

ANNALES

Anali za istrske in mediteranske študije
Annali di Studi istriani e mediterraneei
Annals for Istrian and Mediterranean Studies
Series Historia Naturalis, 35, 2025, 1





ANNALES

Anali za istrske in mediteranske študije
Annali di Studi istriani e mediterranei
Annals for Istrian and Mediterranean Studies

Series Historia Naturalis, 35, 2025, 1

ISSN 1408-533X
e-ISSN 2591-1783

UDK 5

Letnik 35, leto 2025 številka 1

**UREDNIŠKI ODBOR/
COMITATO DI REDAZIONE/
BOARD OF EDITORS:**

Alessandro Acquavita (IT), Nicola Bettoso (IT), Christian Capape (FR), Darko Darovec, Dušan Devetak, Jakov Dulčić (HR), Edy Fantinato (IT), Serena Fonda Umani (IT), Andrej Gogala, Daniel Golani (IL), Danijel Ivajnskič, Hakan Kabasakal (TR), Mitja Kaligarič, Marcelo Kovačič (HR), Petar Kružić (HR), Lovrenc Lipej, Vesna Mačić (ME), Alenka Malej, Borut Mavrič, Patricija Mozetič, Martina Orlando-Bonaca, Michael Stachowitsch (AT), Francesco Tiralongo (IT), Tom Turk, Al Vrezec

**Glavni urednik/Redattore capo/
Editor in chief:**

Darko Darovec

**Odgovorni urednik naravoslovja/
Redattore responsabile per le scienze
naturali/Natural Science Editor:**

Lovrenc Lipej

Urednica/Redattrice/Editor:

Martina Orlando-Bonaca

Prevajalci/Traduttori/Translators:

Martina Orlando-Bonaca (sl./it.)

**Oblikovalec/Progetto grafico/
Graphic design:**

Dušan Podgornik, Lovrenc Lipej

Tisk/Stampa/Print:

Založništvo PADRE d.o.o.

Izdajatelj/Editori/Published by:Zgodovinsko društvo za južno Primorsko - Koper / Società storica del Litorale - Capodistria®
Inštitut IRRIS za raziskave, razvoj in strategije družbe, kulture in okolja / Institute IRRIS for Research, Development and Strategies of Society, Culture and Environment / Istituto IRRIS di ricerca, sviluppo e strategie della società, cultura e ambiente®**Sedež uredništva/Sede della redazione/
Address of Editorial Board:**Nacionalni inštitut za biologijo, Morska biološka postaja Piran / Istituto nazionale di biologia, Stazione di biologia marina di Pirano / National Institute of Biology, Marine Biology Station Piran
SI-6330 Piran /Pirano, Fornače/Fornace 41, tel.: +386 5 671 2900, fax +386 5 671 2901;
e-mail: annales@mbss.org, internet: www.zdjp.si

Redakcija te številke je bila zaključena 20. 06. 2025.

**Sofinancirajo/Supporto finanziario/
Financially supported by:**

Javna agencija za znanstveno-raziskovalno in inovacijsko dejavnost Republike Slovenije (ARIS)

Annales - Series Historia Naturalis izhaja dvakrat letno.**Naklada/Tiratura/Circulation:**

300 izvodov/copie/copies

Revija Annales, Series Historia Naturalis je vključena v naslednje podatkovne baze / La rivista Annales, series Historia Naturalis è inserita nei seguenti data base / Articles appearing in this journal are abstracted and indexed in: BIOSIS-Zoological Record (UK); Aquatic Sciences and Fisheries Abstracts (ASFA); Elsevier B.V.: SCOPUS (NL); Directory of Open Access Journals (DOAJ).

To delo je objavljeno pod licenco / Quest'opera è distribuita con Licenza / This work is licensed under a Creative Commons BY 4.0.

Navodila avtorjem in vse znanstvene revije in članki so brezplačno dostopni na spletni strani <https://zdjp.si/en/p/annalesshn/>
The submission guidelines and all scientific journals and articles are available free of charge on the website <https://zdjp.si/en/p/annalesshn/>
Le norme redazionali e tutti le riviste scientifiche e gli articoli sono disponibili gratuitamente sul sito <https://zdjp.si/en/p/annalesshn/>

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

SREDOZEMSKA 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: Odontaspidae) from the Algerian Coast (Southwestern Mediterranean Sea) 83
O starem zapisu o drobn zobem morskem biku Odontaspis ferox (Chondrichthyes: Odontaspidae) 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

Nicolas ZIANI, Florane TONDU, Rémi BRU, Chloé MOSNIER, Sarah FOXONET, Ruben Bao GALLIEN, Mathias POULY, Modan Lou TONIETTO, Lucille VERDON, Eloïse DEYSSON, Alessandro DE MADDALENA & Hakan KABASAKAL

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 CHÉRIFF, 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 fratrju, 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 Sfaksa 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 CHÉRIFF, 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

received: 2025-04-17

DOI 10.19233/ASHN.2025.07

AN INSIGHT INTO THE DIET OF THE BULL RAY, *AETOMYLAEUS BOVINUS* (GEOFFROY SAINT-HILAIRE, 1817) IN THE NORTHERN ADRIATIC SEA

Lovrenc LIPEJ

Marine Biology Station, National Institute of Biology, Piran, Slovenia
University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies, Koper, Slovenia
e-mail: Lovrenc.lipej@nib.si

Riccardo BATTISTELLA

via S. Stefano 47, Este, Provincia di Padova, Italy

Borut MAVRIČ

Marine Biology Station, National Institute of Biology, Piran, Slovenia

Danijel IVAJNSIČ

Faculty of Natural Sciences and Mathematics, University of Maribor, 2000 Maribor
Faculty of Arts, University of Maribor, 2000 Maribor

ABSTRACT

*This study provides baseline information on the feeding habits of the bull ray, *Aetomylaeus bovinus* (Geoffroy Saint-Hilaire, 1817), in the Gulf of Venezia. Among 1557 prey items isolated from the stomachs of bull ray specimens, gastropods represented the overwhelming majority (93.8%). Within gastropods, *Aporrhais pespelecani* was the dominant species, followed by *Gibbula magus* and *Bolinus brandaris* – all characteristic elements of the biocoenosis of the muddy detritic bottom. We observed differences in prey structure between juveniles and adults, as well as sexes. Among fishes that proved to be particularly important in terms of biomass, the majority of prey items consisted of small pelagic fish, including pilchard (*Sardina pilchardus*) and horse mackerel (*Trachurus* sp.). This paper contributes new data on the feeding ecology of a lesser known and critically endangered batoid species.*

Key words: myliobatids, feeding ecology, nursery, Gulf of Venice

APPROFONDIMENTI SULLE ABITUDINI ALIMENTARI DELLA VACCARELLA, *AETOMYLAEUS BOVINUS* (GEOFFROY SAINT-HILAIRE, 1817) NELL'ADRIATICO SETTENTRIONALE

