UDK 5
ISSN 1408-533X

# ANNALES

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

Series historia naturalis, 24, 2014, 1

KOPER 2014

ISSN 1408-533X UDK 5 Letnik 24, leto 2014, številka 1

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**Prelom/*Composizione/Typesetting:*** Grafis trade d.o.o.

**Tisk/*Stampa/Print:*** Grafis trade d.o.o.

**Izdajatelj/*Editore/Published by:*** Zgodovinsko društvo za južno Primorsko - Koper / *Società storica del Litorale - Capodistria*©

**Za izdajatelja/*Per Editore/ Publisher represented by:*** Salvator Žitko

**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*
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fax 671 2901;
***e-mail:*** annales@mbss.org, ***internet:*** www.zdjp.si

Redakcija te številke je bila zaključena 30. 06. 2014.

**Sofinancirajo/*Supporto finanziario/ Financially supported by:*** Javna agencija za raziskovalno dejavnost Republike Slovenije (ARRS)

*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: BIOSIS-Zoological Record (UK); Aquatic Sciences and Fisheries Abstracts (ASFA); Elsevier B.V.: SCOPUS (NL).

**ANNALES · Ser. hist. nat. · 24 · 2014 · 1**

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

UDK 5 Letnik 24, Koper 2014, številka 1 ISSN 1408-533X

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# EKOLOGIJA MORJA

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Original scientific article
Received: 2014-03-28

UDK 574.58:593.6(262.32)

# MACROFAUNA ASSOCIATED WITH A BANK OF *CLADOCORA CAESPITOSA* (ANTHOZOA, SCLERACTINIA) IN THE GULF OF TRIESTE (NORTHERN ADRIATIC)

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## *ABSTRACT*

*The Mediterranean stony coral* Cladocora caespitosa *(Linnaeus, 1767) is a native colonial, zooxanthellate, shallow-water coral, particularly sensitive to global changes and anthropogenic activities. Due to its shape and size, it is able to host a diversified faunal assemblage, which is still relatively unknown. A recently discovered bank of* C. caespitosa*, discovered close to Cape Ronek (Gulf of Trieste, Slovenia), was investigated in November 2010. Altogether 121 invertebrate taxa, belonging to 9 different phyla were found. Taxa composition in colonies differed markedly from the surrounding areas within the bank. Only 5 taxa (4 % of the total) were found both within and without* C. caespitosa *colonies. Our results confirm the role of* C. caespitosa *as a habitat builder and indicate the importance of the studied bank for biodiversity.*

**Key words:** *Cladocora caespitosa*, bioconstruction, macroinvertebrates, circalittoral, Northern Adriatic

# MACROFAUNA ASSOCIATA AD UN BANCO DI *CLADOCORA CAESPITOSA* (ANTHOZOA, SCLERACTINIA) NEL GOLFO DI TRIESTE (ADRIATICO SETTENTRIONALE)

## *SINTESI*

*La madrepora a cuscino (*Cladocora caespitosa*, Linneus, 1767) è un corallo madreporario di acque poco profonde, sensibile ai cambiamenti climatici ed alle attività antropiche. Grazie alla sua struttura e alle dimensioni, questo madreporario è in grado di ospitare una comunità faunistica molto diversificata. Un banco di* C. caespitosa*, scoperto recentemente vicino a Capo Ronco (Golfo di Trieste, Slovenia), è stato studiato nel novembre 2010. In totale sono stati trovati 121 taxa di invertebrati, appartenenti a 9 diversi phyla. La composizione faunistica all'interno delle colonie differiva notevolmente da quella della zona circostante sul banco. Solo 5 taxa (4 % del totale) sono stati trovati sia all'interno che nei pressi delle colonie. I nostri risultati confermano il ruolo di* C. caespitosa *come biocostruttore e pongono l'accento sull'importanza del banco oggetto di studio per la biodiversità.*

**Parole chiave:** *Cladocora caespitosa*, biocostruzioni, macroinvertebrati, circalitorale, Adriatico settentrionale

## INTRODUCTION

The Mediterranean stony coral *Cladocora caespitosa* (Linnaeus, 1767) is the only native colonial and obligate zooxanthellate coral of the Mediterranean Sea (Zibrowius, 1980; Peirano *et al.,* 1999). It occurs throughout the Mediterranean on rocky and sandy bottoms from shallow waters to those at more than 30 m depth (Zibrowius, 1980). However, in the Adriatic Sea it is rarely found below 30 m (Kružić *et al.*, 2008). *C. caespitosa* is one of the major carbonate producers in the Mediterranean Sea (Peirano *et al.*, 2001) and forms hemisperical, bush-like colonies. Due to its shape and size, it is physiologically and morphologically similar to the typical tropical reef-building corals (Zibrowius, 1982; Schuhmacher & Zibrowius 1985; Peirano *et al*. 1994; Kružić & Požar-Domac, 2003) and consequently, is able to host a diversified faunal assemblage (Koukouras *et al.*, 1998). Much has been reported about the fauna associated with tropical corals (*e.g.,* Cantera *et al.*, 2003; Idjadi & Edmunds, 2006; Martins Garcia *et al.*, 2008) but very little is known about the macrofauna associated with colonies of *C. caespitosa*. Species associated with this Scleractinian coral have been reported from different sites in the Adriatic (Sciscioli & Nuzzaci, 1970; Zavodnik, 1976; Schiller, 1993), Ionian (Lumare, 1965) and Aegean Seas (Arvanitidis & Koukouras, 1994; Koukouras *et al.*, 1998; Antoniadou & Chintiroglou, 2010). Nevertheless, most of these reports focus on specific taxonomic groups, namely polychaetes (Sciscioli & Nuzzaci, 1970; Arvanitidis & Koukouras, 1994) and echinoderms (Zavodnik, 1976). The most comprehensive study of macrofaunal assemblages associated with *C. caespitosa* was carried out by Koukouras *et al.* (1998) in the Aegean Sea.

Colonies of *C. caespitosa* can be solitary, can form ‘beds’ (numerous colonies living more or less close to each other) or ‘banks’ (colonies connected together in large formations) (Zibrowius, 1980; Kühlmann *et al.,* 1991; Schiller, 1993; Morri *et al.,* 1994; Peirano *et al.*, 1994). Solitary colonies can be locally abundant (Zibrowius, 1980), beds are known from several sites, such as the western Mediterranean (Majorca, Port-Cros and Villefrance), northern Adriatic and Ionian coasts (Peirano *et al.*, 1994), while banks are uncommon and have been reported only in the Ligurian Sea (Morri *et al.*, 1994), off the Tunisian coast (Zibrowius, 1980) and in the Adriatic (Kružić & Požar-Domac, 2003) and Aegean Seas (Kühlmann, 1996).

The circalittoral belt in the Gulf of Trieste is mostly composed of the biocoenosis of the muddy detritic bottom, with a patch of coastal detritic biocoenosis in the Bay of Piran (Lipej et. *al.*, 2006). A bank of *C. caespitosa* was recently discovered close to Cape Ronek in Slovenian waters (Lipej *et al.*, 2006). The bank was investigated according to Marine Strategy Framework Directive (MSFD, 2008/56/EC) requirements. During the first survey of this bank, performed using SCUBA diving techniques, coralline algae were sampled. Seven coralline algal species (three of them new for Slovenia) as well as fossil rhodoliths were found (Falace *et al.*, 2011). Given the important role of *C. caespitosa* as bioconstructor, the aim of the present work was to investigate the invertebrate fauna associated with this almost unknown biogenic formation in order to estimate to what extent this coral contributes to local biodiversity. Moreover, since some authors reported that the Mediterranean stony coral is undergoing a rapid decrease in both size and spatial distribution in the Mediterranean Sea (Morri *et al.*, 2001; Rodolfo-Metalpa *et al.*, 2005), it is of great importance to study the biological and ecological aspects of this bank and to consider possible measures of protection as well.

## MATERIAL AND METHODS

### Study area and sampling site

The Gulf of Trieste is a shallow semi-enclosed embayment located in the northernmost part of the Adriatic Sea. It is characterized by the lowest winter temperatures in the Mediterranean Sea, which can fall below 10 °C in winter (Boicourt *et al.*, 1999). Salinity is about 37 on average, but is influenced near the coast by fresh water input from rivers, mainly the Isonzo River (Mozetič *et al.*, 1998). During the summer, a typical thermal stratification of the water column develops due to surface heating and fresh water inflow (Boicourt *et al.*, 1999). In winter, the water column is characterized by consider-

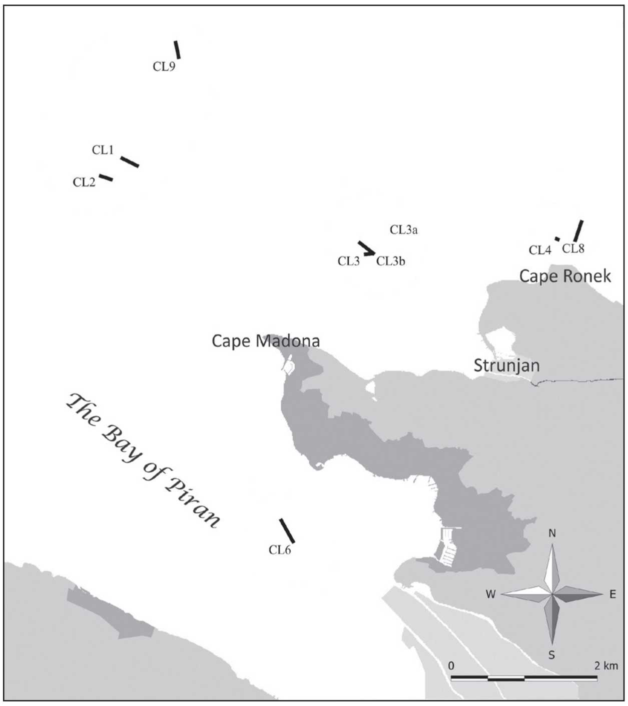

***Fig. 1: Map of the study area with sampling sites.***
***Sl. 1: Obravnavano območje in mesta vzorčenja.***

able vertical homogeneity due to autumnal cooling and wind mixing (Mozetič *et al.*, 1998).

The sampling site (Fig. 1) is located off the coast of Strunjan (Cape Ronek), where a biogenic bank of *C. caespitosa* is present. This bank extends on a surface of about 200 × 100 m, at a depth range between 12.4 and 21 m and is a few meters higher than the surrounding bottom. The bank (Fig. 2) presents the highest density of *C. caespitosa* colonies ever recorded in Slovenian coastal water: 6.52 colonies m$^{-2}$ on average (*unpubl. data*). On this bank colonies are surrounded by an area made of dead corallites and, to a lesser extent, of coralline algae (mainly rhodoliths of *Lithothamnion* spp.) (Fig. 3).

### Fieldwork and laboratory work

Sampling was performed in November 2010, dredging the selected area at a constant speed of 1 knot for 5 minutes. The dredge is considered to be more appropriate than grabs and cores for the estimation of the densities of small benthic species (Pérès & Picard, 1964; Castelli *et al.*, 2003). The biogenic bank was investigated on two levels in order to better characterize the benthic community associated with this formation. The first level comprises the area that surrounds the colonies of *C. caespitosa*. The largest, easily identifiable animals were identified on the boat immediately after the sampling and were then released. The smallest animals were fixed in ethanol (70 %) and classified later in the laboratory. The second level addresses the infauna living inside colonies of *C. caespitosa*. Thirty colonies of *C. caespitosa* were chosen. Each colony was weighed and measured (minimum axis width and maximum axis length), and the percentage of the number of living corallites was visually estimated. The bottom surface covered by those colonies was calculated from colony axes. Afterwards the colonies were preserved in 70 % ethanol. In the laboratory they were broken apart completely and sieved through a 1 mm mesh. Each corallite was broken and invertebrates living inside were carefully collected with fine pipettes and tweezers. Invertebrates were then sorted, counted and identified according to the relevant literature: Tebble (1966), Ghisotti & Sabelli (1970), Parenzan (19701976), Torelli (1982) and Cossignani *et al*. (1992) for molluscs; Fauvel (1923, 1927) and Bianchi (1981) for polychetes; Naylor (1972), Ruffo (19821993), Harrison & Ellis (1991), Falciai & Minervini (1992) and Hayward & Ryland (1995) for crustaceans, Occhipinti Ambrogi (1981) for bryozoans; Tursi (1980) for tunicates and Sarà (1972) for sponges. The nomenclature follows WoRMS (WoRMS, 2013). Only living invertebrates were taken into consideration and counted. Colonial species were also determined and their coverage on a surface of 20 × 20 cm was calculated, but they were excluded from indices calculations.

Each species was assigned to one of the following trophic groups: motile predators (P), ectoparasites and specialized carnivores feeding on larger animals (EC), deposit feeders feeding on organic particles contained in the sediment (DF), suspension feeders capturing seston particles with their gills or with mucous strings (SF), and grazers feeding on algae, cyanobacteria or detritus attached to algal fronds (G). Feeding guilds were assessed according to Fauchald & Jumars (1979), Bianchi (1981), Chintiroglou (1996), Solis-Weiss *et al.* (2004) and Rueda *et al*. (2009).

Moreover, each species was assigned to one of four functional groups, following the classification of Reed & Mikkelsen (1987) and Hrs-Brenko & Legac (2006): free living, motile species (FL), epilithic species, living their

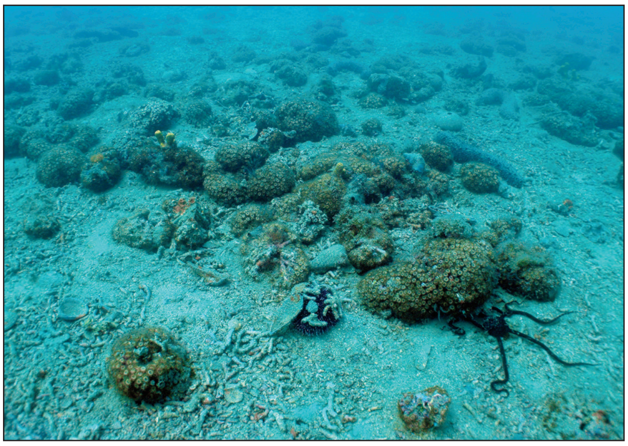

***Fig. 2: The biogenic bank of Cape Ronek with colonies of* C. caespitosa *and the bottom made of dead corallites. (Photo: B. Mavrič)***
***Sl. 2: Biogena formacija pred rtom Ronek s kolonijami sredozemske kamene korale* (C. caespitosa) *in dno, ki ga sestavljajo mrtvi koraliti. (Foto: B. Mavrič)***

***Fig. 3: Colonies of* C. caespitosa *and other epifauna on the biogenic bank at Cape Ronek. (Photo: B. Mavrič)***
***Sl. 3: Kolonije sredozemske kamene korale* (C. caespitosa) *in drugih elementov epifavne na biogeni formaciji pred rtom Ronek. (Foto: B. Mavrič)***

***Tab. 1: Minimum axis and maximum axis (cm), wet weight (kg), coverage of each colony (cm²) and proportion of living corallites per colony of* C. caespitosa.**

***Tab. 1: Minimalna in maksimalna os (cm), mokra teža (kg), pokrovnost posamezne kolonije (cm²) in delež živih koralitov na koloniji sredozemske kamene korale.***

| | **Max axis (width) in cm** | **Min axis (length) in cm** | **Wet weight in kg** | **Surface covered in cm²** | **% of living corallites** |
|---|---|---|---|---|---|
| **Average** | 13.1 | 9.3 | 0.60 | 391.3 | 60 |
| **SD (±)** | 2.7 | 1.5 | 0.24 | 125.3 | 27 |
| **Max** | 20.0 | 13.0 | 1.10 | 816.8 | 100 |
| **Min** | 8.6 | 6.3 | 0.14 | 170.2 | 0 |

entire life attached to a substrate (EP), endolithic species, living in holes bored in hard substrates (EN) and soft bottom dwelling species (SB). Species which were known to live attached to the substrate when juveniles and to move freely when adults (Hrs-Brenko & Legac, 2006) were considered separately (FL/EP).

