometric growth ($b = 3$), with $b > 3$ indicating positive allometry and $b < 3$ indicating negative allometry (Pauly, 1983). Analyses were conducted in StatView 5.0.

RESULTS AND DISCUSSION

The collected specimens were identified as *D. vulgaris* through a combination of key morphological characters: body ovoid and compressed; snout conical and pointed; lips rather thick; scales present on cheek and opercle; preopercle broad, scaleless; base silver-grey coloration with two prominent black bands (one from nape to pectoral fin axil and upper margin of opercle, another across the caudal peduncle overlapping posterior anal and dorsal fin bases), caudal fin dark with black external margin (Fig. 2).

The abnormal specimen exhibited a prominently developed upper margin, arched into a hump, a pointed upper head profile, and a strongly curved lateral line. The caudal peduncle was also curved, with both lobes more developed than those typically observed in normal specimens (Fig. 2).

X-ray imaging revealed four distinct vertebral column deformities in the abnormal specimen. At the level of the abdominal region, the vertebral column is markedly arched, forming two areas of hyperkyphosis separated by a more pronounced lordosis (Fig. 3). In the caudal peduncle region, a second, less developed and less severe lordosis is observed. No signs of scoliosis were detected in the abnormal specimen.

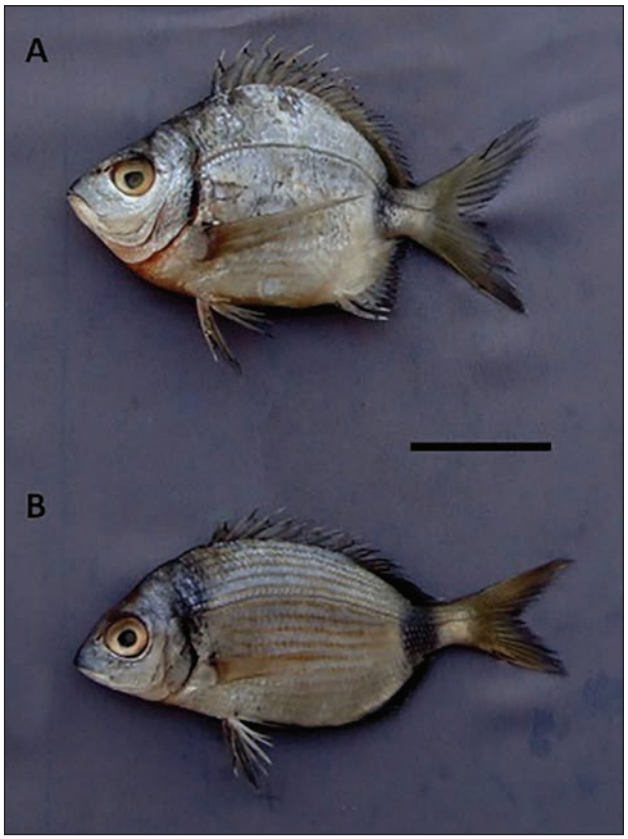

Fig. 2: *D. vulgaris* ***specimens from the northern Tunisian coast. A: Abnormal specimen (ISPAB-Dipl vul 01); B: Normal specimen (ISPAB-Dipl vul 02). Scale bar = 30 mm.***
Sl. 2: Primerki vrste *D. vulgaris* ***iz severne tunizijske obale. A: Nenormalen primerek (ISPAB-Dipl vul 01); B: Normalen primerek (ISPAB-Dipl vul 02). Merilo = 30 mm.***

The number of lateral line scales in the abnormal specimen was 65, significantly higher than in the normal specimens (which had 60; t-test = 37, df = 1, $p < 0.03$). In Bauchot & Hureau (1986), this number ranged from 59 to 65. Similarly, the number of vertebrae in the abnormal specimen – 45 – was significantly higher than the 26 in the normal specimens (t-test = 37, df = 1, $p < 0.01$). Such differences in the number of scales and vertebrae between normal and abnormal specimens are likely attributable to the curvature of the lateral line and the deformities of the vertebral column. The elevated vertebral count also suggests that the vertebrae are not fused (no ankylosis).