SINTESI

*Lo studio riporta le abitudini alimentari della vaccarella, *Aetomylaeus bovinus* (Geoffroy Saint-Hilaire, 1817), nel Golfo di Venezia. Tra le 1557 prede isolate dagli stomaci, i gasteropodi costituivano la grande maggioranza (93,8%), dominati dalla specie *Aporrhais pespelecani*, seguita da *Gibbula magus* e *Bolinus brandaris*. Queste specie sono elementi caratteristici della biocenosi del fondo detritico fangoso. Sono state osservate differenze nella struttura delle prede tra giovani e adulti e tra i sessi. Tra i pesci che sembravano essere particolarmente importanti in termini di biomassa, i piccoli pesci pelagici come la sardina (*Sardina pilchardus*) e il sugarello (*Trachurus* sp.) rappresentavano le prede più grandi. Questo lavoro contribuisce a fornire nuove informazioni sull'ecologia alimentare di una specie di razza meno conosciuta e in pericolo critico.*

Parole chiave: vaccarella, ecologia alimentare, nursery, Golfo di Venezia

INTRODUCTION

The bull ray, *Aetomylaeus bovinus* (Geoffroy Saint-Hilaire, 1817), is a benthopelagic species inhabiting coastal and warm temperate waters, occasionally found offshore, at depths of 10–150 m (Capapé & Quignard, 1975). Bull rays can tolerate greatly reduced salinities (Ebert & Stehmann, 2013) and therefore occasionally enter shallow lagoons (El Kamel et al., 2009) and semi-enclosed bays (Zogaris & Dussling, 2010; Bilgili & Kabasakal, 2023). As a longevous species with late maturity and low reproductive rates – signature traits of a K-selected life history strategy (Stevens et al., 2000) – the bull ray is vulnerable to overfishing, especially in nearshore habitats, where it forms small aggregations to feed (Seck et al., 2002; El Kamel et al., 2010, Zogaris & Dussling, 2010; Akyol et al., 2017). The bull ray is poorly studied in terms of feeding ecology. The only comprehensive study on the feeding habits of *A. bovinus* was conducted by Capapé (1977) in Tunisian waters, based on analyses of 568 specimens at different stages of development.

Bull rays are observed in the northern Adriatic Sea between late spring and early autumn, while in winter they migrate towards southern areas (La Mesa et al., 2017). Due to its longevity, *A. bovinus* was previously considered an indicator species for pollution with heavy metals such as Hg and MeHg (Horvat et al., 2013), arsenic (Šlejkovec et al., 2014), and selenium (Faganeli et al., 2018). Though not commercially targeted, the species is often caught as by-catch and discarded. It is currently considered a critically endangered ray species on the global scale, whose populations suffered substantial depletion in the last years due to overfishing (Jabado et al. 2021). Recently, this status was also confirmed by Soldo & Lipej (2022), who evaluated the species as rare in the Adriatic Sea.

The aim of this study is to investigate the feeding habits of the bull ray in the northern Adriatic Sea (the Gulf of Trieste and neighbouring areas along the western Istrian coast). The feeding ecology of this species is significantly understudied, making any data in this regard vital. Such research is also necessary and useful in elucidating the impact of such predation on the structure of epibenthic macrofaunal assemblages.

MATERIAL AND METHODS

The stomachs of bull rays were collected between 2005 and 2015 from rays caught as by-catch by commercial trawlers. Fishing was conducted at depths of 10 – 50 m in the Gulf of Trieste and along the western Istrian coast (Fig. 1). The sample was comprised of neonates, adult males, and adult females, including

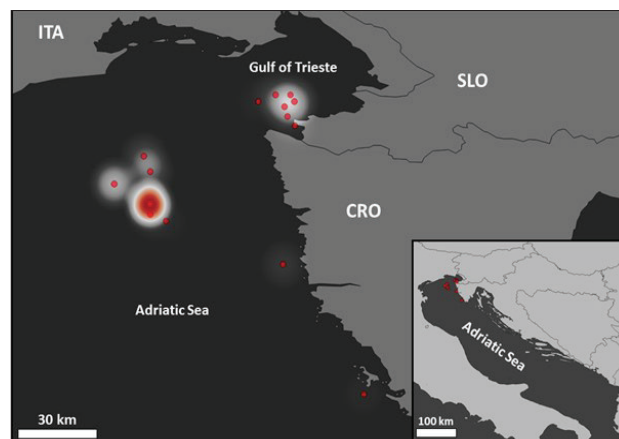


Fig. 1: Map of the studied area and its position in the Adriatic Sea. Areas where bull rays were caught are depicted as red dots. Catch density is additionally presented as a heat map.

Sl. 1: Zemljevid obravnavanega območja in njegov položaj glede na Jadransko morje. Predeli, kjer so ujeli kljunate morske golobe, so označeni z rdečimi krogi. Gostota ulova je prikazana kot kolobarji.

several pregnant specimens. After being defrosted in the lab, each individual was sexed. The specimens were measured (disk width – DW) and weighed. Each stomach was weighed full and emptied. Stomach contents were washed on the sieve and conserved in 95% ethanol. Prey items were analysed using an Olympus SZX16 stereomicroscope and photographed using an Olympus camera DP 74.

Prey items were identified to the lowest taxonomic level (species level where possible), using taxonomic keys and field guides (Riedel, 1991; Falciai & Minervini, 1992), and subsequently counted. A reference collection of gastropod opercula preserved at the Marine Biology Station proved extremely valuable for determination, providing additional diagnostic support. The counting of prey items was based on typical anatomical parts: claws and legs for crustaceans, carapaces for decapods, shells and feet for bivalves, opercula for gastropods (Fig. 2), and partial remains (including otoliths) for teleost species.

Data analysis

Opercula from isolated benthic gastropods were precisely measured (max length and width) and photographed under the microscope. To assess the approximate weight of each gastropod, a correlation length-weight curve obtained from the data of live collected specimens (pulled from the shells) was used. Length-weight correlation curves were calculated for the gastropod species that dominated the bull ray's diet: *Aporrhais pespelecani* (Linnaeus, 1758), *Bolinus*

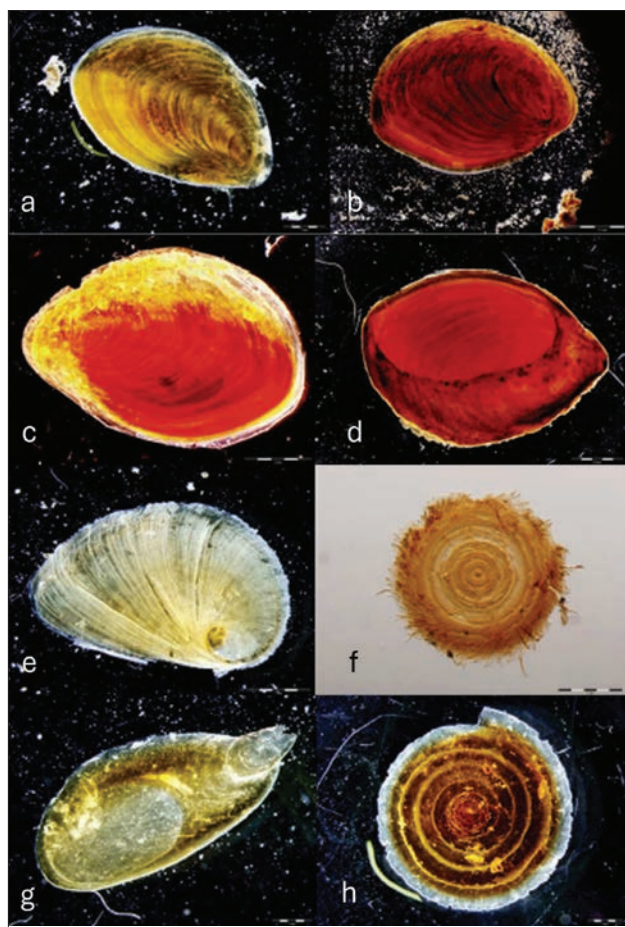


Fig. 2: Opercula of various gastropods present in the diet of the bull ray. Legend: a and b – *Bolinus brandaris*, c and d – *Hexaplex trunculus*, e – *Cerithium vulgatum*, f – *Turritella communis*, g – *Aporrhais pespelecani*, and h – *Gibbula magus*. Scale bar = 1 mm.