Eventually, ecological groups were defined mainly following Pérès (1967), De Min & Vio (1997), and Solis-Weiss *et al*. (2004).

### Data analysis

Correlation between colonies' weight, axes, percentage of living polyps and bottom surface coverage by each colony was analyzed with Spearman's coefficients for non-parametric distributions (Spearman, 1907) using R version 2.4.0.

Number of taxa (S), number of individuals (N), Margaleff index of richness (d), Shannon diversity index (H'), Pielou index of equitability (J') and Simpson index of dominance (L') (Clarke & Warwick, 2001) were calculated for the macrobenthic taxa found within colonies of *C. caespitosa* and for those taxa found on the surrounding area within the bank. A group-average sorting classification (Cluster) analysis based on Sorensen similarity (Clarke & Warwick, 2001) was performed using invertebrates presence/absence data in order to compare Cape Ronek with other sites sampled in Slovenian marine waters using the same method in the same year for other studies related to the implementation of the MSFD. These statistical analyses were carried out using the software package Primer 6, developed by the Plymouth Marine Laboratory.

## RESULTS

### Description of *C. caespitosa* colonies

The analyzed colonies of *C. caespitosa* were small to medium in size with a minimum axis ranging from 6.3 to 13 cm and a maximum axis ranging from 8.6 to 20 cm (Tab. 1). The majority (71 %) had a maximum axis ranging from 10 to 15 cm.

The shape of the colonies varied from almost circular to elliptical and there was no significant correlation between the maximum and minimum axes of colonies ($r_s = 0.295$, $p = 0.113$). Colony weight ranged from 0.14 to 1.1 kg (Tab. 1). Both axes were positively correlated with colony weight, but the maximum axis showed the best correlation ($r_s = 0.641$, $p < 0.001$). The surface covered by each colony was correlated with colony weight ($r_s = 0.742$, $p < 0.001$). The percentage of living polyps in each colony was extremely variable, ranging from colonies with all polyps alive (100 %) to totally dead colonies (0 %) (Tab. 1). This percentage was not correlated with colonies' weights ($r_s = 0.149$, $p = 0.429$) nor with the surface covered by each colony ($r_s = 0.117$, $p = 0.535$).

### Macrofaunal community description

During the present study a total of 121 taxa belonging to 9 different phyla (Porifera, Bryozoa, Cnidaria, Sipunculida, Mollusca, Anellida, Arthropoda, Echinodermata and Tunicata) were found within the bank of *C. caespitosa*. Among the 13 colonial taxa determined, 8 were sponges and 5 were bryozoans. Within non-colonial taxa 3605 individuals were counted.

On the area within the bank that surrounds colonies of *C. caespitosa,* 223 individuals belonging to 26 different taxa were analyzed. Echinoderms were the most abundant phyla (70 %), followed by molluscs (22 %). Taxa richness was higher within molluscs (58 %) and echinoderms (27%) (Fig. 4).

Within the 30 colonies of *C. caespitosa* collected and analysed in the laboratory 89 taxa of infauna were determined (Tab. 2). About 50 % of them were polychaetes, 25 % molluscs and 16 % crustaceans (Fig. 4). Regarding taxa abundance, 3386 organisms were counted (Tab. 2). The most abundant were molluscs (50 %), followed by polychaetes (20 %) and crustaceans (7 %). Many of these specimens were juveniles.

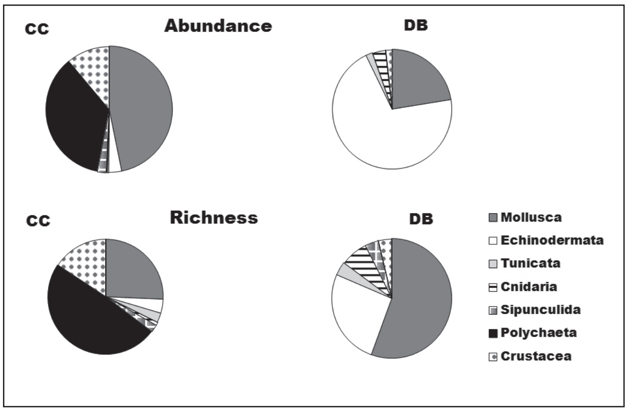

***Fig. 4: Percentage of (A) abundance and taxa richness (B) within different phyla (colonial organisms excluded) within the colonies of* C. caespitosa *(CC) and in the surrounding area within the bank (DB).***
***Sl. 4: Delež abundance (A) in pestrosti taksonov (B) različnih debel (brez kolonijskih organizmov) znotraj kolonij kamene korale (CC) in na okoliškem dnu znotraj biogene formacije (DB).***

Only 5 taxa (4 % of the total) were found in both micro-habitats (within and without *C. caespitosa* colonies) (Tab. 3).

The area within the bank was dominated by the sea urchin *Psammechinus microtuberculatus* (with 42 % of dominance), whereas the infauna of *C. caespitosa* was dominated by two boring bivalves, *Hiatella artica* (with 27 % of dominance) and *Rocellaria dubia* (19 %).

The overall diversity of the community was quite high (Shannon index H′ = 3.05; Tab. 2). The contribution of infaunal organisms associated with colonies of *C. caespitosa* to richness and abundance values of the sampled area was consistent (74 % of total richness and 94 % of total abundance). Also considering infaunal taxa, the Margalef index (d) passed from a value of 4.28 to a value of 13 and the global diversity of the community (H′) increased (Tab. 2). Conversely, the index of equitability (J′) showed no significant differences, since both infaunal communities and the surrounding area within the bank were dominated by few taxa with a high abundance (comparable L′).

The majority of taxa found in the sampled area are of wide ecological distribution or of uncertain bionomic affinity. On the area surrounding colonies only the mollusc *Vermetus triquetrus* is characteristic of the biocoenosis of Photophilic Algae (AP), and the serpulid *Ditrupa arietina* is characteristic of the biocoenosis of Coastal Detritic (DC), but neither were significantly abundant (< 1 % of dominance). In those samples, taxa usually associated with AP were present together with taxa associated with DC.

Among the infauna of colonies of *C. caespitosa,* taxa usually associated with AP and DC were found, but no characteristic species of any biocoenosis were present. Also some typical species for sandy and muddy bottoms namely the bivalves *Diplodonta rotundata* and *Nucula nucleus,* and the polychaetes *Lumbrineris impatiens* and *Cirriformia tentaculata*, were found.

The benthic community on the biogenic bank at Cape Ronek (without the infauna of colonies of *C. caespitosa*) differed greatly from other sampled sites at a comparable depth during the same period in Slovenian waters, as shown in other studies (unpublished data). Cluster analysis shows that Cape Ronek (Fig. 5, ACL8) can't be grouped with any other sites along the Slovenian coast.

### Macrofaunal feeding guilds

Non-colonial organisms were subdivided into four feeding categories: grazers, suspension feeders, predators, ectoparasites and specialized carnivores and deposit feeders. Among them, 36 taxa were predators (P), 35 suspension feeders (SF), 11 grazers (G), and 17 deposit feeders (DF) (Tab. 3). Predators were mainly polychaetes and crustaceans, suspension feeders were represented by molluscs and serpulid polychaetes, grazers were mainly sea urchins, and deposit feeders were other echinoderms and sipunculids.

Within the infauna of *C. caespitosa* colonies, suspension feeders were the dominant group (64 % of total

***Tab. 2: Taxa richness, abundance and diversity indices of invertebrates within* C. caespitosa *colonies (CC), in the surrounding area (DB) and in the overall sampled area (colonial organisms excluded). S = number of taxa, N = number of individuals, d = Margaleff index, J ′= Pielou index, H′ = Shannon-Wiener index ($log_e$), L′ = Simpson index (1-lambda).***
***Tab. 2: Pestrost, taksonov, abundanca in diverzitetni indeksi za nevretenčarje znotraj kolonij kamene korale (CC), na okoliškem dnu (DB) in na celotnem vzorčnem območju (brez kolonijskih organizmov). S = število taksonov, N = število osebkov, d = Margaleffov indeks, J′ = Pieloujev indeks, H′ = Shannon-Wienerjev indeks ($log_e$), L′ = Simpsonov indeks (1-lambda).***

| Sample | S | N | d | J′ | H′ | L′ |
|---|---|---|---|---|---|---|
| CC | 89 | 3386 | 10.828 | 0.641 | 2.879 | 0.875 |
| DB | 24 | 215 | 4.283 | 0.683 | 2.172 | 0.789 |
| TOTAL | 108 | 3605 | 13.06 | 0.651 | 3.050 | 0.889 |

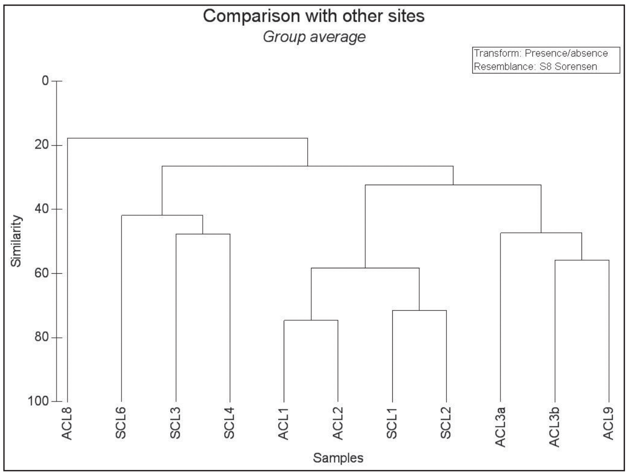

***Fig. 5: Comparison between the sampling site (ACL8) and other sites along the Slovenian coast sampled with the same technique in the same year (unpubl. data). Spring samples: SCL1, SCL2, SCL3, SCL4, SCL6; autumn samples: ACL1, ACL2, ACL3a, ACL3b, ACL8, ACL9.***
***Sl. 5: Primerjava med postajo vzorčenja (ACL8) in drugimi postajami ob slovenski obali, ki so jih avtorji vzorčili z isto metodo v istem letu (neobjavljeni podatki). Pomladni vzorci: SCL1, SCL2, SCL3, SCL4, SCL6; jesenski vzorci: ACL1, ACL2, ACL3a, ACL3b, ACL8, ACL9.***

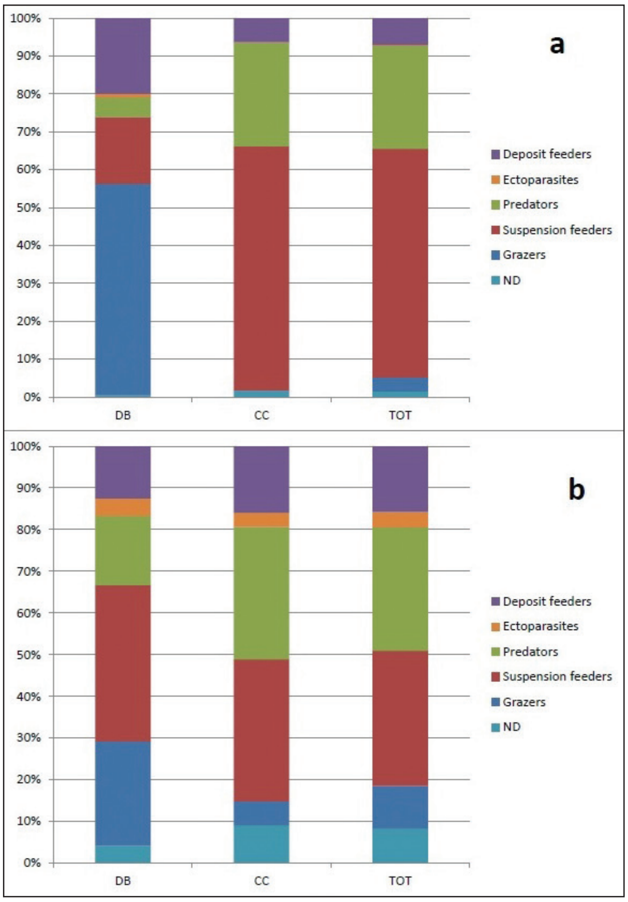

***Fig. 6: Abundance (a) and taxa richness (b) of feeding guilds in the total sampled area (TOT), inside*** *C. caespitosa* ***colonies (CC) and within the bank without infauna (DB). ND = no data available.***
***Sl. 6: Abundanca (a) in pestrost taksonov (b) prehranjevalnih cehov na celotnem vzorčnem območju (TOT), znotraj kolonij kamene korale (CC) in na okoliškem dnu znotraj bioformacije brez infavne (DB). ND = ni razpoložljivih podatkov.***

abundance and 34 % of total taxa richness) (Fig. 6), but predators had the highest richness (35 % of total taxa richness). Among suspension feeders, the most dominant were the bivalves *H. artica* and *R. dubia,* followed by the bivalve *Anomia ephippum,* serpulids (mainly *Serpula concharum*) and the crustacean decapod *Pisidia longimana*. The most abundant predators were polychaetes belonging to the families Eunicidae, Syllidae and Polynoidae, together with decapods like *Alpheus dentipes* and *Athanas nitescens*.

On the bank around colonies of *C. caespitosa,* grazers were dominant (more than 56 % of total abundance and 37 % of total taxa richness). Relevant also was the presence of suspension feeders and predators (see Fig. 6). The most abundant grazers were sea urchins *P. microtuberculatus* and *Sphaerechinus granularis*, while the most abundant suspension feeder was the bivalve *Arca noae*. Predators were mainly represented by molluscs (*Calliostoma zizyphinum* and *Hexaplex trunculus*) and cnidarians.

### Macrofaunal functional groups

The proportion of taxa richness among functional groups from the bank around colonies of *C. caespitosa* and functional groups within the colonies did not differ significantly (Fig. 7). Free living taxa were dominant (45 % within colonies and 54 % on the area around them), followed by epilithic (25 % both within colonies and on the surrounded area), while endolithic were only 8 % of all taxa, both within colonies and on the detritic bottom within the bank.

The results were different regarding relative abundance. Among the infauna, endolithic taxa were dominant (50 % of total abundance), followed by free-living organisms (27 %), and by epilithic taxa (13 %). Conversely, on the surrounding area free living organisms were dominant (78 % of total abundance), followed by epilithic animals (16 %), while endolithic taxa were very scarce (2 %) (Fig. 7).