The general morphology of the abnormal specimen and the deformation of the lateral line can be considered primary consequences of the vertebral column malformation, which in this case includes both hyperkyphosis and lordosis. Such abnormalities are frequently reported in the ichthyological literature (see Dawson, 1964, 1966, 1971; Dawson & Heal 1971; Jawad & Ibrahim,

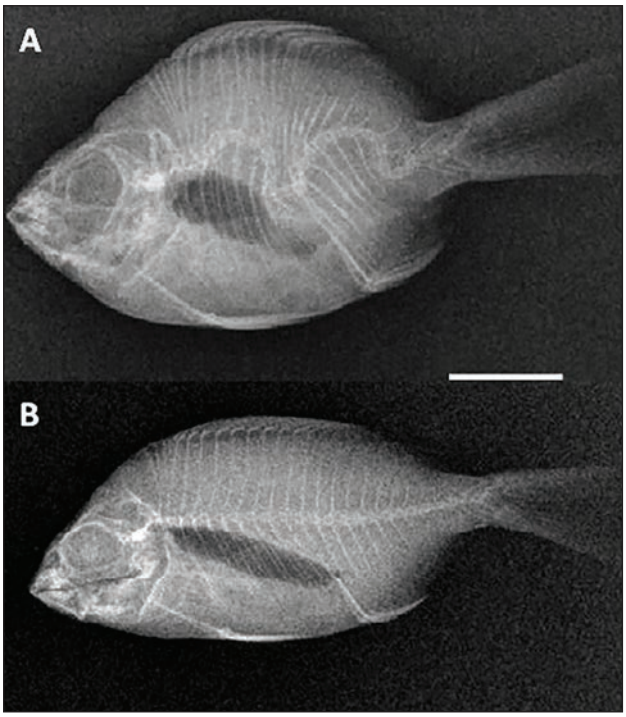

Fig. 3: X-ray images of** D. vulgaris **from the northern Tunisian coast. A: Abnormal specimen (ISPAB-Dipl vul 01); B: Normal specimen (ISPAB-Dipl vul 02). Scale bar = 30 mm.
Sl. 3: Rentgenske slike primerkov vrste** D. vulgaris **s severne tunizijske obale. A: Nenormalen primerek (ISPAB-Dipl vul 01); B: Normalen primerek (ISPAB-Dipl vul 02). Merilo = 30 mm.

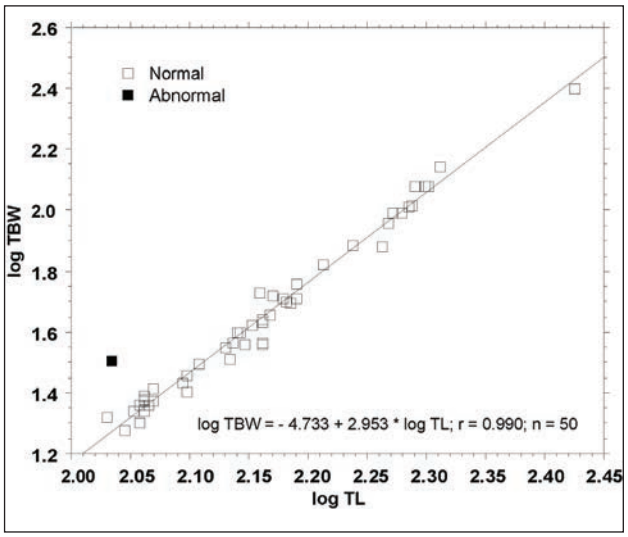

Fig. 4: Total length (TL) to total body weight (TBW) relationship, expressed in logarithmic coordinates, for** D. vulgaris **specimens collected off the northern Tunisian coast.
Sl. 4: Odnos med totalno dolžino (TL) in celokupno telesno maso (TBW), izraženo z logaritemskimi koordinatami za primerke vrste** D. vulgaris**, ujete ob severni tunizijski obali

2018; Jawad & Akyol, 2023).