Sl. 2: Poklopci (operkuli) različnih polžev, ki se pojavljajo v prehrani kljunatega morskega goloba. Legenda: a in b – *Bolinus brandaris*, c in d – *Hexaplex trunculus*, e – *Cerithium vulgatum*, f – *Turritella communis*, g – *Aporrhais pespelecani* in h – *Gibbula magus*. Merilo = 1 mm.

brandaris (Linnaeus, 1758), *Gibbula magus* (Linnaeus, 1758), and *Hexaplex trunculus* (Linnaeus, 1758).

The opercula of *B. brandaris* and *H. trunculus* exhibit numerous morphological similarities, making them challenging to distinguish. To ensure accurate identification, every operculum assignable to either species was carefully examined under the microscope and compared against reference specimens collected from the natural environment (those used for the correlation length-weight curves). The majority of muricid opercula were conclusively identified as *B. brandaris*. In addition to opercular shape, the width-to-length ratio proved valuable for species discrimination in ambiguous cases (Fig. 3), as *B. brandaris* and *H. trunculus* have

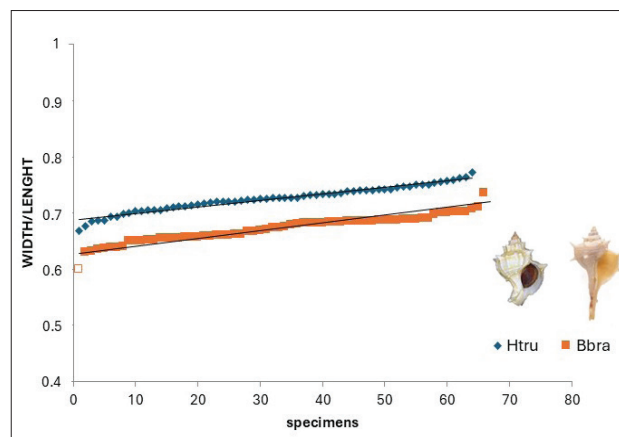


Fig. 3: Relationship between width and length of opercula of two similar species *Hexaplex trunculus* (blue diamonds) and *Bolinus brandaris* (orange squares), obtained from specimens as by-catch from the fishermen. This relationship was useful to discriminate the opercula of the two muricid species found in the stomachs of the bull rays.

Sl. 3: Odnos med dolžino in širino poklopcev pri dveh sorodnih vrstah volekov *Hexaplex trunculus* (modri karo) in *Bolinus brandaris* (oranžni kvadrati), na podlagi živih primerkov, ulovljenih kot prilov ribičev. Ta odnos je bil uporaben za razlikovanje poklopcev obeh volekov, najdenih v prehrani kljunatega morskega goloba.

different opercular proportions. For the few specimens that could not be confidently identified, we recorded them as generic *Murex* sp.

The feeding habits of the bull ray were described using relative frequency of occurrence (PF = number of stomachs containing prey *i*/total number of full stomachs × 100), relative numerical abundance (PN = number of prey *i*/total number of prey × 100), and relative gravimetric composition (PB = weight of prey *i*/total weight of all prey × 100). To minimise potential errors inherent in individual parameters, all measures were integrated into a single composite Index of Relative Importance (IRI%) calculated as:

$$[IRI = PF \times (PN + PB)] \text{ (Pinkas et al., 1971),}$$

which reduces potential misinterpretations from relying on any single given value. Prey biomass was obtained either from species-specific correlation diagrams (length-weight relationships) or literature estimates (Ravara, 2012). According to Capapé & Quignard (1974), we defined sexual maturity at 800 mm disk width (DW) for males and 900–1000 mm for females, classifying individuals below these thresholds (DW < 800 mm in males and DW < 900 mm in females) as juveniles. Dietary diversity was assessed using the Shannon-Wiener diversity index:

$$H' = - (\sum p_i \ln p_i)$$

Diversity was also assessed separately according to sex and size classes. To evaluate the diet overlap between juveniles and adults and between males and females, we used the Morisita-Horn index (Krebs, 1989):

$$C_H = 2 * (\sum p_{ij} p_{ik}) / (\sum p_{ij}^2 + \sum p_{ik}^2)$$

where C_H is the simplified Morisita-Horn index representing the overlap between predators j and k ; P_{ij} is the proportion of prey i in the total prey consumed by predator j ; P_{ik} is the proportion of prey i in the total prey consumed by predator k ; and n is the total number of prey categories. The index ranges from 0 (no dietary overlap) to 1 (complete dietary overlap), with values over 0.6 indicating significant resource sharing.

To assess the trophic level of the bull ray, a TROPH index was calculated using TrophLab software (Pauly et al., 2000), available through FishBase (www.fishbase.org):

$$TROPH_i = 1 + \sum_{j=1}^G DC_{ij} \times TROPH_j$$

$TROPH_j$ represents the fractional trophic level of prey j , and DC_{ij} denotes the proportion of j in the diet of consumer species i .

RESULTS

Biometry

A total of 42 bull ray specimens were measured and weighed, of which 19 were identified as males and 22 as females, while in one juvenile specimen the sex could not be determined. Maximum recorded disc width (DW) was 222 cm for females and 115 cm for males, with minimum DWs of 27 cm and 37 cm, respectively. The correlation between size and weight was statistically significant ($y=0.0233x^2 + 10.49x-11590$; $r^2=0.92$). Females were larger and heavier than males (Figure 4), with individual weights exceeding 100 kilograms.

Overall diet

The feeding habits of a total of 41 bull ray specimens were analysed. In one specimen, stomach content analysis was not possible, and 10 stomachs (24.4%) were found to be empty. Of the 1557 prey items isolated from the stomachs, gastropods represented the overwhelming majority (93.8%). Analysis of the opercula against the comparative collection confirmed *Bolinus brandaris* as the highly predominant muricid species. The most preyed upon gastropod was *Aporrhais pespelecani*

(PN%=50.61%), present in 75% of all stomachs, followed by *B. brandaris* (PN%=19.33%; PF%=60.71), and *Gibbula magus* (PN%=18.37; PF%=53.57). Other gastropods, including *Hexaplex trunculus*, *Turritella communis*, and *Cerithium vulgatum*, were negligible in terms of relative abundance and only occurred in a single stomach. In adult bull rays, fish represented a substantial portion of prey biomass (45.30%), second only to gastropods (52.86%), while in juveniles, gastropods prevailed (PB=86.08%).