More precisely, in the fauna within colonies the dominant endolithic species were *H. artica* (27 % of dominance) and *R. dubia* (19 %), accompanied by endolithic sipunculids (*Phascolosoma* sp.) and polychaetes (*Eunice siciliensis*, *Lysidice ninetta* and *Dodecaceria conchar-*

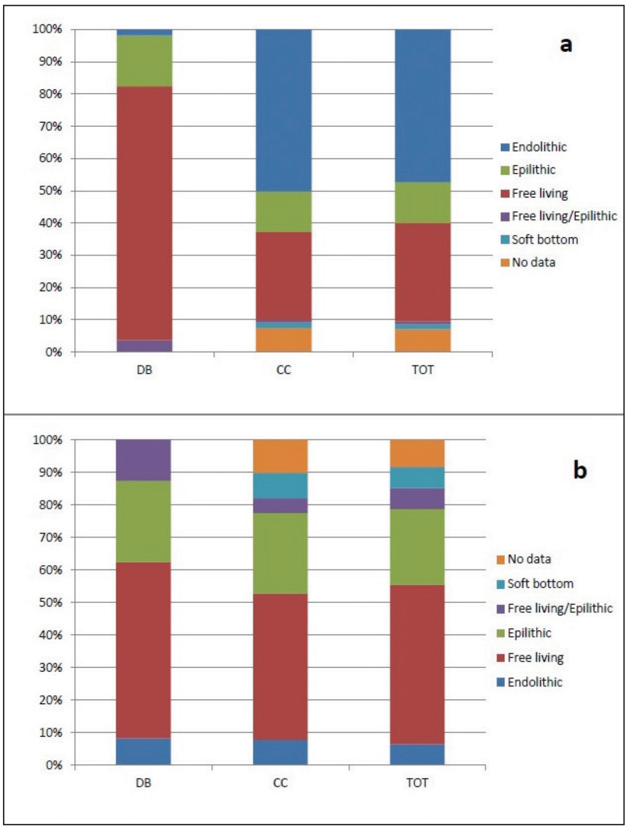

***Fig. 7: Abundance (a) and taxa richness (b) of functional groups in the total sampled area (TOT), inside* C. caespitosa *colonies (CC), and on the surrounding detritic bottom within the bank (DB). EN = endolithic, EP = ephilithic, FL = free living, Fl/EP = changing mode with growth, SB = soft bottom, ND = no data available.***

***Sl. 7: Abundanca (a) in pestrost taksonov (b) funkcionalnih skupin na celotnem vzorčnem območju (TOT), znotraj kolonij kamene korale (CC) in na okoliškem dnu znotraj bioformacije (DB). EN = endolitski, EP = epilitski, FL = prostoživeč, Fl/EP = spremeni način z rastjo, SB = mehko dno, ND = ni razpoložljivih podatkov.***

*um*). The bivalves *H. artica* and *R. dubia* were present also on the surrounded area, but with a low number of individuals (< 2 % of dominance).

The sea urchin *P. microtuberculatus* (41 % of dominance) was the dominant free-living species on the bank around colonies, while among infauna the dominant free-living species was the polychaete *Ceratonereis costae* with only 9 % of dominance.

## DISCUSSION

The biogenic bank at Cape Ronek is made of a detritic layer of dead corallites and, to a lesser extent, of coralline algae, on the top of which living colonies of *C. caespitosa* grow. Only four comparable formations (in Sicily, Sardinia, Corsica and the Aegean Sea) have been reported in the Mediterranean Sea (Peirano *et al.*, 1994; Koukouras *et al.*, 1998). Such formations offer a diversified habitat for benthic fauna, which is still mostly unknown.

### *Cladocora caespitosa*'s role as a bioconstructor

In optimal ecological conditions the colonial coral *C. caespitosa* forms large connected formations called coral bioherms or banks (Kružić & Benković, 2008). To our knowledge, up to now only one paper (Koukouras *et al.*, 1998) reported data on macrofauna living on such biogenic formations. Those banks were located close to Diaporos Island (Aegean Sea) and presented a similar structure made of dead corallites on the top of which living colonies of *C. caespitosa* grow, comparable to that which we found in the Slovenian sea. Compared with the bank at Cape Ronek, the Aegean formations were smaller (max 4 × 5.5 m *vs.* 200 × 100 m at Cape Ronek). Colonies on the bank at Cape Ronek were of medium-small size, with a maximum axis smaller than 20 cm.

At Cape Ronek, dead corallites and coralline algae created a secondary hard bottom where living colonies of *C. caespitosa* and other typically hard bottom species were able to settle. Consequently, the studied bank hosts a unique faunistic community which, even without taking into consideration *C. caespitosa* infauna, differed greatly from communities in other sites at a comparable depth (Fig. 5, ACL8). The massive presence of species with a wide ecological distribution and the almost complete absence of species described as characteristic of any biocoenosis make the exact nature of this community difficult to assess.

The consistent contribution of infaunal organisms to the total richness and abundance of the studied area confirms the importance of living colonies of *C. caespitosa* for local biodiversity. Moreover, only a few species were found to inhabit both examined microhabitats (the colonies of *C. caespitosa* and the area around the colonies). The general structure of these communities was very different, since the assemblage of the bank around colonies was dominated by echinoderms and big molluscs, while the community within the colonies was dominated by small animals like polychaetes, molluscs and crustaceans. The relatively low number of co-occurring species suggests that this coral, acting as a refugee for animals originating from different habitats, is able to create an 'enclave' supporting different species and is not simply changing species abundance. These results suggest that *C. caespitosa* plays an important role as a habitat builder both through living colonies and with the accumulation of dead and subfossil corallites.

### Infaunal community associated with *C. caespitosa*

Of the 89 taxa found within colonies 57 were determined to the species level and 21 species are here

***Tab. 3: List of invertebrate taxa found in the bank of* C. caespitosa*: inside (infauna, CC) and/or outside (DB) colonies. Feeding guilds: P = predator, EC = ectoparasite and specialized carnivore, G = grazer, O = omnivore, SF = suspension feeder, DF = deposit feeder, ND = no data available. Functional groups: FL = free living, motile, EP = epilithic (fouling), EN = endolithic (boring), ND = no data available.***

***Tab. 3: Seznam taksonov nevretenčarjev, najdenih na formaciji sredozemske kamene korale: znotraj (infavna, CC) in/ali v okolici (DB) kolonij. Prehranjevalni cehi: P = predator, EC = ektoparazit in specializiran karnivor, G = strgalec, O = vsejed, SF = suspenzijofag, DF = detritivor, ND = ni razpoložljivih podatkov. Funkcionalne skupine: FL = prostoživeč, gibljiv, EP = epilitski (pritrjen), EN = endolitski (vrtalec), ND = ni razpoložljivih podatkov.***

| **Taxa** | **Location** | **Feeding guilds** | **Functional groups** |
|---|---|---|---|
| **Mollusca** | | | |
| *Acantochitona fascicularis* | CC | G | FL |
| *Anomia ephippum* | CC | SF | EP |
| *Arca noe* | CC and DB | SF | EP |
| *Bittium reticulatum* | CC | G | FL |
| Bivalvia indet | CC | SF | ND |
| *Calliostoma zizyphinum* | DB | EC | FL |
| Cardidae juv | CC | SF | ND |
| *Cerithiopsis tubercularis* | CC | EC | FL |
| *Chama gryphoides* | CC | SF | EP |
| *Chiton sp.* | DB | G | FL |
| *Chlamys sp.* | DB | SF | FL/EP |
| *Mimachlamys varia* | CC | SF | FL/EP |
| Dendrodoridae indet. | DB | ND | FL |
| *Diodora graeca* | CC | G | FL |
| *Diodora cf. italica* | DB | G | FL |
| *Diplodonta rotundata* | CC | SF | ND |
| *Fissurella nabecula* | CC | G | FL |
| *Galeomma turtoni* | CC | ND | FL |
| *Gibbula magus* | DB | G | FL |
| *Hexaplex trunculus* | DB | P | FL |
| *Hiatella artica* | CC and DB | SF | EN |
| *Telochlamys multistriata* | DB | SF | FL/EP |
| *Limaria hians* | CC | SF | FL/EP |
| *Limaria tuberculata* | DB | SF | FL/EP |
| *Marshallora adversa* | CC | EC | FL |
| *Modiolarca subpicta* | CC | SF | EP |
| *Modiolus barbatus* | CC | SF | EP |
| *Mytilus sp.* | DB | SF | EP |
| *Nucula nucleus* | CC | DF | ND |
| *Ostrea edulis* | CC | SF | EP |
| *Pseudochama gryphina* | CC | SF | EP |
| *Rocellaria dubia* | CC and DB | SF | EN |
| *Striarca lactea* | CC | SF | EP |
| *Vermetus triquetrus* | DB | SF | EP |
| **Echinodermata** | | | |
| *Amphipholis squamata* | CC | SF/DF | FL |
| *Astropecten irregularis* | DB | P | FL |
| *Cucumaria planci* | DB | DF/SF | FL |
| *Holothuria tubulosa* | DB | DF/SF | FL |
| *Ophioderma longicauda* | DB | SF/DF | FL |
| *Paracentrotus lividus* | DB | G | FL |
| *Psammechinus microtuberculatus* | DB | G | FL |
| *Sphaerechinus granularis* | DB | G | FL |
| Echinoidea juv | CC | G | FL |
| *Ophiotrix* cf. *fragilis* | CC | SF/DF | FL |
| **Tunicata** | | | |
| *Microcosmus* sp. | CC and DB | SF | EP |
| Tunicata indet. | CC | SF | EP |
| **Cnidaria** | | | |
| *Adamsia palliata* | DB | P | EP |
| Cnidaria indet. | CC and DB | P | EP |
| **Sipunculida** | | | |
| *Phascolosoma* sp. | CC | DF | EN |
| *Aspidosiphon* sp. | CC | DF | EN |
| **Polychaeta** | | | |
| *Eunice torquata* | CC | P | FL |
| *Eunice schizobranchia* | CC | P | FL |

| | | | |
|---|---|---|---|
| *Eunice siciliensis* | CC | P | EN |
| *Eunice vittata* | CC | P | FL |
| *Eunice harassi* | CC | P | FL |
| Eunicidae 1 | CC | P | ND |
| Eunicidae 2 | CC | P | ND |
| *Lysidice ninetta* | CC | P | EN |
| *Marphysa sanguinea* | CC | P | SB |
| *Nematonereis unicornis* | CC | P | FL |
| *Lumbrineris impatiens* | CC | P | SB |
| *Lumbrineris coccinea* | CC | P | FL |
| *Lumbrineris latreilli* | CC | P | SB |
| *Lumbrineris gracilis* | CC | P | FL |
| Syllinae indet. | CC | P | ND |
| *Haplosyllis spongicola* | CC | P | FL |
| *Ceratonereis costae* | CC | P | FL |
| *Nereis rava* | CC | P | FL |
| *Serpula concharum* | CC | SF | EP |
| *Vermiliopsis striaticeps* | CC | SF | EP |
| *Hydroides pseudouncinatus* | CC | SF | EP |
| *Serpula vermicularis* | CC | SF | EP |
| *Spirobranchus triqueter* | CC | SF | EP |
| *Spirobranchus lamarcki* | CC | SF | EP |
| *Ditrupa arietina* | CC | SF | DB |
| Spirorbidae indet. | CC | SF | EP |
| Serpulidae indet. | CC | SF | EP |
| Sabellidae indet. | CC | SF | EP |
| *Harmothoe areolata* | CC | P | FL |
| *Harmothoe spinifera* | CC | P | FL |
| *Polynoe sp.* | CC | P | FL |
| Polynoidae indet. | CC | P | FL |
| *Notomastus cfr. latericeus* | CC | DF/SF | FL/EP |
| *Dodecaceria concharum* | CC | DF/SF | EN |
| *Cirriformia tentaculata* | CC | DF/SF | SB |
| *Aphelochaeta sp.* | CC | DF/SF | SB |
| Polychaetae indet. | CC | ND | ND |
| Cirratulidae indet. | CC | DF/SF | ND |
| Phyllodocidae indet. | CC | ND | FL |
| *Phyllodoce* cf. *mucosa* | CC | P | FL |
| Maldanidae indet | CC | DF | SB |
| Terebellidae indet | CC | DF | FL/EP |
| *Amphitrite variabilis* | CC | DF | EP |
| **Crustacea** | | | |
| *Alpheus dentipes* | CC | O/P | FL |
| Amphipoda indet. | CC | ND | FL |
| Anisopoda indet. | CC | SF | FL |
| *Athanas nitescens* | CC | O/P | FL |
| *Balanus sp.* | CC | SF | EP |
| *Galatea sp.* | CC | DF | FL |
| *Gnathia sp.* | CC | P | FL |
| *Janira maculosa* | CC | ND | FLi |
| *Leucothoe sp.* | CC | ND | Fli |
| *Liljeborgia dellavallei* | CC | ND | FLI |
| *Maera grossimana* | CC | ND | FL |
| *Pilumnus cf. hirtellus* | CC | G/P/DF | FL |
| *Pisidia longimana* | CC | SF | FL |
| *Synalpheus gambarelloides* | CC | P/EC | FL |
| *Thoralus chranchii* | CC | O/P | FL |
| **Porifera** | | | |
| *Aplysina aerophoba* | DB | SF | EP |
| *Haliclona mediterranea* | DB | SF | EP |
| *Hippospongia communis* | DB | SF | EP |
| *Geodia cydonium* | DB | SF | EP |
| *Ircinia variabilis* | DB | SF | EP |
| *Ircinia fasciculata* | DB | SF | EP |
| *Chondrosia reniformis* | DB | SF | EP |
| *Tethya aurantium* | DB | SF | EP |
| **Bryozoa** | | | |
| *Schizobrachiella sanguinea* | DB | SF | EP |
| *Schizoporella errata* | DB | SF | EP |
| *Schizoporella cf. unicornis* | CC | SF | EP |
| Diastoporidae indet. | CC | SF | EP |
| Celleporidae indet. | CC | SF | EP |

reported for the first time as inhabitants of the Mediterranean stony coral *C. caespitosa*. The present results are not directly comparable with data reported by other researchers (Lumare, 1965; Sciscioli & Nuzzaci, 1970; Zavodnik, 1976; Schiller, 1993; Arvanitidis & Koukouras, 1994; Antoniadou & Chintiroglou, 2010) since the field sampling and the statistical analysis were different. The overall diversity (Shannon diversity) of the infauna of the bank at Cape Ronek was quite high. However, even higher values were reported for the bank in the Aegean Sea (Koukouras *et al.*, 1998), but such results could be distorted by the smaller colonies' size in the Slovenian bank and consequently the lower sampled volume. Considering colonial organisms as well, in particular sponges, the diversity would be higher. Those organisms were excluded from indices calculation due to the difficulties in the proper quantification of endolithic colonial organisms.

Scleractinian corals are known to influence the invertebrate community in two ways (Reed & Mikkelsen, 1987). Firstly, increasing the three dimensional structures of the seafloor and locally modifying water movement, they create a physical space for facultative associated invertebrates, which can be endolithic, epilithic or free living species. Secondly, they may host obligate symbionts, which can be ectoparasites or predators feeding on coral tissue (*e.g.* some molluscs, as reported by Robertson (1970) and Reed & Mikkelsen (1987)), or commensals eating coral mucus and entrapped detritus (*e.g.* some decapods, as reported by Castro (1978) and Carricart-Ganivet *et al.* (2004)). The consistent abundance and richness of endolithic, epilithic and free living invertebrates found in the present work is related to *C. caespitosa* morphology, which is similar to the typical tropical reef-building scleractinian corals. Its long and packed corallites provide a cryptic habitat for many small invertebrate species (Zibrowius, 1982; Schuhmacher & Zibrowius, 1985). The presence of species typical of sandy and muddy bottoms among the infauna is probably related to the role of trapping sediment played by *Cladocora* colonies. The sediment trapped among corallites consolidates coral structure and offers a suitable habitat for small soft bottom species like the polychaetes *Lumbrineris impatiens* and *Cirriformia tentaculata*.

We were unable to find any evidence of obligatory species-specific relationships between the Mediterranean stony coral and the associated infauna since, to our knowledge, all invertebrates found within *C. caespitosa* colonies so far (Koukouras *et al.*, 1998; present work) were also present in other communities in the Mediterranean Sea, mainly on hard substrate. Nevertheless, in the present work the presence of deposit feeders such as ophiurids and sipunculids suggests that a facultative commensalism exists with associated taxa feeding on mucus produced by coral and entrapped within sediments.

## Threats and conservation

*C. caespitosa* is a species subject to mass-mortality events, such as those recently recorded in the NW Mediterranean Sea (Rodolfo-Metalpa *et al.*, 2005). Global warming and the related acidification of the ocean pose a serious threat for this species and the associated macrofauna (Rodolfo-Metalpa *et al.*, 2005, 2006, 2011). In the Adriatic Sea additional pressures are present, such as coastal modifications and the spread of the non-native invasive green algae *Caulerpa racemosa* (Kružić & Benković, 2008), which has not yet been recorded in the Gulf of Trieste. Moreover, evidence of *C. caespitosa* bleaching in the Gulf of Trieste indicates that this species is subjected to some stress, probably related to increasing seawater temperatures (Lipej *et al.,* 2013).