However, the observed deformities did not appear to impair the survival of the abnormal specimen in the wild, as it exhibited growth comparable to that of normal specimens from the same size class. This is supported by the total length (TL) to total body weight (TBW, in g) relationship shown in Fig. 4: log TBW = -4.733 + 2.953 * log TL; r = 0.990, indicating a slight negative allometry. While Matsuoka (1987) and Boglione *et al.* (2006) reported lethal effects of severe skeletal deformities in teleost species living in natural environments, other studies – including Khenfech *et al.* (2011) on the annular sea bream *Diplodus annularis* (Linnaeus, 1758) from the Lagoon of Bizerte, and Rafrafi-Nouira *et al.* (2019, 2021) on other sparid species, such as the striped sea bream *Lithognathus mormyrus* (Linnaeus, 1758) and the saddled bream *Oblada melanura* (Linnaeus, 1758), captured off Ras Jebel – showed that deformed specimens can coexist in the wild alongside normal conspecifics.

Abnormalities in fish species occur during the early stages of development and may have a genetic origin. However, mechanical causes from capture and/or handling cannot be entirely ruled out either. For instance, specimens entangled in gillnets may successfully escape, but often experience morphological deformities and distortion in the normal vertebral shape, leading to the remodelling of the vertebral column due to extrinsic forces (Jawad & Ibrahim, 2018). Additionally, these deformities could even indicate unfavourable environmental conditions, the presence of pollutants, or other stressors in the wild (Sfakianakis *et al.*, 2004). In fact, several cases of abnormalities have been documented in animal species collected from the Lagoon of Bizerte, a restricted brackish area polluted by both inorganic and organic nutrients, and heavy metals (Mzoughi *et al.*, 2002).

Global warming of marine waters worldwide may also contribute to skeletal deformities in fish (Jawad & Ibrahim, 2018). The Mediterranean Basin has faced this escalating problem for at least two decades (Ben Raïs Lasram & Mouillot, 2009), with the rising sea temperatures attracting alien species from the Red Sea (through the Suez Canal) and the eastern tropical Atlantic (through the Strait of Gibraltar). Such species have been increasingly encroaching on Tunisia's northern coast and reports of skeletal abnormalities in fish have become more frequent in this region than previously documented (Rafrafi-Nouira, 2016). However, thorough investigations – coupled with environmental monitoring – are still needed to clarify the local roles of pollutants and temperature in these deformities (Rafrafi-Nouira, 2016, 2019).

MORFOLOŠKE DEFORMACIJE PRI FRATRU, *DIPLODUS VULGARIS* (OSTEICHTHYES: SPARIDAE), IZ SEVERNIH TUNIZIJSKIH VOD (OSREDNJE SREDOZEMSKO MORJE)

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POVZETEK

V vzorcu fratrov, Diplodus vulgaris*, zbranih s severne obale Tunizije, je bila pri enemu primerku očitna nenormalna morfologija. Ta primerek je imel vidno razvit zgornji rob, usločen v grbo, koničast zgornji profil glave in močno ukrivljeno pobočnico. Rentgensko slikanje je pokazalo nenormalne ukrivljenosti v hrbtenici, kot sta hiperkifoza in lordoza. Analiza dolžinsko-masnega razmerja na 49 normalnih osebkih in nenormalnem osebku, je pokazala rahlo negativno alometrijo, kar nakazuje, da so takšni osebki sposobni živeti skupaj z normalno populacijo v naravi.*

Ključne besede: *Diplodus vulgaris*, hiperkifoza, lordoza, okoljsko onesnaževanje, dolžinsko-masni odnos

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