Among other taxonomic groups, teleosts accounted for 2.70%, hermit crabs 1.99%, and polychaetes 1.16%. Sipunculids and bivalves were negligible in terms of relative abundance (0.19% and 0.13%, respectively). Fish prey mostly consisted of small pelagic species, including pilchard (*Sardina pilchardus*) and horse mackerel (*Trachurus* sp.), and even a few specimens of anchovy (*Engraulis encrasicolus*) and gilt sardine (*Sardinella aurita*). The bull ray's TROPH value was calculated as 3.40 ± 0.58 .

Diet differences between sexes

Both sexes specialise in gastropod predation, with males predominantly catching *Aporrhais pespelecani* (PN – 70.5% vs. 36.1%; IRI% – 29.4 vs. 3.7%) and females favouring muricids such as *Bolinus brandaris* (PN – 31.9% vs. 11%; IRI% – 28.9% vs. 4.3%). Notably, fish – a secondary food category – were only preyed on by females (Figs. 5 and 6). Females exhibited greater dietary diversity than males (The Shannon-Wiener diversity index H' : 1.73 vs 1.02). However, the Morisita-Horn index showed substantial dietary overlap between sexes (0.79) which indicates shared prey resources. The calculated TROPH values for males were 3.37 ± 0.58 and 3.43 ± 0.58 for females.

Diet differences between juveniles and adults

Both juveniles and adults primarily consume gastropods, the dominant prey category in their diets. Juveniles mainly feed on *Gibbula magus* (PN – 34.5% vs. 5.5%; IRI% – 77.9 vs. 32.2%), while adults show preference for *Bolinus brandaris* (PN – 33.4% vs. 1.6%; IRI% – 33.4% vs. 0.4%). Juveniles prey more heavily upon anomurans (especially *Paguristes eremita*) than adults (Fig. 7), which is evident when we compare the frequency of occurrence. Adults consumed more fish – which are more important in terms of biomass – suggesting an ontogenetic dietary shift (Fig. 7). The pattern mirrors intersexual differences, likely influenced by the fact that females represent the majority of the adult population. In the sample examined, adults had a more diversified diet than juveniles (H' : 1.44 vs.

Tab. 1: Diet composition of bull rays in the study area: N – number of prey items of different species, PN – relative abundance (%), PB – relative biomass (%), PF – frequency of occurrence and IRI% – index of relative importance (%). Specimens which we were not able to identify as *Hexaplex* or *Bolinus* are grouped under *Murex* sp. and marked with an asterisk.

Tab. 1: Prehrana kljunatega morskega goloba na obravnavanem območju: N – število različnih vrst plena, PN – relativna abundanca (%), PB – relativna biomasa (%), PF – frekvenca pojavljanja in IRI% – indeks relativne pomembnosti plena (%). Primerki, ki jih nismo uspeli določiti kot čokate ali bodičaste voleke, smo združili v kategorijo *Murex* sp. in jih označili z zvezdico.

taxa		N	PN%	PB%	PF%	IRI%
Mollusca	<i>Aporrhais pespelecani</i>	788	50.61	20.03	75.00	53.24
	<i>Gibbula magus</i>	286	18.37	10.91	53.57	15.76
	<i>Hexaplex trunculus</i>	13	0.83	4.86	10.71	0.61
	<i>Bolinus brandaris</i>	301	19.33	6.68	60.71	15.87
	»Murex« sp.*	55	3.53	17.62	39.29	8.35
	Muricidae	1	0.06	0.32	3.57	0.01
	<i>Turitella communis</i>	1	0.06	0.02	3.57	<0.01
	<i>Cerithium vulgatum</i>	1	0.06	0.06	3.57	<0.01
	Cerithidae/Naticidae	15	0.96	0.97	14.29	0.28
	Bivalvia	2	0.13	0.07	3.57	0.01
Crustacea	Anomura	3	0.19	0.32	10.71	0.05
	<i>Paguristes eremita</i>	19	1.22	3.09	17.86	0.77
	<i>Pagurus anachoretus</i>	1	0.06	0.11	3.57	0.01
	Paguridea	8	0.51	0.73	14.29	0.18
Annelida	Polychaeta	18	1.16	0.07	14.29	0.18
	Sipunculida	3	0.19	0.05	7.14	0.02
Pisces	<i>Engraulis encrasicolus</i>	2	0.13	0.95	7.14	0.08
	<i>Sardina pilchardus</i>	24	1.54	23.90	14.29	3.65
	<i>Sardinella aurita</i>	1	0.06	0.21	3.57	0.01
	<i>Trachurus</i> sp.	14	0.90	4.34	14.29	0.75
	<i>Solea</i> sp.	1	0.06	4.69	3.57	0.17

1.08). The Morisita-Horn index analysis revealed no significant difference between the diets of juveniles and adults, since the overlap in the diet was 0.74. The calculated TROPH values for juveniles were 3.38 ± 0.58 , and 3.42 ± 0.41 for adult specimens.

DISCUSSION

The feeding habits of the bull ray were assessed on a rather small sample (41), consisting entirely of by-catch specimens occasionally entangled in fishing nets.

However, some studies suggest that as few as 15–30 non-empty stomachs may be enough to adequately describe prey diversity in certain shark species (Alonso et al., 2002; Lucifora et al., 2006). Our analysis included 41 stomachs, of which 10 were empty. The empty stomachs belonged to the smallest specimens – DW 27 cm (female) and DW 37 cm (male) – with DWs below the reported size of specimens at birth (Seck et al., 2002). We can therefore presume that pregnant bull rays aborted their pups during fishing interaction, as cases of parturition induced by

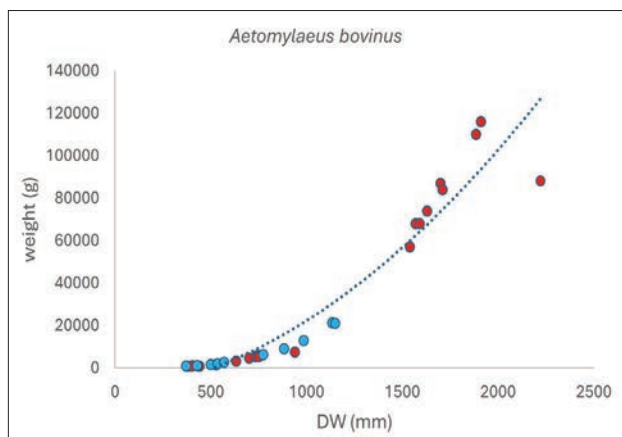


Fig. 4: Size-weight relationships in the bull rays from the studied area. Legend: DW – disk width (mm), red circles – females, blue circles – males.

Sl. 4: Dolžinskomasni odnos kljunatih morskih golobov na obravnavanem območju. Legenda: DW – premer diska (mm), rdeči krogci – samice, modri krogci – samci.

capture are well-documented (Adams et al., 2018; de Sousa Rangel et al., 2020).

The number of stomachs analysed in our study seems to be adequate to provide relevant insight into the feeding habits of the bull ray. Our results show that with 31 full stomachs, 90% of the asymptotic species richness was reached (see Fig. 8). Our results are generally consistent with one of the few available studies on the species' diet published by Capapé (1977), who found the bull ray preying mainly on four food categories: bivalves, cephalopods, gastropods, and fish. In his study, which was based on a substantially larger sample of stomachs, additional, even peculiar animal taxa were identified among the prey items of the bull ray, such as polychaetes, sipunculids, and echinoderms.