Since large biogenic formations of *C. caespitosa* are extremely rare in the Mediterranean Sea (Cape Ronek, Sicily, Sardinia, Corsica and Diaporos Island), the peculiarity and high diversity of the associated community and the threat posed by habitat loss and climate change indicate the immediate need for more conservation action. Increasing our knowledge of the role played by *C. caespitosa* in maintaining marine biodiversity at different levels is of crucial importance for conservation efforts. Studies of tropical corals affected by bleaching events have shown that interactions with other associated taxonomic groups emerged as very important for coral resilience and recovery (McCook *et al.*, 2001; Baker *et al.*, 2008). Therefore, further intensive investigation is required to elucidate the complex interactions between *C. caespitosa* and the community of invertebrates living inside and near its corallites. A better understanding of these relationships is basic not only to quantify the importance of *C. caespitosa* as habitat builder, but also to elucidate the potential role of associated organisms in the maintenance of coral health and recovery after stressful events.

## ACKNOWLEDGEMENTS

This study was financially supported in part by the Ministry of Agriculture and Environment of Slovenia. A special thanks to Marko Tadejević and Nicola Bettoso for their immeasurable help and those joyful moments during the fieldwork. We are grateful also to Dr. Katja Stopar for her help during laboratory work and to Dr. Nicola Bettoso, Dr. Floriana Aleffi and Dr. Lisa Faresi (ARPA FVG, Italy) for their help in taxa determination.

# MAKROFAVNA, POVEZANA Z BIOFORMACIJO SREDOZEMSKE KAMENE KORALE, *CLADOCORA CAESPITOSA* (ANTHOZOA, SCLERACTINIA), V TRŽAŠKEM ZALIVU (SEVERNI JADRAN)

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## *POVZETEK*

*Sredozemska kamena korala (*Cladocora caespitosa*, Linneus, 1767) je predstavnik kolonijskih koralnjakov zmernega pasu. Občutljiva je na podnebne spremembe in na antropogene dejavnosti. Zaradi svoje oblike in velikosti lahko kamena korala gosti zelo raznoliko živalsko skupnost. Novembra 2010 so avtorji raziskovali bioformacijo sredozemske kamene korale, ki je bila pred kratkim odkrita pred rtom Ronek (Tržaški zaliv, Slovenija). Potrdili so prisotnost 121 taksonov nevretenčarjev, ki spadajo v 9 različnih debel. Sestava favne znotraj kolonij je bila precej različna od tiste v njihovi okolici znotraj bioformacije. Le 5 taksonov (4 % vseh) je bilo najdenih tako znotraj kolonij kot v njihovi okolici. Rezultati potrjujejo vlogo sredozemske kamene korale kot biogradnika in poudarjajo pomen te izjemne bioformacije za biotsko raznovrstnost.*

**Ključne besede:** *Cladocora caespitosa*, biogradniki, makro-nevretenčarji, cirkalitoral, severni Jadran

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# RECENTNE SPREMEMBE V SREDOZEMSKI IHTIOFAVNI

# CAMBIAMENTI RECENTI NELLA ITTIOFAUNA MEDITERRANEA

# RECENT CHANGES IN THE MEDITERRANEAN ICHTHYOFAUNA

Original scientific article
Received: 2014-03-28

UDK 597.5:591.52(262.3)

# ADDITIONAL RECORDS OF NON-INDIGENOUS, RARE AND LESS KNOWN FISHES IN THE EASTERN ADRIATIC

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## *ABSTRACT*

*Authors report additional records of five fish species (*Caranx crysos, Fistularia commersonii, Ruvettus pretiosus, Tylosurus acus imperialis, Zu cristatus*) that are considered non-indigenous, rare and less known species in the Adriatic Sea.* C. crysos *and* F. commersonii *can be considered as established species in the Adriatic Sea.*

**Key words:** *Caranx crysos, Fistularia commersonii, Ruvettus pretiosus, Tylosurus acus imperialis, Zu cristatus,* Adriatic Sea

# NUOVE SEGNALAZIONI DI PESCI NON INDIGENI, RARI E MENO CONOSCIUTI NELL'ADRIATICO ORIENTALE

## *SINTESI*

*Gli autori riportano nuove segnalazioni di cinque specie ittiche (*Caranx crysos, Fistularia commersonii, Ruvettus pretiosus, Tylosurus acus imperialis *e* Zu cristatus*) che vengono considerate specie non indigene, rare e meno conosciute nel mare Adriatico.* C. crysos *e* F. commersonii *possono essere considerate come specie stabilizzate nel mare Adriatico.*

**Parole chiave:** *Caranx crysos, Fistularia commersonii, Ruvettus pretiosus, Tylosurus acus imperialis, Zu cristatus,* mare Adriatico

## INTRODUCTION

In the Adriatic Sea, at least 24 non-indigenous fish species have been reported in the last two decades of which 13 are Lessepsian migrants (Dulčić & Dragičević, 2011). Pečarević *et al*. (2013) reported on 22 fish non-indigenous fish species that have been recorded in the Eastern Adriatic.

Many of fish species are by no means “rare” in the general sense of the term but are little-known, often because they are small, secretive, and have neither commercial nor sporting or any other value (Dulčić & Lipej, 2002).

Numerous species, previously either rare or completely absent, have recently became more common in the Adriatic Sea. However, although first records of the species are usually documented, tracing of species establishment or subsequent expansion is rarely reported. As a consequence, status of species which are considered rare or very rare is usually left unchanged in spite of species establishment or further expansion. Additionally, subsequent records may indicate that previous occurrences were not just accidental, but may suggest that new region is included in the zoographic range of the species (Golani & Levy, 2005).

The aim of the present work is to report additional records of fishes which have hitherto been regarded as rare or less known and those which have only recently been recorded in the Adriatic Sea for the first time.

***Fig. 1: Map indicating locations of records of*** *Caranx crysos* ***(square),*** *Zu cristatus* ***(dot),*** *Ruvettus pretiosus* ***(+),*** *Fistularia commersonii* ***(O),*** *Tylosurus acus imperialis* ***– 2 specimens (star).***

***Sl. 1: Zemljevid z označenimi lokalitetami, kjer so bili ujeti primerki vrst Caranx crysos (kvadrat),*** *Zu cristatus* ***(pika),*** *Ruvettus pretiosus* ***(+),*** *Fistularia commersonii* ***(O),*** *Tylosurus acus imperialis* ***– 2 primerka (zvezdica).***

## MATERIAL AND METHODS

The geographical area concerned in this study is eastern Adriatic (Croatian and Montenegrin waters). Information on the occurrence of studied species mostly originates from the citizens (mostly professional and sport fishermen) which provided either photographs upon which the determination of the species was based or the entire specimen. When possible, basic measurements were taken such as TL (total length) and W (weight). Some of the collected specimens (*Caranx crysos*, *Fistularia commersonii*, *Tylosurus acus imperialis*) were deposited in the Ichthyological collection of the Institute for Marine Biology in Kotor, Montenegro.

Morović (1973) proposed classification of fishes regarding their rarity: a) if the species is recorded fewer than five times, it should be treated as a very rare species, b) if there are up to ten records, then the species is considered to be rare, c) fish species caught in certain areas and only in a specific season should be treated as fairly rare. He also suggested that the number of occurrences should be evaluated based on scientifically documented reports.

## RESULTS AND DISCUSSION

In this paper we report records of non-indigenous, rare and less known fishes from the eastern Adriatic (Croatian and Montenegrin waters) (Fig. 1).

### Non-indigenous species

CARANGIDAE

*Caranx crysos* (Mitchill, 1815)

**Material examined.** Three specimens of blue runner were caught in the eastern Adriatic: first specimen (TL =

***Fig. 2: A specimen of*** *C. crysos* ***caught on 9 December, 2103 near settlement Orahovac near Kotor (Boka Kotorska Bay, Montenegrin waters). (Photo: Z. Ikica)***

***Sl. 2: Primerek vrste*** *C. crysos****, ujet 9. decembra 2013 pri naselju Orahovac blizu Kotorja (Boka Kotorska, črnogorske vode). (Foto: Z. Ikica)***

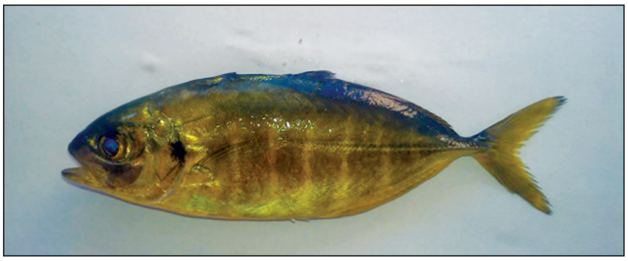

***Fig. 3: A specimen of* C. crysos *caught in Pelješac channel in October 2013 (southern Adriatic, Croatian waters) 2013. (Photo: N. Alač)***

***Sl. 3: Primerek vrste* C. crysos*, ujet v pelješkem kanalu v oktobru 2013 (južni Jadran, hrvaške vode). (Foto: N. Alač)***

15.6 cm, W = 38.1 g, CC1) (Fig. 2) was caught by beach seine "*srdelara*" on 9 December, 2103 near settlement Orahovac near Kotor (Boka Kotorska Bay, Montenegrin waters); second specimen was caught near Rogoznica (near Šibenik, Croatian waters) by spear-gun on 14 August, 2013 (unfortunately without any other data on specimen, except photograph; third specimen (Fig. 3) was caught in Pelješac channel, Southern Adriatic in October 2013 (approx. 12 cm TL).

**Remarks.** Blue runner, *Caranx crysos*, is distributed in the eastern Atlantic from Senegal to Angola, including the western Mediterranean, St. Paul's Rock, and Ascension Island. It has also been reported from Mauritania and the western Atlantic from Nova Scotia in Canada to Brazil, including the Gulf of Mexico and the Caribbean (Froese & Pauly, 2014). First record of this species, for the Adriatic, was in the Northern Adriatic (western coast of Istria peninsula, Croatia) (TL = 368 mm, W = 634 g) on 27 August, 2008 (Dulčić *et al.,* 2009), while second record was in the south-eastern Adriatic on 1 March, 2013 near Ulcinj (Montenegrin waters) (Dulčić *et al.*, 2014). Considering available information, it seems that *C. crysos* established its population in the Adriatic. This statement is supported by the fact that juveniles and adults of the species have been recorded in the area of the whole eastern Adriatic, and the frequency of the records is increasing. Furthermore, due to certain similarity between this species and some autochthonous congeneric species, especially in juvenile phase, it is possible that its abundance is underestimated.

FISTULARIDAE

*Fistularia commersonii* Rüppell, 1838

**Material examined.** Two specimens of Lessepsian migrant *Fistularia commersonii* were caught in Montenegrin waters: first specimen (TL = 119.1 cm, W = 558.4 g, FC3) (Fig. 4) was caught by gill-net called "*polandara*" on 1 December, 2013 near Tivat (Blue horizons, 42° 23´ N, 18° 40´ E), second specimen (Fig. 5) was caught near Budva on 16 November, 2013 with a spear gun (unfortunately we did not get any other data on specimen).

***Fig. 4: A specimen of* F. commersonii *caught by gill-net called "polandara" on 1 December 2013, near Tivat (Montenegro). (Photo: Z. Ikica)***

***Sl. 4: Primerek vrste* F. commersonii*, ujet v mrežo polandaro 1. decembra 2013 blizu Tivata. (Foto: Z. Ikica)***

***Fig. 5: A specimen of* F. commersonii *caught near Budva on 16 November, 2013. (Photo: Z. Ikica)***

***Sl. 5: Primerek vrste* F. commersonii*, ujet 16. novembra 2013 blizu Budve. (Foto: Z. Ikica)***

**Remarks.** The bluespotted cornetfish, *F. commersonii*, originally distributed in the Indian and Pacific Oceans (Froese & Pauly, 2014), is today one of the most successful invaders of the Mediterranean Sea and European waters (Azzurro *et al.*, 2012). First Adriatic records of this species consider two specimens caught on 7 November, and 15 December, 2006 in trammel nets off the coastal waters of Tricase Porto (southwestern Adriatic, Italy) and Sveti Andrija (southeastern Adriatic, Croatia), respectively (Dulčić *et al.,* 2008). Juveniles of this species were caught in Molunat Bay (Croatian waters) (Dulčić *et al.*, 2013). Additional records of *F. commersonii* could support previously proposed hypothesis about self-sustaining population in the southern Adriatic (Croatian and Montenegrin waters).

## Rare and less known species

GEMPYLIDAE

*Ruvettus pretiosus* Cocco, 1829

**Material examined.** Two specimens of oilfish (Fig. 6) were caught near peninsula Prevlaka (southern Adriatic) in summer 2012. Only approximate weight of the fishes were provided by the fishermen (W1 = approx. 15 kg, W2 = approx. 10 kg).

**Remarks.** Oilfish is an oceanic, benthopelagic species found on the continental slope and underwater at about 100-700 m (Jardas, 1996). It is rare in the Adriatic, occurring mostly in the southern part. One speci-

***Fig. 6: Two specimens of oilfish** R. pretiosus **were caught near peninsula Prevlaka (southern Adriatic, Croatian coast) in summer 2012. (Photo: N. Cvitković)***

***Sl. 6: Primerka vrste** R. pretiosus**, ujeta blizu polotoka Prevlaka (južni Jadran, hrvaške vode) poleti 2012. (Foto: N. Cvitković)***

men recorded in the northern Adriatic represents the northernmost extension in the range of this species in the Adriatic (Bettoso & Dulčić, 1999). It was reported for the first time in the Adriatic by Kolombatović (1882) near the island Šolta (eastern Adriatic, Croatian waters) in 1875. After that in 1960 one specimen (TL = 175 cm, W = 22.5 kg) was caught near settlement Igrane near Makarska. Overall, only 5 documented records, including two from this study, are reported from the Adriatic. It seems that *R. pretiosus* is a very rare species occurring only sporadically in the Adriatic waters.

BELONIDAE

*Tylosurus acus imperialis* (Rafinesque, 1810)

**Material examined.** Two specimens of the agujon needlefish *Tylosurus acus imperialis* (Rafinesque, 1810) were caught in Montenegrin waters: on 17 June, 2007 a 1070 mm (TL) specimen was caught by gillnet at 5–7 m depth near Budva (W = 1820 g, fully mature female with visible large, whitish eggs; TAI1); on 9 June, 2011 in early morning a specimen (Fig. 7) was caught in front of St. Nikola Island, Budva (Montenegro) (42° 16´ N, 18° 50´ E), in shallow waters (6.5 m depth) (specimen was found still alive, entangled in a gillnet "*polandara*").

***Fig. 7: A specimen of** T. acus imperialis **was caught in front of St. Nikola Island, Budva (Montenegro). (Photo: Z. Ikica)***

***Sl. 7: Primerek vrste** T. acus imperialis **je bil ujet pred otokom Sv. Nikole blizu Budve (Črna gora). (Foto: Z. Ikica)***

**Remarks.** *Tylosurus acus imperialis* is distributed in the Eastern Atlantic (Cape Verde and Morocco) and the Mediterranean Sea (Froese & Pauly, 2014). Two records from this study were the first records of this species for the eastern Adriatic (Montenegrin waters). Prior to these records, two male and one female specimens of the agujon needlefish were collected off the southwestern Adriatic coast representing the first record for the Adriatic Sea (Bello, 1995). This species could still be considered very rare in the eastern Adriatic although there are some indications that its abundance in Montenegrin waters is underestimated (Đurović, pers. comm.).

TRACHIPTERIDAE

*Zu cristatus* (Bonelli, 1819)

**Material examined.** Two specimens of scalloped ribbonfish were recently recorded in the eastern Adriatic. First specimen (TL = approx. 20 cm) (Fig.8) was found stranded ashore near Zadar in December 2009. Second specimen (TL= approximately 50 cm) (Fig.9) was caught in summer of 2013, near cape Pelegrin (northern coast of Island Hvar) with a beach seine *"girarica"*. Additionally, in November 2004 a juvenile specimen of *Zu cristatus* was caught in the harbour of Vis on Vis Island (identification based on photograph, but with no additional data).

**Remarks.** The scalloped ribbon fish (Pisces: Trachipteridae) is a cosmopolitan meso-bathypelagic species of circumglobal distribution occurring in the tropical through temperate Mediterranean Sea, Atlantic, Indian and

***Fig. 9: A specimen of** Z. cristatus **caught by gill-net in July 2013 near Cape Pelegrin, Hvar channel (northern coast of Island Hvar, Croatian waters). (Photo: V. Žuanić)***

***Sl. 9: Primerek vrste** Z. cristatus**, ujet v ribiško mrežo v juliju 2013 blizu rta Pelegrin (severna obala otoka Hvara, hrvaške vode). (Foto: Vinko Žuanić)***

***Fig. 8: A specimen of*** *Z. cristatus* ***was found thrown ashore near Zadar (Croatian waters) on 3 December, 2009. (Photo: P. Bavdek)***
***Sl. 8: Primerek vrste*** *Z. cristatus****, naplavljen na obalo blizu Zadra (hrvaške vode) 3. decembra 2009. (Foto: P. Bavdek)***

Pacific oceans (Froese & Pauly, 2014). It is rare in the Adriatic Sea, occurring only sporadically (Jardas, 1996). It was reported that 16 individuals (mostly juveniles) were recorded in the northern and central Adriatic between 1846 and 1973 (Jardas, 1980). The last documented record of adult specimen was on 31 December, 1973 in Hvar channel (eastern central Adriatic) near the town of Bol (southern coast of Island Brač). There were no documented records of adults and juveniles in the eastern Adriatic in the period from 1973 until 1987. Pallaoro & Jardas (1996) reported a finding of scalloped ribbon fish (TL = 59.5 cm) caught in 1987 in the middle eastern Adriatic. Meanwhile, early stages (eggs) of scalloped ribbon fish were reported for the first time in the Adriatic waters in 1998 (Dulčić, 2002). Scalloped ribbonfish is considered as less known species for the Adriatic and reasons for its occasional presence are unknown.

## ACKNOWLEDGMENTS

We are thankful to Mr. Pero Ugarković and Mr. Miko Boljević for providing us some specimens of *Caranx crysos*, *Tylosurus acus imperialis* and *Fistularia commersonii* and photo of *Ruvettus pretiosus*. We are also thankful to Mr. Vinko Žuanić, Mr. Neven Alač and Mrs. Petra Bavdek for photos of *Zu cristatus* and *Caranx crysos*.

# NOVI ZAPISI O TUJERODNIH, REDKIH IN MANJ ZNANIH VRSTAH RIB V VZHODNEM JADRANU

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## *POVZETEK*

*Avtorji poročajo o novih zapisih petih vrst rib (*Caranx crysos, Fistularia commersonii, Ruvettus pretiosus, Tylosurus acus imperialis, Zu cristatus*), ki so tujerodne, redke ali manj znane vrste v Jadranskem morju. Za vrsti* C. crysos *in* F. commersonii *menijo, da jih lahko uvrstimo med ustaljene vrste v Jadranskiem morju.*

**Ključne besede:** *Caranx crysos, Fistularia commersonii, Ruvettus pretiosus, Tylosurus acus imperialis, Zu cristatus,* Jadransko morje

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Short scientific article
Received: 2014-03-22

UDK 597.556.331.52:574.91(262.2)

# FIRST RECORDS OF SIDEBURN WRASSE *PTERAGOGUS PELYCUS* (OSTEICHTHYES: LABRIDAE) OFF THE SYRIAN COAST (EASTERN MEDITERRANEAN)

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## *ABSTRACT*

*This paper reports the first records of two specimens of sideburn wrasse* Pteragogus pelycus *Randall, 1981 from the Syrian coast. These records confirm the occurrence of* P. pelycus *Randall, 1981 in the eastern Mediterranean and suggest that a sustainable population is progressively established since two decades in this sea.*

**Key words:** Lessepsian migrants, description, morphometric measurements, meristic counts, distribution

# PRIME SEGNALAZIONI DI *PTERAGOGUS PELYCUS* (OSTEICHTHYES: LABRIDAE) AL LARGO DELLA COSTA SIRIANA (MEDITERRANEO ORIENTALE)

## *SINTESI*

*L'articolo riporta le prime segnalazioni di due individui del labride* Pteragogus pelycus *Randall, 1981 al largo della costa della Siria. A seguito di tali segnalazioni, gli autori confermano la presenza di* P. pelycus *Randall, 1981 nel Mediterraneo orientale e ipotizzano che una popolazione sostenibile si sia progressivamente stabilita nell'area negli ultimi due decenni.*

**Parole chiave:** migranti lessepsiani, descrizione, misurazioni morfometriche, conteggi meristici, distribuzione

## INTRODUCTION

Sideburn wrasse *Pteragogus pelycus* Randall, 1981 is widely distributed in the western Indian Ocean, from South Africa coast (Randall, 1986), Mozambique (Smith, 1969), Seychelles, Mauritius and Madagascar Islands (Randall, 2013) to Red Sea (Golani *et al.*, 2002). *P. pelycus* migrated toward northern areas and penetrated through Suez Canal into the Mediterranean Sea, where it was recorded for the first time in Haifa Bay by Golani & Sonin (1992).

*P. pelycus* extended its distribution range in the eastern Mediterranean and was recorded off Rhodes Island (Corsini & Economidis, 1999), northern Cyprus (Kaya *et al.*, 2000), eastern Aegean Sea, where the species is one of the most abundant wrasses in *Posidonia* beds (Kalogirou *et al.,* 2010), the coast of Turkey (Taskavak *et al.*, 2000; Oz *et al.,* 2007) and Lebanon (Harmelin-Vivien *et al.*, 2005). Additionally, *P. pelycus* was recorded off the Mediterranean coast of Egypt which is considered to date as the southwesternmost extension range of the species in the Mediterranean Sea (Halim & Rizkalla, 2011; Azzurro *et al.*, 2012).

Surveys conducted in the Syrian waters since 2000 allowed to collect some Lessepsian migrants (Ali *et al.*, 2010, 2012, 2013a, 2013b), and, in the present paper, we report the capture of two specimens of *P. pelycus* that allow us to comment and discuss the spread of the species in the broader eastern Mediterranean, to assess its actual status in the same region.

## MATERIAL AND METHODS

Two specimens of *P. pelycus* were caught on 15 February, 2014, using a bottom cage net made of metal wire, at a depth of approximately 38 m, on rocky bottom. The capture site was located 1.5 km off Tartous Harbour (34° 51′ N and 35° 48′ E; Fig. 1). Both specimens were measured to the nearest millimetre and weighed to the nearest gram. Morphometric measurements with percents of standard length (SL) and counts followed Randall (1981, 1986) and Golani *et al.* (2002); they are included in Table 1. Samples were preserved in 10 % buffered formalin and deposited in the Ichthyological Collection of the Marine Sciences Laboratory, Agriculture Faculty at Tishreen University, Syria, under the catalogue numbers 260 M.S.L (Fig 2) and 261 M.S.L, respectively.

## RESULTS AND DISCUSSION

Both Syrian specimens of *P. pelycus* were identified referring to Randall (1981, 1986) and Golani *et al.* (2002) with main characteristic features as follows: moderately deep and compressed body, its depth 2.62.7 in SL, head profile straight to slightly concave, head length 3.43.6 in SL, interorbital convex, eye diameter 3.5 in head length (Tab. 1), no long filaments extending from tips of dorsal fins, caudal fin rounded, lateral line complete with dark brown-red spots, mouth terminal slightly

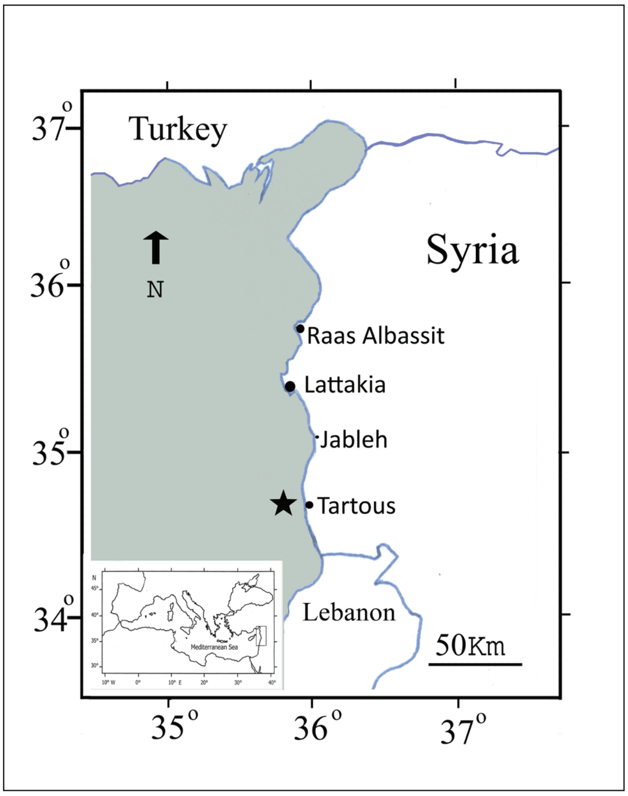

***Fig. 1: Map of the Mediterranean showing Syria and map of the coast of Syria pointing out the capture sites of sideburn wrasse* Pteragogus pelycus *(black star).***
***Sl. 1: Položaj raziskovanega območja na zemljevidu Sredozemskega morja z lokalitetami, kjer je bila v sirskih vodah ujeta ustnača vrste* Pteragogus pelycus *(črna zvezdica).***

***Fig. 2: Sideburn wrasse* P. pelycus *captured off the Syrian coast: (specimen referenced 260 M.S.L, in the Ichthyological Collection of Tishreen University, Syria); scale bar = 20 mm.***
***Sl. 2: Primerek ustnače vrste* P. pelycus*, ujet v sirskih vodah (primerek s kataloško številko 260 M.S.L. v ihtiološki zbirki Univerze v Tishreenu v Siriji); merilo = 20 mm.***

***Tab. 1: Morphometric measurements in mm and as a percentage of standard length (% SL), meristic counts and weight in gram recorded in the 2 specimens of sideburn wrasse* P. pelycus *caught off the Syrian coast.***
***Tab. 1: Morfometrične meritve v mm in izražene v deležu standardne dolžine (% SL), meristična štetja ter teža v gramih pri dveh primerkih ustnače* P. pelycus*, ujetih ob obali Sirije.***

| **Reference of specimens** | **260 M.S.L** | | **261 M.S.L** | |
|---|---|---|---|---|
| **Morphometric measurements** | **mm** | **% SL** | **mm** | **% SL** |
| Standard length | 75 | 100.0 | 74 | 100.0 |
| Total length | 93 | 124.0 | 92 | 124.3 |
| Head length | 21 | 28.0 | 21 | 28.4 |
| Interorbital space | 4 | 5.3 | 4 | 5.4 |
| Eye horizontal diameter | 6 | 8.0 | 6 | 8.1 |
| Eye vertical diameter | 6 | 8.0 | 6 | 8.1 |
| Iris horizontal diameter | 2 | 2.7 | 2 | 2.7 |
| Iris vertical diameter | 2 | 2.7 | 2 | 2.7 |
| Snout length | 7 | 9.3 | 8 | 10.8 |
| Upper jaw length | 9 | 12.0 | 8 | 10.8 |
| Lower jaw length | 8 | 10.7 | 8 | 10.8 |
| Pectoral fin length | 14 | 18.7 | 15 | 20.3 |
| Pectoral fin base | 4 | 5.3 | 5 | 6.8 |
| Dorsal fin length | 54 | 72.0 | 52 | 70.3 |
| Dorsal fin base | 44 | 58.7 | 43 | 58.1 |
| Dorsal fin height | 7 | 9.3 | 8 | 10.8 |
| Pelvic fin length | 37 | 49.3 | 32 | 43.2 |
| Pelvic fin base | 2 | 2.7 | 2 | 2.7 |
| Anal fin length | 28 | 37.3 | 29 | 39.2 |
| Anal fin base | 20 | 26.7 | 19 | 25.7 |
| Anal fin height | 4 | 5.3 | 4 | 5.4 |
| Body depth | 28 | 37.3 | 28 | 37.8 |
| Pre-pectoral length | 25 | 33.3 | 23 | 31.1 |
| Pre-dorsal length | 24 | 32.0 | 23 | 31.1 |
| Pre-anal length | 42 | 56.0 | 41 | 55.4 |
| Pre-pelvic length | 25 | 33.3 | 25 | 33.8 |
| Caudal peduncle length | 10 | 13.3 | 10 | 13.5 |
| Suborbital depth | 5 | 6.7 | 4 | 5.4 |
| First dorsal spine length | 5 | 6.7 | 5 | 6.8 |
| Longest spine length of dorsal fin | 10 | 13.3 | 8 | 10.8 |
| **Meristic counts** | | | | |
| Dorsal fin spinous rays | 11 | | 11 | |
| Dorsal fin soft rays | 9 | | 8 | |
| Pelvic fin spinous rays | 1 | | 1 | |
| Pelvic fin soft rays | 5 | | 5 | |
| Anal fine spinous rays | 3 | | 3 | |
| Anal fin soft rays | 8 | | 9 | |
| Pectoral fin spinous rays | - | | - | |
| Pectoral fin soft rays | 13 | | 13 | |
| Caudal fin soft rays | 13 | | 12 | |
| Lateral line scales | 23 | | 23 | |
| **Total weight (g)** | 11.61 | | 10.92 | |

oblique, with two pairs of large recurved canine teeth. Colour olivaceous, an oblique elliptical black spot present on operculum with yellow ring ner its edge, fins yellowish with black spots on the upper part of the first 2-4 interspinous dorsal membrane (Fig. 2).

Morphometric measurements (including percent of SL), meristic counts, morphology and colour are in total agreement with Randall (1981, 1986) and Golani *et al.* (2002). So, these findings of *P. pelycus* constitute the first records of the species reported from the Syrian coast. Consequently, the addition of *P. pelycus* in the local ichthyofauna brings the number of species to 270, including 43 chondrichthyan species and 227 teleost species (Saad *et al.*, 2004; Saad, 2005; Ali *et al.*, 2010, 2013a, 2013b).

These two new records suggest that a sustainable population of *P. pelycus* is at present established in the eastern Mediterranean. However, the western extension range of *P. pelycus* seems to be rather limited; since its first record which occurred twenty-two years ago (Golani & Sonin, 1992). *P. pelycus* reached only to date the Mediterranean coast of Egypt (Halim & Rizkalla, 2011; Azzurro *et al.*, 2012). Such pattern could be due to the fact *P. pelycus* lives in restricted habitats where it feeds on invertebrate species strictly related to endemic Mediterranean Sea grass niches (Kalogirou *et al.*, 2010). Additionally, lacks of information concerning new findings of *P. pelycus* from the western Mediterranean cannot be totally ruled out.