Mollusc specialisation

The bull ray consumes gastropods and bivalves by crushing their shells with strong dental plates and can therefore be defined as a batoid specialised in durophagous feeding (Wilga & Motta, 2000). The dominant gastropod species preyed upon by bull rays – *Aporrhais pespelecani*, *Gibbula magus*, and *Bolinus brandaris* – are characteristic and abundant in the biocoenosis of the muddy detritic bottom, where their shells also represent an essential substrate for the settlement of multi-species biogenic clumps (Stachowitsch & Fuchs, 1995). This biocoenosis geographically corresponds to the area where fishing vessels operated when catching bull rays, so we can assume that the diet of the bull ray reflects the availability of shelled prey species in the environment. *Aporrhais pespelecani*, the most frequently consumed and most abundant prey species, is known for its burrowing

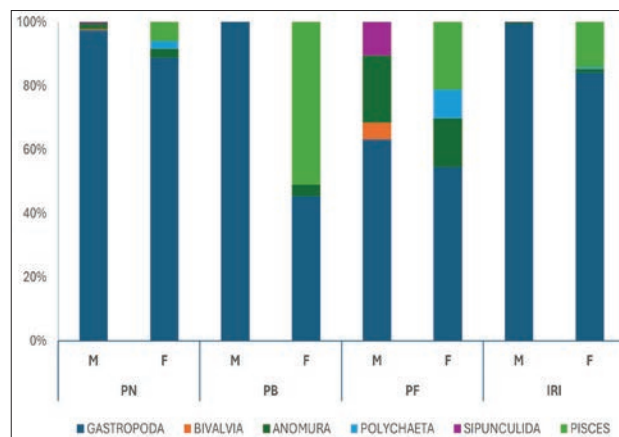


Fig. 5: Comparison of diet compositions in male (M) and female (F) bull rays from the studied area: PN – relative abundance (%), PB – relative biomass (%), PF – frequency of occurrence, and IRI% – index of relative importance (%). **Sl. 5:** Primerjava prehrane samcev (M) in samic (F) kljunatega morskega goloba na obravnavanem območju: PN – relativna abundanca (%), PB – relativna biomasa (%), PF – frekvenca pojavljanja in IRI% – indeks relativne pomembnosti plena (%).

behaviour (Yonge, 1937). In a recent study carried out in the Sea of Marmara (Türkiye), hard-shelled molluscs were also identified as the main food items of another, closely related batoid, *Myliobatis aquila* (Gül & Demirel, 2020). Adult bull rays preyed on more muricids (*Hexaplex trunculus*, *Bolinus brandaris*, *Murex* sp.) than juveniles, both in term of relative abundance (PN%=40.8 vs. 2.3) and biomass (PB%=37.0 vs. 6.3). This may be explained by the fact that adults, having larger and stronger jaws, are better equipped to feed on muricids, which are characterised by their thick shells. Juvenile bull rays showed a preference for other species, such as *A. pespelecani* and *G. magus* (PN%=56.81 vs. 34.49, respectively), which were also the overall most frequently consumed prey (PF%=92.86 vs. 57.14).

The occurrence of anomurans in the diet of the bull ray is likely related to the frequent use of empty muricid shells as shelters by certain hermit crabs. *Paguristes eremita*, the dominant anomuran found in the diet of the bull rays from the present study, is the largest and most robust anomuran species in the area and is known to inhabit heavier gastropod shells with a wider aperture (family Muricidae) (Manjon-Cabeza & García Raso, 1999). In our study, anomurans were predominantly found in the diet of juveniles; however, it is difficult to assess whether the consumption of *P. eremita* and other anomurans was intentional or incidental. Other related species, such as the bullnose ray (*Myliobatis freminvillei*), have also been reported to occasionally feed on anomurans (Szczepansky & Bengtson, 2014). No data are currently available to

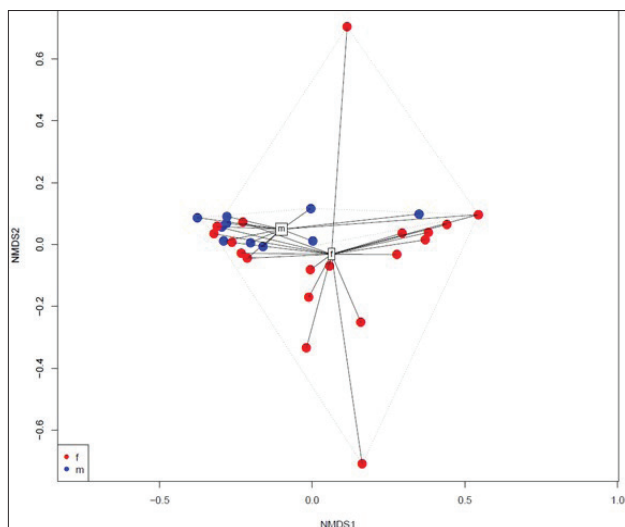


Fig. 6: Differences/similarities in prey composition and abundance with respect to factor sex (blue circles =males, red circles=females) in the NMDS space.

Sl. 6: Razlike/podobnosti v vrstni sestavi in številčnosti plena glede na spol (modri krogci=samci, rdeči krogci=samice).

determine whether some myliobatids can discriminate between shells occupied by anomurans and those containing gastropods.

The TROPH values for bull rays (3.37-3.43) were higher than those for a related durophagous species, the common eagle ray (*Myliobatis aquila*) (Lipej et al., in press) – calculated at 3.20 ± 0.44 to 3.25 ± 0.39 – but lower than the values reported for the blackspotted smoothhound *Mustelus punctulatus* (3.70 ± 0.6) (Lipej et al., 2012).

The feeding habits of the bull ray are, to some extent, similar to those of its relative, the common eagle ray *Myliobatis aquila*, which is also specialised in hunting molluscs, which represent 75% of its diet (Lipej et al., in press). However, while the eagle ray is mainly targeting bivalves, our findings show that the bull ray feeds mainly on gastropods. Among gastropods, eagle rays primarily consume species such as *Cerithium vulgatum* and *Turritella communis* (collectively ~20% of relative abundance), which were rarely preyed on by bull rays (each less than 0.1% of PN%). This dietary divergence between two related species inhabiting the same environment may reduce their competition.

Fish in the diet

Although fish represented only a small amount in terms of relative abundance, this food category is important in terms of biomass. Our results demonstrate an ontogenetic shift in the diet from gastropods to fish (*sensu* Koen Alonso et al., 2002; Ellis & Musick, 2007).

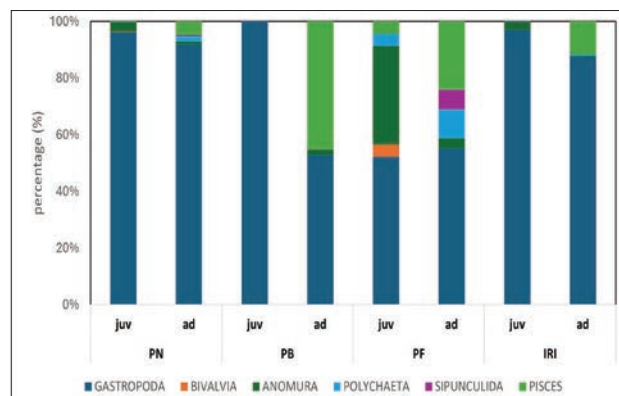


Fig. 7: Comparison of diet composition between juveniles (juv.) and adult specimens (ad.) of bull rays in the study area: PN – relative abundance (%), PB – relative biomass (%), PF – frequency of occurrence and IRI% – index of relative importance (%).