# PRVI ZAPIS O POJAVLJANJU USTNAČE VRSTE *PTERAGOGUS PELYCUS* (OSTEICHTHYES: LABRIDAE) OB SIRSKI OBALI (VZHODNO SREDOZEMSKO MORJE)

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## *POVZETEK*

*Prispevek obravnava prvi zapis o pojavljanju dveh primerkov ustnače* Pteragogus pelycus *(Randall, 1981) iz sirskih voda. Ti podatki vnovično potrjujejo pojavljanje vrste* P. pelycus *v vzhodnem Sredozemskem morju in kažejo, da se je ta vrsta v vzhodnem Sredozemlju po prvih zapisih izpred dvajsetih let danes že popolnoma ustalila.*

**Ključne besede:** Lessepske selivke, opis, morfometrične meritve, meristika, razširjenost

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# IHTIOLOGIJA

# ITTIOLOGIA

# ICHTHYOLOGY

Original scientific article
Received: 2014-02-18

UDK 597.556.33:591.16(262.26)

# REPRODUCTIVE CYCLE AND SIZE AT FIRST SEXUAL MATURITY OF COMMON PANDORA *PAGELLUS ERYTHRINUS* (SPARIDAE) FROM THE BAY OF MONASTIR (TUNISIA, CENTRAL MEDITERRANEAN)

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## *ABSTRACT*

*This study, dealing with the reproduction of the common pandora,* Pagellus erythrinus *(Sparidae) from the Bay of Monastir, focussed 640 specimens collected from September 2011 to August 2012. These specimens were sampled monthly during landings of coastal fisheries. Among the whole samples, 85 individuals were not sexually identified. The sexed specimens were composed of 260 males (46.84 %) and 295 (53.15 %). The monthly sex ratio showed significant differences between males and females. Females outnumbered males for sizes between 130 and 199 mm, while males outnumbered females from the 200 mm size up. Sexes combined, the length-weight relationship had a negative allometry. The reproduction period of the common pandora starts in April and ends in August. The gonado-somatic index (GSI) reaches the highest values in June for males and in July for females. Size at first maturity (TL) occurred at 167.5 and 153.2 mm for males and females respectively.*

**Keywords**: *Pagellus erythrinus*, sex ratio, reproduction period, length at first sexual maturity

# CICLO RIPRODUTTIVO E DIMENSIONI ALLA PRIMA MATURITÀ SESSUALE DI PAGELLO FRAGOLINO *PAGELLUS ERYTHRINUS* (SPARIDAE) NELLA BAIA DI MONASTIR (TUNISIA, MEDITERRANEO CENTRALE)

## *SINTESI*

*Per il presente studio, incentrato sulla riproduzione del pagello fragolino,* Pagellus erythrinus *(Sparidae), nella baia di Monastir, sono stati considerati 640 esemplari pescati da settembre 2011 ad agosto 2012. I pesci sono stati prelevati mensilmente durante gli sbarchi dei pescatori locali. Il campione comprendeva 260 maschi (46,84 %) e 295 femmine (53,15 %), mentre 85 individui non sono stati identificati sessualmente. Il rapporto fra i sessi ha evidenziato differenze significative tra maschi e femmine. Le femmine superavano in numero i maschi per la lunghezza compresa tra 130 e 199 mm, mentre i maschi superavano in numero le femmine per le taglie superiori ai 200 mm. La relazione lunghezza-peso ha indicato per il campione totale (maschi e femmine) un'allometria negativa. Il periodo di riproduzione del pagello fragolino inizia ad aprile e finisce ad agosto. L'indice gonadico (GSI) ha raggiunto i valori più elevati nel mese di giugno per i maschi e in luglio per le femmine. La lunghezza alla prima maturità sessuale (TL) era pari a 167,5 mm per i maschi e 153,2 mm per le femmine.*

**Parole chiave:** *Pagellus erythrinus*, rapporto fra i sessi, periodo di riproduzione, lunghezza alla prima maturità sessuale

## INTRODUCTION

Common pandora, *Pagellus erythrinus* (Sparidae), is a demersal fish reported in the Black Sea, the Mediterranean Sea and the eastern Atlantic (Bonnet, 1969; Bauchot & Hureau, 1986; Fischer *et al.*, 1987; Fredj & Maurin, 1987). Investigations carried out in different Mediterranean areas showed that common pandora, preferably, inhabits on the continental shelf (Spedicato *et al.*, 2002) and lives on sandy, rocky or gravelly substrates (Mytélineou, 1989). Depending on size, common pandora is widely distributed from shallow coastal waters to 300 m depth. (Orsi Relini & Romeo, 1985; Somarakis & Machias, 2002; Spedicato *et al.*, 2002).

The biology of common pandora was studied in different regions; such as the Gulf of Lion (Girardin & Quignard, 1985), the Ionian Sea (Papaconstantinou *et al.*, 1988), the Aegean Sea (Metin *et al.*, 2011; Moutopoulos *et al.*, 2013), the western Mediterranean (Valdés *et al.*, 2004), the central Adriatic (Zei & Zupanović, 1961) and the south of the Mediterranean along the Algerian coast (Lachekhab, 2006).

In Tunisia, studies on growth and reproduction were conducted on common pandora from the Gulf of Gabès (Ghorbel, 1996; Ghorbel & Ktari, 1982; Ghorbel *et al.*, 1997) and the Gulf of Tunis (Zarrad *et al.*, 2010). Fassatoui & Romdhane (2010) studied the genetic variability in relation to the size of common pandora from the northern coast of Tunisia. In spite of the presence of *P. erythrinus* along the Tunisian coasts, there are no studies related to the biology of populations in the eastern fishing area, which is a transition zone between the northern coast and the Gulf of Gabès.

Consequently, the aim of our study is to determine the reproduction period and the size at first sexual maturity of common pandora from the Bay of Monastir.

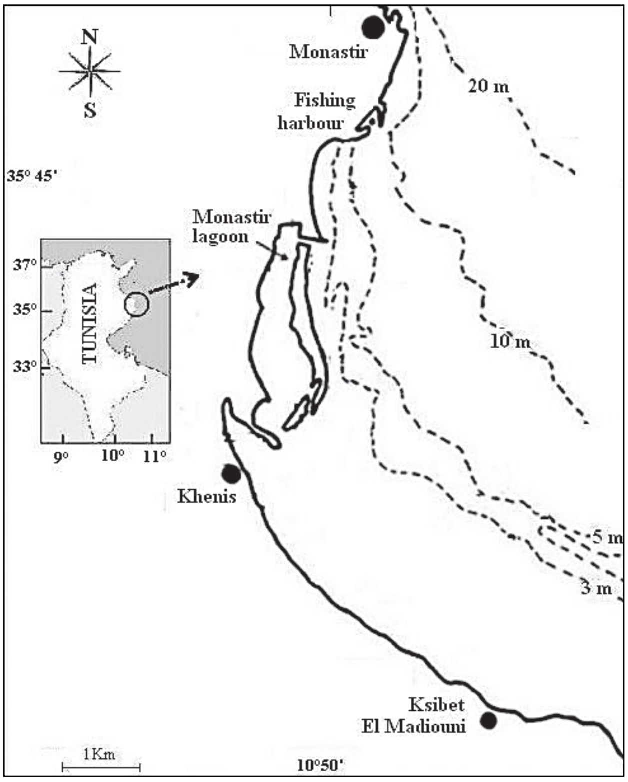

***Fig. 1: Location of the Bay of Monastir; ● - sampling sites.***
***Sl. 1: Lokacija zaliva Monastir; ● - mesta vzorčenja.***

## MATERIALS AND METHODS

### Sampling area

The sampling area, Bay of Monastir, is located in the Gulf of Hammamet, geomorphologic transition zone be-

***Tab. 1: Macroscopic scale adopted to determine stages of gonadal development of** Pagellus erythrinus.*
***Tab. 1: Lestvica za makroskopsko določanje zrelosti moških in ženskih gonad ribona (**Pagellus erythrinus**).***

| **Stages** | **Female** | **Male** |
|---|---|---|
| **I: Immature** | Ovary small, thin filament, transparent, invisible oocytes | Testes thin, white, slightly translucent |
| **II: Sexual resting** | Close to the stage I, larger volume, light pink colour | Close to the stage I, larger volume |
| **III: Gonadal maturation** | Gonad large, light orange to dark, ovarian granular, oocytes easily visible through the membrane | Testicles soft and white, flow of a whitish liquid after incision |
| **IV: Mature gonads and spawning** | Ovary very large, occupying almost the entire abdominal cavity, very thin ovarian membrane. Oocytes easily visible and expelled at the slightest pressure | Testes white, occupy the total abdominal cavity, sperm flows following a slight pressure |
| **V: Post-spawning** | Ovary flaccid, vascularized, pink salmon colour, oocytes smaller with presence of hyaline spaces | Flaccid testes slightly vascularized |

tween the northern region of Tunisia and the southern Gulf of Gabès (Fig. 1). This bay is characterized by the occurrence of a herbarium of *Posidonia oceanica,* which constitutes a spawning and nursery biotopes for numerous vertebrate and invertebrate species (Ben Mustapha & El Abed, 2002). Beyond the *Posidonia* meadow and from a depth of 30 m, coralligenous biocenoses can be found on sandy substrate (Ben Mustapha & Afli, 2002). The Bay of Monastir, submitted to a very intense fishing activity, provides 44 % of the national fish production (Anonymous, 2012). The exploitation of bio-resources in this fishery implements different fishing gear targeting a variety of species with different lifespan living from the shallow coastal waters to the open sea.

### Biological data

A total of 640 specimens were collected from September 2011 to August 2012 once or twice a month. The total length (TL; nearest 0.1 mm) and different weights (W, nearest 0.01 g) of each individual were recorded: Wt - total mass, Wev - eviscerated fish mass, Wg - gonad mass and Wl - liver mass. All specimens were sexed and sexual maturity was determined through the macroscopic observation of the gonads. Five stages were identified: I - immature, II - sexual resting, III - gonadal maturation, IV - mature gonads and spawning, V - post-spawning (Fehri-Bedoui & Gharbi (2008) (Tab. 1).

The sex ratio (SR, female *vs.* male) was calculated monthly according to the size of the fish:

$$SR = \frac{f}{m+f} \times 100$$

where m is number of males and f is number of females. The sex ratios, observed by month and by size classes, were statistically tested for significant deviations from the expected 1:1 ratio F using a  test:

$$\chi^2_{obs} = (m^2/F) + (f^2/F) - F$$

$$F = (m+f)/2$$

In order to monitor the sexual cycle and determine the spawning period, the percentage of different stages of sexual maturity and the average of the gonado-somatic index (GSI) were calculated monthly for both females and males:

$$GSI = (Wg/Wev) \times 100$$

During reproduction fish undergoes physiological changes due to the mobilization of its energetic reserves. Thus, the average liver somatic index (LSI) and the average of the condition factor (Kc) were calculated monthly for females and males:

$$LSI = (Wl/Wev) \times 100$$

$$Kc = (Wev/TL^b) \times 100$$

The allometric constant b is determined from the length-weight relationship:

$$Wt = a \times TL^b$$

The size at first maturity is the size at which 50 % of individuals are mature ($TL_{50}$). During the reproduction

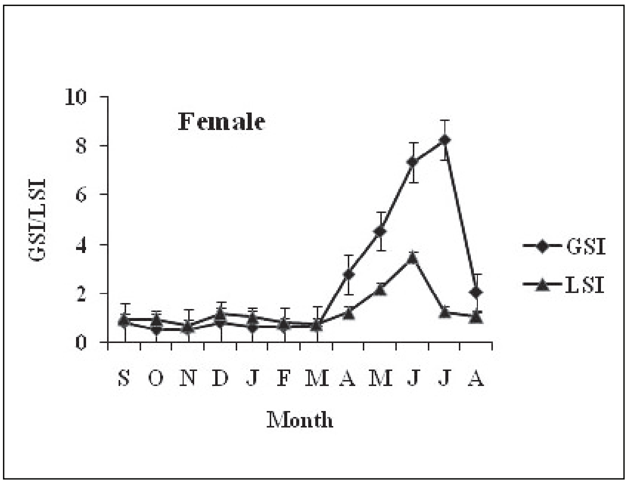

*Fig. 2: Monthly variations of the gonado-somatic index (GSI) and liver-somatic index (LSI) of* Pagellus erythrinus *females in the Bay of Monastir.*
*Sl. 2: Mesečne variacije gonado-somatskega indeksa (GSI) in jetrno-somatskega indeksa (LSI) samic ribona* (Pagellus erythrinus) *v zalivu Monastir.*

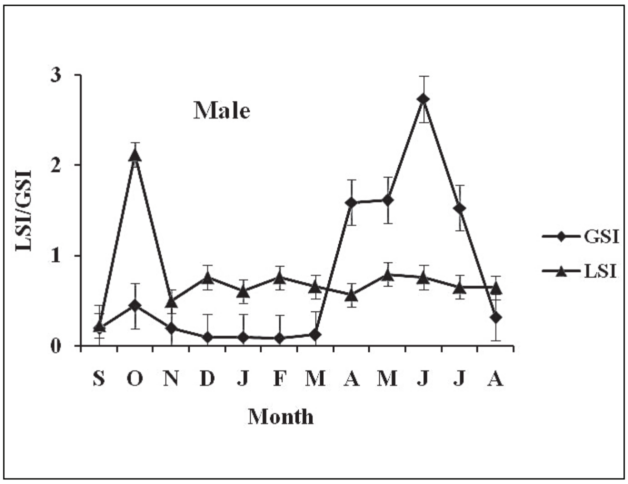

*Fig. 3: Monthly variations of the gonado-somatic index (GSI) and liver-somatic index (LSI) of* P. erythrinus *males in the Bay of Monastir.*
*Sl. 3: Mesečne variacije gonado-somatskega indeksa (GSI) in jetrno-somatskega indeksa (LSI) samcev* P. erythrinus *v zalivu Monastir.*

season, the collected individuals were classified as mature and immature individuals. Mature individuals with gonads in stages III and IV were classified by size class at an interval of 10 mm. The proportions of mature individuals (Pr) and their corresponding size classes (TL) were adjusted to a logistic curve (Saila *et al.*, 1988) such as:

$$Pr = 1/(1 + e^{-r(TL-TL_{50})})$$

## RESULTS

### Sex ratio

Total length of males and females ranged from 110 to 270 mm. A number of 85 individuals were unsexed ($110 \leq TL_{mm} \leq 200$). Of 555 specimens, 260 (46.84 %) were males and 295 (53.15 %) were females. The monthly sex ratio showed significant differences ( = 279.7 > = 3.84) (Tab. 2).

Females outnumbered males for sizes between 130 and 199 mm, while males outnumbered females from the 200 mm size with significant differences (Tab. 3).

### Sexual cycle, gonado-somatic index, liver-somatic index and condition factor

Macroscopically, different stages of gonadal development were easily identified in both sexes. The monthly values of GSI were ranged from 0.39 to 7.87 in females and from 0.25 to 2 in males (Figs. 2, 3). In females, the GSI values were low from September to March; this period corresponds to two stages of the reproductive cycle, the post spawning and the sexual rest. The values of the GSI increased by the end of March and reached the maximum in July (7.87). This period corresponds to the maturation of the gonads; it is followed by the spawn which extends to August. Statistically, the GSI values showed high significant differences ($p < 0.001$) for both sexes.

In females, the gonadal maturation period extends from March to June, while the spawning period lasts only two months (July-August). In males, changes in the GSI were similar to those of females. It appears that there is simultaneity in the chronology of the various gonadal stages. However, the males were fluent one month before female spawning.

In the Bay of Monastir, the reproduction period of *P. erythrinus* in spring and summer was confirmed by the monthly percentages of the different stages of sexual maturity in both sexes (Figs. 4A, B). In females, the curve of the LSI showed the same trend as the GSI. It exhibited low values (0.6 to 1.3) out of the reproduction period (September to March), which increased (from 1.24 to 3.4) during the gonadal maturation stage (April to June) and decreased during the spawning period (Fig. 2). In contrast, in males the LSI had the highest value (2) in post spawning and decreased and varied slightly during the other stages (Fig. 3).

The growth parameter b obtained from the length-weight relationship of common pandora ($W_{ev} = 0.03 \times TL^{2.72}$, where a is 0.03 and b is 2.72), calculated from 640 specimens, allowed us to calculate the condition factor (Kc) for both sexes. The Kc presented slight monthly variations: $2.47 \leq Kc_{♂} \leq 3.04$; $3.33 \leq Kc_{♀} \leq 3.81$ (Tab. 4). The lowest values were recorded in January for

***Tab. 2: Monthly variations of the sex ratio (SR) of** P. erythrinus **in the Bay of Monastir. N = number, * = statistically significant difference at** $p < 0.05$.*

***Tab. 2: Mesečne variacije v razmerju spolov (SR) ribona (**P. erythrinus**) v zalivu Monastir. N = število, * = statistično značilna razlika pri** $p < 0,05$.*

| Month | $N_{♂}$ | $N_{♀}$ | Total | SR | $\chi^2_{obs}$ | *p* |
|---|---|---|---|---|---|---|
| Sept | 7 | 23 | 30 | 76.66 | 23.53 | * |
| Oct | 9 | 6 | 15 | 40.00 | 8.10 | * |
| Nov | 11 | 3 | 14 | 21.42 | 11.57 | * |
| Dec | 21 | 27 | 48 | 56.25 | 24.75 | * |
| Jan | 22 | 24 | 46 | 52.17 | 23.08 | * |
| Feb | 16 | 27 | 43 | 62.79 | 24.31 | * |
| Mar | 27 | 45 | 72 | 62.5 | 40.50 | * |
| Apr | 51 | 37 | 88 | 42.04 | 46.22 | * |
| May | 51 | 39 | 90 | 43.33 | 46.60 | * |
| Jun | 20 | 15 | 35 | 42.85 | 18.21 | * |
| Jul | 15 | 42 | 57 | 73.68 | 41.28 | * |
| Aug | 10 | 7 | 17 | 41.17 | 9.09 | * |
| Total | 260 | 295 | 555 | 53.15 | 279.7 | * |

***Tab. 3: Sex ratio variations (SR) according to size of** P. erythrinus **in the Bay of Monastir. TL = total length, N: = number, ** = statistically significant differences at** $p < 0.05$**, - =** $\chi^2$ **test non applicable.***

***Tab. 3: Variacije v razmerju spolov (SR) ribona (**P. erythrinus**) v zalivu Monastir. TL = skupna dolžina, N = število, ** = statistično značilna razlika pri** $p < 0,05$**, - = test** $\chi^2$ **ni apliciran.***

| TL (mm) | $N_{♂}$ | $N_{♀}$ | Total | SR | $\chi^2_{obs}$ | p |
|---|---|---|---|---|---|---|
| 110-119 | 3 | 1 | 4 | 25.00 | - | - |
| 120-129 | 10 | 9 | 19 | 47.36 | 9.55 | ** |
| 130-139 | 5 | 11 | 16 | 68.75 | 10.25 | ** |
| 140-149 | 7 | 16 | 23 | 69.56 | 15.02 | ** |
| 150-159 | 19 | 45 | 64 | 70.31 | 42.56 | ** |
| 160-169 | 10 | 46 | 56 | 82.14 | 51.14 | ** |
| 170-179 | 10 | 13 | 23 | 56.52 | 11.89 | ** |
| 180-189 | 22 | 27 | 49 | 55.10 | 25.01 | ** |
| 190-199 | 21 | 22 | 43 | 51.16 | 25.32 | ** |
| 200-209 | 27 | 23 | 50 | 46.00 | 43.06 | ** |
| 210-219 | 44 | 16 | 60 | 26.66 | 36.78 | ** |
| 220-229 | 32 | 6 | 38 | 15.78 | 9.57 | ** |
| 230-239 | 10 | 4 | 14 | 28.57 | 7.07 | ** |
| 240-249 | 6 | 1 | 7 | 14.28 | 1.00 | ** |
| 250-259 | 1 | 1 | 2 | 50.00 | - | - |
| 260-269 | 13 | 0 | 13 | 0.00 | 3.00 | ** |
| 270-279 | 2 | 0 | 2 | 0.00 | - | - |
| 300-309 | 1 | 0 | 1 | 0.00 | - | - |

both sexes, while the highest values were recorded during spring, in May for females and March for males.

### Size at first sexual maturity

The sigmoid functions, linking the proportions of mature individuals and the total length of the fish allow to follow the degree of sexual maturity by size and to accurately estimate the length $TL_{50}$ - 153.2 mm for female and 167.5 for male with high correlation coefficients: $R^2_{♀} = 0.95$; $R^2_{♂} = 0.97$ (Figs. 5A, B).

## DISCUSSION

Predominance of females between 130 mm and 190 mm in size and the predominance of the males having

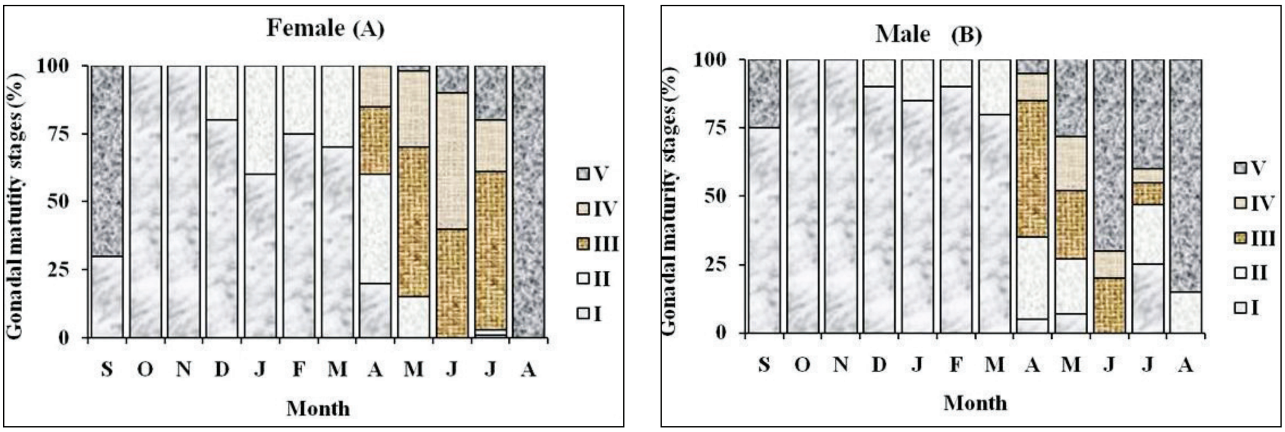

***Fig. 4 (A-B): Monthly evolutions of the percentage of gonadal maturity stages of** P. erythrinus **(A) female and (B) male in the Bay of Monastir; maturity stages: I to V.***

***Sl. 4: Mesečne spremembe v deležih zrelosti gonad (A) ženskih in (B) moških osebkov** P. erythrinus **v zalivu Monastir; stopnje zrelosti I do V.***

***Tab. 4: Monthly variations of the condition factor (Kc) of** P. erythrinus* ***female and male in the Bay of Monastir.***
***Tab. 4: Mesečne spremembe kondicijskega faktorja (Kc) moških in ženskih osebkov** P. erythrinus* ***v zalivu Monastir.***

| Month | Kc♀ | Kc♂ |
|---|---|---|
| Sept | 3.7±0.39 | 0.73±0.36 |
| Oct | 3.6±0.35 | 2.66±0.2 |
| Nov | 3.5±0.23 | 2.77±0.14 |
| Dec | 3.55±0.42 | 2.94±0.5 |
| Jan | 3.33±0.41 | 2.47±0.13 |
| Feb | 3.54±0.35 | 2.7±0.35 |
| Mar | 3.52±0.43 | 3.04±0.43 |
| Apr | 3.74±0.37 | 2.84±0.23 |
| May | 3.81±0.29 | 2.77±0.41 |
| Jun | 3.46±0.19 | 2.62±0.13 |
| Jul | 3.59±0.35 | 2.74±0.15 |
| Aug | 3.65±0.16 | 2.84±0.25 |

upper sizes suggests a probable sexual inversion of female toward male. These observations were confirmed by the presence of a protogynous hermaphrodism in this species found along the Tunisian coast in the Gulf of Gabès (Ghorbel & Ktari, 1982; Ghorbel, 1996) and the Gulf of Tunis (Zarrad *et al.*, 2010). The protogyny of common pandora was observed in the Mediterranean (Papaconstantinou *et al.*, 1988; Mytilinéou, 1989) and in the Eastern Atlantic (Pajuelo & Lorenzo, 1988).

For the whole collected sample (sexes combined), the length-weight relationship has a negative allometry. This result corroborates with those found in the eastern Mediterranean (Livadas, 1989), in the Aegean Sea (Hoşsucu & Çakir, 2003; Metin *et al.*, 2011) and in the Adriatic (Rijavec & Lupanovic, 1965). However, a positive allometry in length-weight relationship, was observed on the common pandora from the Atlantic (Pajuelo & Lorenzo, 1998) and in the central Mediterranean (Ghorbel, 1996), Adriatic (Bolje, 1992) and Aegean Seas (Mytilinéou, 1989) (Tab. 5). This disparity in findings could be attributed to the differences in the impact of the protogyny on the growth of both sexes. Similar patterns were observed in some populations from the Atlantic and the Mediterranean due to the fact that the growth of males and females showed significant differences (Hoşsucu & Çakir, 2003; Coelho *et al.*, 2010).

Monthly variations of GSI showed that the reproduction season occurred from April to August with a peak in June for males and in July for females. This period was reported by other authors who investigated the Mediterranean basin and the adjacent areas (Tab. 5). Ghorbel (1996) noted that *P. erythrinus* spawns between May and July in the Gulf of Gabès. Zarrad *et al.* (2010) reported that the reproduction of this Sparidae extended from April to October in the Gulf of Tunis. Common pandora required a long spawning period with two peaks, in June and October (Metin *et al.*, 2011). Tsikliras *et al.* (2010) reported a summer reproduction period extending between June and August for the common pandora of the Adriatic Sea. Papaconstantinou *et al.* (1988) noted that common pandora spawned from June to September in the Ionian Sea. The reproduction over several consecutive months was also reported in the eastern Atlantic (Tab. 5). A period of reproduction was recorded from March to July in the south of Portugal (Coelho *et al.*, 2010). A longer reproductive period (April-September) was observed for the same species off the Canary Islands (Pajuelo & Lorenzo 1998).

Monthly variations in the liver somatic index, showing the same trend as those of the GSI in the females, indicate that this fish probably stores its energetic reserves in liver during the gonadal maturation period. Such reserves might be used for the energetic requirements of the spawning. Slight variations of the condition factor

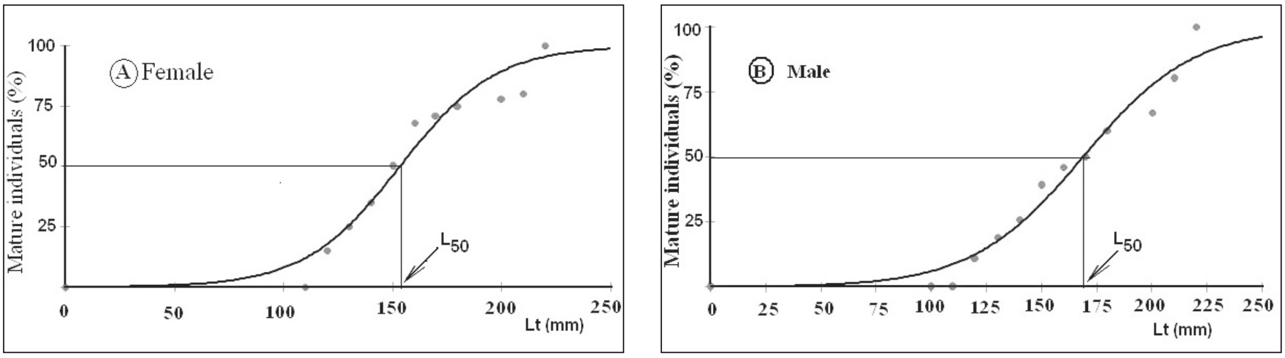

***Fig. 5: Logistic curves for estimation of the size at first sexual maturity ($L_{50}$) of** P. erythrinus* ***(A) female and (B) male in the Bay of Monastir.***
***Sl. 5: Logistične krivulje za oceno dolžine ob prvi spolni zrelosti, $L_{50}$ (A) ženskih in (B) moških osebkov** P. erythrinus* ***v zalivu Monastir.***

***Tab. 5: Spawning period (framed months) and length at first maturity (TL$_{50}$) according to different geographical regions.***
***Sl. 5: Obdobje drstenja (uokvirjeni meseci) in velikost ob prvi spolni zrelosti (TL$_{50}$) v različnih geografskih regijah.***

| **Area** | **Spawning period** | **TL$_{50}$ (mm)** | | **Source** |
|---|---|---|---|---|
| | | ♂ | ♀ | |
| | | **Northern Mediterranean** | | |
| **Western**<br>Gulf of Lion | J-F-M-A-M-**J-J-A**-S-O-N-D | 140, 170 | 140, 170 | Girardin & Quignard (1985) |
| **Central**<br>Adriatic Sea | J-F-M-A-M-**J-J-A-**S-O-N-D | - | - | Tsikliras *et al.* (2010) |
| **Eastern**<br>Aegean Sea | J-F-M-A-M-**J-J-A-S**-O-N-D | 150 | 113 | Metin *et al.* (2011) |
| | | **Southern Mediterranean** | | |
| Gulf of Tunis | J-F-M-**A-M-J-J-A-S**-O-N-D | 157.8 | 145.8 | Zarrad *et al.* (2010) |
| Gulf of Gabès | J-F-M-A-**M-J-J**-A-S-O-N-D | 145.9 | 135.5 | Ghorbel (1996) |
| Bay of Monastir | J-F-M-**A-M-J-J-A**-S-O-N-D | 167.5 | 153.2 | Present study |
| | | **Eastern Atlantic** | | |
| Southern Portugal | J-F-**M-A-M-J-J**-A-S-O-N-D | 175.8 | 172.8 | Coelho *et al.* (2010) |
| Canary Islands | J-F-M-**A-M-J-J-A-S**-O-N-D | 174 | 232 | Pajuelo & Lorenzo (1998) |

were observed over the year even during the reproduction period. Probably, the summer environmental factors, long period of sunlight, high temperature as well as abundant food, maintain a normal metabolic activities of the common pandora as it was reported for fishes in general (Brett, 1979).

The size at sexual maturity of *P. erythrinus* showed changes related to Tunisian areas: TL$_{50}$ is 153.2 mm and 167.5 mm for females and males, respectively. These values are higher than that found for the same species in the Gulf of Tunis (TL$_{50♀}$ = 146 mm, TL$_{50♂}$ = 146 mm) (Zarrad *et al.*, 2010). Ghorbel (1996) reported a significantly earlier onset of sexual maturity for specimens from the Gulf of Gabès (TL$_{50♀}$ = 135.5 mm, TL$_{50♂}$ = 145.9 mm) (Tab. 5). The regional variability in size at first sexual maturity of this species is also observed in the Aegean Sea: TL$_{50♀}$ = 113 mm and TL$_{50♂}$ = 150 mm (Metin *et al.*, 2011). Girardin (1981) and Girardin & Quignard (1985) observed two sizes at first maturity (LT$_{50}$ = 140 and 170 mm) for both females and males in the Gulf of Lion. In the eastern Atlantic, TL$_{50}$ of common pandora is higher than that observed in Mediterranean. For both sexes it was180 mm in Southern Portugal (Santos *et al.*, 1995). Coelho *et al.* (2010) reported in the same area different TL$_{50}$ values for male and female (TL$_{50♂}$ = 175.8 mm, TL$_{50♀}$ = 175.8 mm). Also, the size at first maturity reaches a higher value (TL = 232 mm) in common pandora population of the Canary Islands (Pajuelo & Lorenzo, 1998).