Sl. 7: Primerjava prehrane mladičev (juv.) in odraslih primerkov (ad.) kljunatega morskega goloba na obravnavanem območju: PN – relativna abundanca (%), PB – relativna biomasa (%), PF – frekvenca pojavljanja in IRI% – indeks relativne pomembnosti plena (%).

The species found in the diet of the bull ray are the dominant small pelagic taxa commonly caught in the study area. The only exception is the sole (*Solea* sp.), which is a benthic species. This aligns with findings reported by Capapé (1977) from Tunisian waters, where small pelagic species frequently occurred in the diet of bull rays. Due to size and gape limitations, bull rays and their relatives may only prey on fishes smaller than 50 cm in total length (Wetherbee et al., 2012), meaning small species or larger species at early

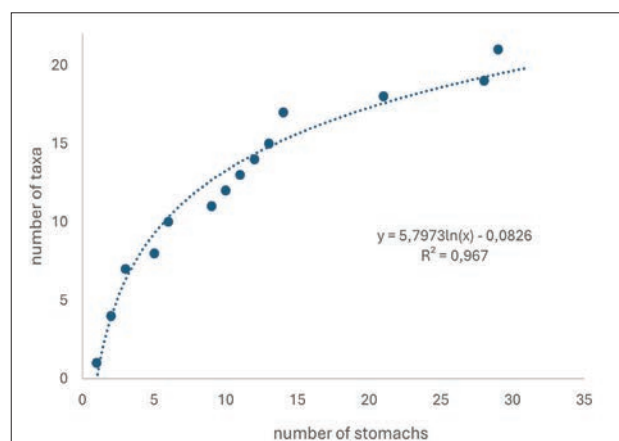


Fig. 8: The cumulative number of prey types identified with increasing sample size (number of stomachs).

Sl. 8: Kumulativno število določenih primerkov plena glede na naraščajoč vzorec (število želodcev).

life stages. The presence of pelagic species in the diet of predominantly benthic-feeding bull rays may be related to the availability of these species as dead discards abandoned on the sea floor or bull rays feeding on specimens with which they were entangled in the fishing nets during trawling operations. Fish cages are also an important source of food that attracts elasmobranchs (Barash *et al.*, 2018; Akyol *et al.*, 2022; Kurtay *et al.*, 2023). Akyol *et al.* (2022) reported bull rays feeding on dead fish around a sea-cage fish farm in Iskenderun Bay (Türkiye), noting that the rays showed no interest in the pellets used to feed cultured fish. In the study area, discards of small pelagic fish from pelagic trawlers occurred regularly and may represent a significant food source for bull rays.

The importance of the Gulf of Trieste and adjacent areas as bull ray habitat

While the bull ray was once considered a relatively rare batoid species in the Adriatic Sea (Jardas, 1985), subsequent studies based on the capture of numerous specimens confirmed its presence in the Gulf of Trieste (Dulčić *et al.*, 2008; Lipej *et al.*, 2009) and throughout the broader northern Adriatic region (La Mesa *et al.*, 2017). Dulčić *et al.* (2008) confirmed regular bull ray occurrence in the area, though like other elasmobranch species of low or no commercial value, specimens are typically discarded at sea (Mavrič *et al.*, 2004). The presence of several gravid females with developed embryos and numerous juvenile specimens indicates the area's importance for the reproduction of the species. Further investigation is needed to evaluate its potential nursery function, as speculated by some authors (Dulčić *et al.*, 2008; Lipej *et al.*, 2009). This speculation gains support from Capapé & Quignard's (1975) findings that the species reproduces from March till October, with gestation lasting six months. Notably, the study area hosted some record-sized individuals (1540–2220 mm DW, 68–116 kg), the largest ever documented (Dulčić *et al.* 2008; Lipej *et al.*, 2009).

Over the recent years, increasing myliobatid sightings have been reported through social media, including observations of bull rays in shallow waters. The Gulf of Trieste – a rather shallow basin with many riverine inflows enhancing its productivity – appears to attract bull rays to brackish areas such as lagoons, river mouths, and estuaries. This behaviour aligns with reports by Zogaris & Dussling (2010) of two occurrences of bull rays in the Amvrakikos Gulf (Greece) in August 2000 (two dead specimens found, probably discarded by fishermen) and August 2004 (12 live specimens sighted). This giant shallow lagoon-like gulf supports a rich and abundant mollusc community that evidently attracts bull rays. Similarly, El Kamel *et al.* (2009, 2010) reported the captures of juvenile and adult *A. bovinus* in the Tunisian Lagoon of Bizerte, associating them with the local presence of abundant mollusc populations (Zaouali, 1979) – a known prey preference for the bull ray. Higher occurrences of bull rays have also been observed off the estuaries of three main river systems in northern Italy (the Po, Adige, and Brenta Rivers) (La Mesa *et al.*, 2017) – areas productive due to riverine nutrient input and characterised by a high abundance of molluscs, crustaceans, and small pelagics (e.g., anchovies), which constitute major components of the bull ray's diet. Recently, sightings of bull rays have also been reported by local media in the marine protected area of Miramare (Ciriaco, 2020; Anonymous, 2023) and at Punta Madona in Piran (2023–2025), where divers observed individual bull rays as well as “cemeteries” of broken mollusc shells close to the shore (*pers. observations*).

ACKNOWLEDGMENTS

We would like to express our gratitude to many colleagues who helped us in this study, especially Jernej Uhan, Martina Orlando-Bonaca, Tihomir Makovec, Francesca Garaventa, Radoš Jenko and others. Many thanks also to Ariana Stojnić, M.Sc., SIC Company, Vabriga, who provided us with occasional specimens entrapped as a bycatch in the waters along the western coast of Istria.

VPOGLED V PREHRANJEVALNE NAVADE KLJUNATEGA MORSKEGA GOLOBA,
AETOMYLAEUS BOVINUS (GEOFFROY SAINT-HILAIRE, 1817)
V SEVERNEM JADRANU

Lovrenc LIPEJ

Marine Biology Station, National Institute of Biology, Piran, Slovenia &
University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies, Koper, Slovenia
e-mail: Lovrenc.lipej@nib.si

Riccardo BATTISTELLA

via S. Stefano 47, Este, Provincia di Padova, Italy

Borut MAVRIČ

Marine Biology Station, National Institute of Biology, Piran, Slovenia

Danijel IVAJNŠIČ

Faculty of Natural Sciences and Mathematics, University of Maribor, 2000 Maribor
Faculty of Arts, University of Maribor, 2000 Maribor

POVZETEK

*Raziskava poroča o osnovnih podatkih o prehranjevalnih navadah kljunatega morskega goloba *Aetomylaeus bovinus* (Geoffroy Saint-Hilaire, 1817) v Beneškem zalivu. Med 1557 primerki plena, izoliranimi iz želodcev, so veliko večino predstavljali polži (93,8 %). Med njimi je prevladovala vrsta *Aporrhais pespelecani*, sledili sta ji *Gibbula magus* in *Bolinus brandaris*. Te vrste so značilni elementi biocenoze muljastega detritnega dna. Opazili smo razlike v strukturi plena med mladimi in odraslimi primerki ter med spoloma. Med ribami, ki so se izkazale za pomembne predvsem z vidika biomase, so največ plena predstavljale male pelagične ribe, kot sta sardela (*Sardina pilchardus*) in šur (*Trachurus* sp.). Članek prispeva nove podatke o prehranjevalni ekologiji manj znane in kritično ogrožene vrste skatov.*

Ključne besede: morski golobi, prehranjevalna ekologija, jaslice, Beneški zaliv

REFERENCES

- Adams, K.R., L.C. Fetterplace, A.R. Davis, M.D. Taylor & N. Knott (2018): Sharks, rays and abortion: the prevalence of capture-induced parturition in elasmobranchs. *Biological Conservation*, 217, 11–27.
- Akyol, O., I. Aydın, O. El-Kamel-Moutalibi & C. Capapé (2017): Bull ray, *Aetomylaeus bovinus* (Geoffroy Saint-Hilaire, 1817) (Myliobatidae) in the Mediterranean Sea and captures of juveniles from Izmir Bay (Aegean Sea, Turkey). *Journal of Applied Ichthyology*, 33, 1200–1203.
- Akyol, O., H. Şen & C. Capapé (2022): Occurrence of a shoal of bull ray *Aetomylaeus bovinus* (Myliobatidae) around a sea-sage farm in Iskenderun Bay (Türkiye, NE Mediterranean Sea). *COMU Journal of Marine Sciences and Fisheries*, 5(2), 199–202.
- Alonso, M.K., E.A. Crespo, N.A., Garcia, S.N. Pedraza, P.A. Mariotti, N.J. Mora (2002): Fishery and ontogenetic driven changes in the diet of the spiny dogfish, *Squalus acanthias*, in Patagonian waters, Argentina. *Environ. Biol. Fish.* 63(2), 193–202.
- Anonymous, (2023): <https://www.triesteprima.it/cronaca/vaccarelle-tonni-delfini-avvistamenti-golfo.html>
- Barash, A., R. Pickholtz, H. Nativ, S. Malamud, A. Scheinin & D. Tchernov (2018): Seasonal arrival and feeding of injured sharks at fish farms in the Eastern Mediterranean. *Journal of the Black Sea / Mediterranean Environment*, 24(1), 86–90.
- Başusta, N. & A. Başusta (2019): Records of adult and newborn specimen of *Aetomylaeus bovinus* (E. Geoffroy Saint-Hilaire, 1817) from Mersin Bay, Northeastern Mediterranean Sea. 3rd International Congress on Advances in Bioscience and Biotechnology (ICABB), July 10–14, 2019, Kiev, Ukraine, 5–7.
- Bilgili, A. & H. Kabasakal (2023): Encounters with threatened batoids from the perspective of a spearfisherman suggesting an aggregation site in southeastern Aegean Sea, Turkey. *Regional Studies in Marine Science*, 61, 102894. <https://doi.org/10.1016/j.rsma.2023.102894>.
- Capapé, C. & J.-P. Quignard (1975): Contribution à la systématique et à la biologie de *Pteromylaeus bovinus* (Geoffroy Saint-Hilaire, 1817), (Pisces, Myliobatidae) des côtes tunisiennes. *Bull. Mus. Hist. Nat., Paris*, 3e série, n° 338, Zool., 240, 1329–1347.
- Capapé, C. (1977): Étude du régime alimentaire de la Mourinevachette, *Pteromylaeus bovinus* (Geoffroy Saint-Hilaire, 1817), (Pisces, Myliobatidae) des côtes tunisiennes. *J. Cons. Explor. Mer*, 37(3), 214–220.
- Ciriaco, S. (2020): Vaccarella a Miramare. Area Marina Protetta Miramare. <https://www.facebook.com/watch/?v=967642130343693>
- De Sousa Rangel, B., D. de Castro Ribeiro, J.M.A. Chagas, L. Spada, R.G. Moreira & C. da Silva Ribeiro (2020): Effects of biological traits on capture-induced parturition in a freshwater stingray and perspectives for species management. *Journal of Fish Biology*, 97, 546–551.
- Dulčić, J., L. Lipej, M. Orlando Bonaca, R. Jenko, B. Grbec, O. Guélorget & C. Capapé (2008): The bull ray, *Pteromylaeus bovinus* (Myliobatidae), in the northern Adriatic Sea. *Cybius*, 32(2), 119–123.
- Ebert, D.A. & M.W. Stehmann (2013): Sharks, batoids and chimaeras of the north Atlantic. *FAO Species Catalogue for Fishery Purposes*. No. 7, FAO, Rome.
- El Kamel, O., N. Mnasri, J. Ben Souissi, M. Boumaïza, M.M. Ben Amor & C. Capapé (2009): Inventory of elasmobranch species caught in the Lagoon of Bizerte (North-eastern Tunisia, central Mediterranean). *Pan-American Journal of Aquatic Sciences*, 4(4), 383–412.
- El Kamel, O., N. Mnasri, M. Boumaïza, M.M. Ben Amor, C. Reynaud, & C. Capapé (2010): Additional records of the bull ray *Pteromylaeus bovinus* (Chondrichthyes: Myliobatidae), in the Lagoon of Bizerte (northern Tunisia, central Mediterranean). *Annales, Series Historia Naturalis*, 20(2), 169–174.
- Ellis, J.K. & J.A. Musick (2007): Ontogenetic changes in the diet of the sandbar shark, *Carcharhinus plumbeus*, in lower Chesapeake Bay and Virginia (USA) coastal waters. *Environ. Biol. Fish.* 80, 51–67. <https://doi.org/10.1007/s10641-006-9116-2>.
- Faganeli, J., I. Falnoga, M. Horvat, K. Klun, L. Lipej & D. Mazej (2018): Selenium and Mercury Interactions in Apex Predators from the Gulf of Trieste (Northern Adriatic Sea). *Nutrients*, 10(3), 278, DOI: 10.3390/nu10030278.
- Falciai, L. & R. Minervini (1992): Guida dei Crostacei Decapodi d'Europa, 1st ed.; Franco Muzio Editore: Padova, Italy.
- Gül, G. & N. Demirel (2020): Trophic interactions of uncommon batoid species in the Sea of Marmara. *J. Black Sea/Mediterranean Environment*, 26, 294–309.
- Jabado, R.W., E. Chartrain, G. Cliff, D. Derrick, M. Dia, M. Diop, P. Doherty, J. Dossa, G.H.L. Leurs, K. Metcalfe, G. Porriños, I. Seidu, A. Soares, A. Tamo, W.J. VanderWright & A.B. Williams (2021): *Aetomylaeus bovinus*. The IUCN Red List of Threatened Species 2021: e.T60127A124441812. <https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T60127A124441812.en>. Accessed on 18 March 2025.

- Jardas, I. (1985):** Check-list of the fishes (*sensu lato*) of the Adriatic Sea (Cyclostoma, Selachii, Osteichthyes) with respect of taxonomy and established number. *Biosistematika*, 11(1), 45–74.
- Horvat, M., N. Degenek, L. Lipej, J. Snoj Tratnik, J. Faganeli (2013):** Trophic transfer and accumulation of mercury in ray species in coastal waters affected by historic mercury mining (Gulf of Trieste, northern Adriatic Sea). *Environmental Science and Pollution Research*, 21(6). DOI: 10.1007/s11356-013-2262-0
- Krebs, C.J. (1989):** *Ecological Methodology*. Harper & Row, 1989, New York.
- Koen-Alonso, M., E. Crespo, N. García, S. Pedraza, P. Mariotti & N. Mora (2002):** Fishery and Ontogenetic Driven Changes in the Diet of the Spiny Dogfish, *Squalus acanthias*, in Patagonian Waters, Argentina. *Environmental Biology of Fishes*, 63, 193–202.
- Kurtay, E., O. Akyol, A. Özgül & C. Capapé (2023):** Record of a bull ray *Aetomylaeus bovinus* (Myliobatidae) in a sea-cage tuna farm in the Aegean coast of Türkiye (Eastern Mediterranean Sea). *J. Black Sea/Mediterranean Environment*, 29, 2, 217–223.
- La Mesa, G., A. Annunziatellis, E. Filidei Jr. & C.M. Fortuna (2016):** Bycatch of Myliobatid Rays in the Central Mediterranean Sea: the Influence of Spatiotemporal, Environmental, and Operational Factors as Determined by Generalized Additive Modelling, *Marine and Coastal Fisheries*, 8(1), 382–394.
- Legendre P. & E.D. Gallagher (2001):** Ecologically meaningful transformations for ordination of species data. *Oecologia* 129, 271–280. doi: 10.1007/s004420100716.
- Lipej, L., B. Mavrič & J. Dulčić (2009):** Size of the bull ray, *Pteromylaeus bovinus* (Geoffroy Saint-Hilaire, 1817), from the northern Adriatic. *Journal of Applied Ichthyology* 25(suppl.1), 103–105.
- Lipej, L., B. Mavrič, S. Rešek, M. Cherif & C. Capapé (2011):** Food and feeding habits of the blackspotted smooth-hound, *Mustelus punctulatus* (Elasmobranchii: Carcharhiniformes: Triakidae), from the Northern Adriatic. *Acta ichthyologica et piscatoria*, 41(3), 171–177.
- Lipej, L., R. Battistella, B. Mavrič & D. Ivajnšič (in press):** Diet of the Common Eagle Ray, *Myliobatis aquila* (Linnaeus, 1758) in the northern Adriatic Sea. *Fishes*.
- Lucifora, L.S., V.B. García, R.C. Menni & A.H. Escalante (2006):** Food habits, selectivity, and foraging modes of the school shark *Galeorhinus galeus*. *Mar. Ecol. Prog. Ser.*, 315, 259–270.
- Manjon-Cabeza, M.E. & J.E. García Raso (1999):** Shell utilization by the hermit crabs *Diogenes pugilator* (Roux, 1829), *Paguristes eremita* (Linnaeus, 1767) and *Pagurus forbesii* Bell, 1845 (Crustacea: Decapoda: Anomura) in a shallow-water community from southern Spain. *Bullettin of Marine Science*, 65(2), 391–405.
- Mavrič, B., R. Jenko, T. Makovec & L. Lipej (2004):** On the occurrence of the Pelagic Stingray, *Dasyatis violacea* (Bonaparte, 1832), in the Gulf of Trieste (Northern Adriatic). *Annales, Ser. Hist. Nat.*, 14(2), 181–186.
- Oksanen, J., R. Kindt, P. Legendre, R.B. O'Hara, G.L. Simpson, P. Solymos et al. (2023):** The Vegan Package. Community Ecology Package. Available online at: <http://R-Forge.r-Project.Org/Projects/Vegan/> (Accessed 1 February 2023).
- Pinkas, L., M.S. Oliphant & I.L.K. Iverson (1971):** Food habits of albacore, blue-fin tuna, and bonito in California waters. *Fish Bull. Calif.*, 152, 1–105.
- R Core Team (2023):** R Development Core Team R: A Language and Environment for Statistical Computing 2023 (Vienna, Austria: R Core Team).
- Ravara, D. (2012):** *Ecologia alimentare del palombo comune (Mustelus mustelus, Linnaeus 1758) e del palombo punteggiato (Mustelus punctulatus, Risso 1826) presenti nel Nord Adriatico*. Master Thesis. Università degli studi di Trieste, Trieste, 114 pp.
- Riedel, R. (1991):** *Fauna e flora del Mediterraneo. Dalle Alghe ai Mammiferi; una Guida Sistematica alle Specie che Vivono nel mar Mediterraneo*, 1st ed.; Franco Muzzio Editore: Padova, Italy.
- Seck A.A., Y. Diatta, A. Gueye-Ndiaye A. & C. Capapé (2002):** Observations on the reproductive biology of the bull ray, *Pteromylaeus bovinus* (E. Geoffroy Saint-Hilaire, 1817) (Chondrichthyes: Myliobatidae) from the coast of Senegal (Eastern tropical Atlantic). *Acta Adriatica*, 43, 87–96.
- Smith, P.E. & M.T. Zaret (1982):** Bias in estimating niche overlap. *Ecology*, 63(5), 1248–1253.
- Soldo, A. & L. Lipej (2022):** An annotated checklist and the conservation status of chondrichthyans in the Adriatic. *Fishes*, 7, 245. <https://doi.org/10.3390/fishes7050245>.
- Stachowitsch, M. & A. Fuchs (1995):** Long term changes in the benthos of the northern Adriatic. *Annales, Series Historia Naturalis*, 7, 7–16.
- Stevens, J.D., R. Bonfil, N.K. Dulvy & P.A. Walker (2000):** The effects of fishing on sharks, rays, and chimaeras (chondrichthyans), and the implications for marine ecosystems. *ICES Journal of Marine Science*, 57, 476–494.
- Szczepanski, J.A & D.A. Bengtson (2014):** Quantitative food habits of the bullnose ray, *Myliobatis freminvillii*, in Delaware Bay. *Environ. Biol. Fishes*, 97, 981–997.
- Šlejkovec, Z., A. Stajanko, I. Falnoga, L. Lipej, D. Mazej, M. Horvat & J. Faganeli (2014):** Bioaccumulation of Arsenic Species in Rays from the Northern Adriatic Sea. *Int. J. Mol. Sci.*, 15(12), 22073–22091. <https://doi.org/10.3390/ijms151222073>

Wetherbee, B.M., E. Cortes & J.J. Bizzarro (2012): Food consumption and feeding habits. In: *Biology of Sharks and Their Relatives*, J.C. Carrier et al., (Eds.), CRC Press, Taylor & Francis Group, Boca Raton & New York, pp. 239-264.

Wilga, C.D. & P.J. Motta (2000): Durophagy in sharks: feeding mechanics of the hammerhead *Sphyrna tiburo*. *The Journal of Experimental Biology*, 203, 2781-2796.

Yonge, C.M. (1937): The Biology of *Aporrhais pes-pelecani* (L.) and *A. serresiana* (Mich.). *J. Mar. Bio. Ass. UK*, 21(2), 687-703. DOI: <https://doi.org/10.1017/S0025315400053819>.

Zogaris, S. & U. Dussling (2010): On the occurrence of the Bull Ray *Pteromylaeus bovinus* (Chondrichthyes: Myliobatidae) in the Amvrakikos Gulf, Greece. *Medit. Mar. Sci.*, 11/1, 177-184.