Common pandora from the Bay of Monastir exhibited the spawning period similar to this reported from other regions of the Mediterranean and eastern Atlantic. However, the species reached sexual maturity at different sizes according to sexes and geographical distribution. The common pandora maturity seems to be regulated by two geographical gradients, the North-South as well as East-West gradient.

## ACKNOWLEDGMENTS

The authors wish to acknowledge the suggestions and comments of two anonymous reviewers, which helped to improve the quality of the manuscript.

# REPRODUKTIVNI CIKLUS IN VELIKOST OB PRVI SPOLNI ZRELOSTI RIBONA *PAGELLUS ERYTHRINUS* (SPARIDAE) V ZALIVU MONASTIR (TUNIS, OSREDNJE SREDOZEMLJE)

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## *POVZETEK*

*V študiji o razmnoževanju ribona,* Pagellus erythrinus *(Sparidae), v zalivu Monastir je bilo od septembra 2011 do avgusta 2012 mesečno vzorčenih skupno 640 osebkov v ulovih priobalnega ribolova. Določili smo 260 samcev (46,84 %) in 295 samic (53,15 %), 85 osebkov je bilo spolno nedoločljivih. V mesečnih razmerjih med spoloma so bile znatne razlike. Ženski osebki so prevladovali v dolžinskem razredu (TL) med 130 in 199 mm, moški osebki pa od 200 mm navzgor. V odnosu dolžina – teža kaže skupni vzorec (moški in ženski osebki) negativno alometrijo. Obdobje razmnoževanja traja od aprila do avgusta z viškom gonado-somatskega indeksa (GSI) v juniju za samce in juliju za samice. Velikost (TL) ob prvi spolni zrelosti je dosežena pri 167,5 mm za samce in 153,2 mm za samice.*

**Ključne besede:** *Pagellus erythrinus*, razmerje spolov, reprodukcijsko obdobje, dolžina ob prvi spolni zrelosti

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Short scientific article
Received: 2014-05-08

UDK 597.315.6:591.9(262.53)

# STATUS OF ANGELSHARK, *SQUATINA SQUATINA* (ELASMOBRANCHII: SQUATINIFORMES: SQUATINIDAE) IN THE SEA OF MARMARA

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## *ABSTRACT*

*On 4 January 2014, a female specimen of* Squatina squatina *was entangled in trammel-net, at a depth of about 50 m. The specimen was 174 cm long (total length) and weighed approximately 35 kg. The recent single capture of* S. squatina *in the southeastern Sea of Marmara confirms the contemporary presence of the species in this land-locked small marine region; however, the paucity of the species in the fishing records of Marmaric fishes since 2000, confirms its rarity in the studied marine area.*

**Keywords:** Angelshark, *Squatina squatina*, Sea of Marmara, status, endangered, protection

# STATO DELL'ANGELO DI MARE, *SQUATINA SQUATINA* (ELASMOBRANCHII: SQUATINIFORMES: SQUATINIDAE), NEL MARE DI MARMARA

## *SINTESI*

*Il 4 gennaio 2014, una femmina di* Squatina squatina *è rimasta impigliata in una rete tramaglio, ad una profondità di circa 50 metri. La lunghezza totale dell'esemplare era pari a 174 cm per circa 35 kg di peso. La recente singola cattura di* S. squatina *nella parte sud-orientale del mare di Marmara conferma la presenza temporanea della specie in questa piccola semichiusa regione marina. Tuttavia, la scarsità di segnalazioni della specie nei registri di cattura della fauna ittica del mare di Marmara dal 2000, conferma la sua rarità nell'area marina studiata.*

**Parole chiave:** angelo di mare, *Squatina squatina*, mare di Marmara, stato, specie in via di estinzione, protezione

## INTRODUCTION

The angelshark, *Squatina squatina* (Linnaeus, 1758) is a temperate-water bottom-dwelling shark of the European and North African continental shelves, present on or near the bottom from the close inshore, littoral zone to at least 150 m depth (Ebert & Stehmann, 2013). Its distribution range extends from North Eastern and Central Eastern Atlantic coasts to the entire Mediterranean and Black Seas (Serena, 2005; Ebert & Stehmann, 2013). Presence of *S. squatina* has been well documented both in historical (Ninni, 1923; Deveciyan, 1926; Rhasis Erazi, 1942) and contemporary records (Akşiray, 1987; Kabasakal, 2002, 2003; Kabasakal & Kabasakal, 2004); however, in a recent ichthyological survey of Turkey, *S. squatina* is considered as a severely declined shark in Turkey's seas (Fricke *et al*., 2007).

Although the occurrence of *S. squatina* in the Sea of Marmara is well-documented in historical records and in the ichthyological inventories of the last quarter of the 20th century, the paucity of the species in the fishing records since 2000 necessiates an update of its status in Marmaric waters. With this aim, in the present article, authors report a recent catch of *S. squatina* in the Sea of Marmara, which confirms the contemporary occurrence of the species in marmaric waters.

## MATERIAL AND METHODS

Since 2000, *S. squatina* has been studied by members of the Ichthyological Research Society (IRS), as part of an extensive survey of sharks occurring in Turkey's seas. The actions of the society have been supported by local fishermen and divers, who have helped researchers in reporting sightings and collection of by-caught specimens. In the framework of this collaboration, the authors were informed on the recent and seldom captures or sightings of *S. squatina* from the several parts of the Sea of Marmara. Identification and nomenclature of the present specimen is based on Serena (2005) and Ebert & Stehmann (2013). Total length (TL) was measured to the nearest 0.5 cm with a measurement tape, and the weight of the specimen was recorded by means of a scale at the fishmarket to the nearest 0.1 kg. Morphological characters of the present angel shark were examined at the fishing port on fresh specimen. Photographs of the examined specimen are kept in the archives of IRS and available for inspection on request.

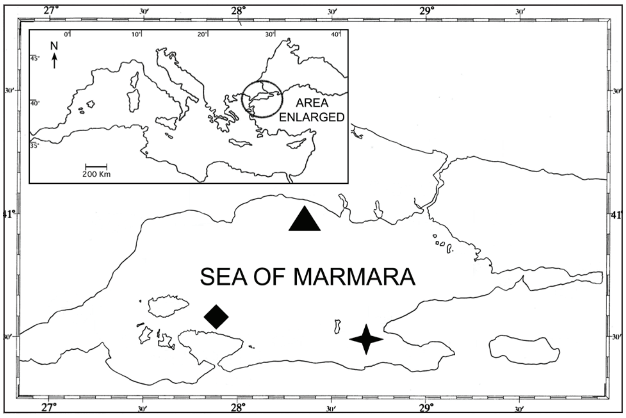

***Fig. 1: Map showing positions in the Sea of Marmara where*** *S. squatina* ***specimens were caught: present specimen caught on 4 January, 2014 (✦), the female caught in November 1995 (◆) and the specimen of*** *Squatina* ***spp. harpooned in 1950's (▲).***

***Sl. 1: Zemljevid z označenimi lokalitetami v Marmarskem morju, kjer so bili ujeti navadni sklati*** *(S. squatina)****: obravnavani primerek, ulovljen 4. januarja 2014 (✦), samica, ulovljena v novembru 1995 (◆) in harpunirani primerek sklata v petdesetih letih prejšnjega stoletja (▲).***

## RESULTS AND DISCUSSION

On 4 January 2014, a female specimen of *S. squatina* was entangled in trammel-nets, at a depth of about 50 m (Fig. 1). The specimen measured 174 cm in total length and weighed approximately 35 kg (Figs. 2A, B). The following characters are based on the present specimen: trunk is broad; origin of first dorsal fin is in line with pelvic fin rear extremity; 35 teeth were counted on the upper jaw and 42 on the lower jaw; simple tips were observed on nasal barbels and anterior nasal flaps are weakly fringed; a single triangular lobe is present on lateral head folds on each side; dorsal surface is very rough due to very sharp, hook-shaped and closely spaced dermal denticles; entire ventral surface is also covered with dermal denticles; patches of small thorns are present on snout and on interorbital space; dorsal surface is uniformly dark greyish brown with small blackish spots scattered on the background coloration, and ventral surface is whitish.

Maximum total length of *S. squatina* can reach up to 250 cm (Serena, 2005), and females are sexually mature at 126 to 167 cm (Ebert & Stehmann, 2013). According to Capapé *et al*. (1990) females of *S. squatina* reaches sexual maturity at 128 cm in the Mediterranean Sea. Based on these facts and the total length of aforementioned female, it can be assumed that it was sexually mature. According to Capapé *et al*. (1990), the duration of the reproductive cycle of species of the genus *Squatina* is probably 2 years. Same authors assumed that in adult females oocyte growth might span also a 2-year period. Capapé *et al*. (1990) also reported a remarkably low fecundity (7 to 18 uterine ova or embryos) for *S. squatina*, based on pregnant females caught off Tunisia's coasts.

Basic data collected following the search of old literature, published documents, interviews with fisherman, as well as personal observations, revealed that *S. squatina* has historically occurred in Turkey's marine waters,

***Fig. 2: Two specimens of*** *S. squatina* ***from the Sea of Marmara. (A) Dorsal view of the present female caught on 4 January, 2014, while it was displaying in the fish market; (B) anterior view of the present female; (C) female*** *S. squatina* ***caught in November 1995 (TL 87 cm; ◆ in Fig. 1), details of this specimen are given in Kabasakal (2003).***
***Sl. 2: Primerka navadnega sklata (****S. squatina****) iz Marmarskega morja. (A) Zgornji del samice, ulovljene 4. januarja 2014 in fotografirane na ribji tržnici; (B) sprednji del samice; (C) samica sklata, ujeta novembra 1995 (TL 87 cm; ◆ na sliki 1), podrobnosti o tej samici je podal Kabasakal (2003).***

while a clear decline is obvious in recent decades. First account on the presence of the angelshark in the seas of Turkey was recorded by Ninni (1923; reported as *S. angelus*), in which the species was considered by the author as a common and abundant species of shark in the Sea of Marmara. In addition to Ninni's account, records of *S. squatina* have also been reported by Deveciyan (1926) and Rhasis Erazi (1942). Recently, a single subadult female was caught at a depth of 50 m in southern Sea of Marmara (Kabasakal, 2003; Fig. 2C).

Besides those records, the species has also been recorded along the Aegean and Mediterranean coasts of Turkey. *S. squatina* comprised 1.1 % of total number of elasmobranchs (n = 4632) caught in the seas of Turkey during an extensive survey of elasmobranchs carried out between 1995 and 1999 (Kabasakal, 2002). The same species represented 0.46 % of total shark catches (n = 1068) recorded during fishery surveys carried out between 1995 and 2004 in the northern Aegean Sea (Kabasakal & Kabasakal, 2004). In a recent survey of the Marmaric fish fauna, Keskin & Eryilmaz (2010) considered *S. squatina* as a rare shark in the Sea of Marmara.

The rarity of *S. squatina* in different parts of the Mediterranean Sea has been highlighted by several authors in recent literature on sharks of this area. According to Lipej *et al.* (2004), *S. squatina*, once common and abundantly caught in the Adriatic Sea, is now considered to be rare throughout the region. A preliminary analysis of MEDITS data shows clear evidence of decline for most sharks and rays, as well as the risk of localised extirpation for some species which in the past were considered common, among which *S. squatina* is comprised (Serena & Relini, 2006). According to Hadjichristophoru (2006), *S. squatina* is an occasional shark in waters off Cyprus. Moreover, *S. squatina* is considered to be a rare shark also off the Mediterranean coast of Israel (Golani, 2006). Başusta *et al.* (2006) reported that the angelshark is included in the list of main species rarely observed, endangered or protected in the Mediterranean. During a survey of abundances of demersal sharks conducted in Central Mediterranean Sea between 1994 and 2009

***Fig. 3: A large specimen of*** *Squatina* ***sp., harpooned by a free-diver off Selimpaşa coast (▲ in Fig. 1), northern Sea of Marmara, in 1950's.***
***Sl. 3: Velik primerek sklata (****Squatina* ***sp.), ki ga je harpuniral potapljač na dah v vodah obale Selimpaşa (▲ na sliki 1), v severnem delu Marmarskega morja v petdesetih letih prejšnjega stoletja.***

only one specimen of *S. squatina* was caught off Malta's coast in 2005. Ragonese *et al.* (2013) concluded that rarity of the species is now confirmed in that region.

In the monumental work of Deveciyan (1926), the author reported that during the 1920's *S. squatina* was abundantly caught in Turkey's waters, particularly in June and July. Based on historical photographs of the species, now it is known that *Squatina* spp. has also been targeted by spearfishermen in Marmaric waters (Fig. 3). Serena (2005) considered *S. squatina* as a target species for demersal fishery in some parts of the Mediterranean. In addition to Serena's consideration, Bradai *et al.* (2006) reported that *S. squatina* is a regularly observed shark in Gulf of Gabès (Western Mediterranean). Contrary to the above statements, recent reports have pointed out a serious decline of angelshark populations in several parts of the Mediterranean (Lipej *et al.*, 2004; Başusta *et al.*, 2006; Golani, 2006; Hadjichristophoru, 2006; Serena & Relini, 2006; Ragonese *et al.*, 2013); however, this decline does not mean that *S. squatina* was not caught. A similar trend in the decline of *S. squatina* catches has been observed in Bay of Biscay, where the annual catches of the species has been around 25,000 tons in 1850's off Arcachon coast and drastically declined to less than 300 kg in late 1990's (Quéro, 1998).

According to FAO status evaluation for conservation and exploitation status of sharks and rays, *S. squatina* is categorized in B1, which means that it is a directly exploited or caught as bycatch species, that cannot be placed in any of the FAO status categories due to lack of data (Serena, 2005). Same author also stated that *S. squatina* is a vulnerable species in the entire Mediterranean. Regarding the status of the species in the seas of Turkey, *S. squatina* is a critically endangered shark in the aforementioned region, which is considered very sensitive to human activities (Fricke *et al.*, 2007). Due to the severe decline of the species, Fricke *et al.* (2007) also considered *S. squatina* as a high priority species for conservation action in Turkey's waters.

## CONCLUSIONS

The recent single capture of *S. squatina* in the southeastern Sea of Marmara confirms the contemporary presence of the species in this land-locked small marine region**.** However, the paucity of the species in the fishing records of Marmaric fishes since 2000, confirms its rarity in the studied marine area. Due to life history parameters of *S. squatina*, such as low fecundity, long reproductive cycle (2 year) and large size at which females at sexual maturity (128 cm, which equals 51.2 % of reported maximum total length, 250 cm), this species is considered as highly vulnerable either to targeted or untargeted fisheries. Although, *S. squatina* is reported to be a high priority species for conservation action (Fricke *et al.*, 2007), currently there are no regulatory measures regarding the fishing of the species implemented in the Turkey fisheries act. Therefore, immediate precautions should be taken for the release of specimens caught alive, such as the adult female of the present study, as a first step for the protection of *S. squatina* in the Sea of Marmara.

## ACKNOWLEDGEMENTS

The authors wish to thank Mr. Bülent Kopuz who kindly and rapidly informed us of the capture of the female *S. squatina* and sent the photopraphs. Mr. Mark Taylor, an Istanbul based scuba instructor and underwater photographer, for kindly revising the English text. We are also indebted to Mr. Okan Yeşmil, an Istanbul based Scuba diver and collector of historical diving gears, for the photograph of the *Squatina* spp., seen in Figure 3. Special thank goes to our son Derin for his endless support and love.

# STATUS NAVADNEGA SKLATA (*SQUATINA SQUATINA)* (ELASMOBRANCHII: SQUATINIFORMES: SQUATINIDAE) V MARMARSKEM MORJU

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## *POVZETEK*

*Četrtega januarja 2014 je bila na globini približno 50 m ujeta samica navadnega sklata (*Squatina squatina*) v trislojno stoječo mrežo. Primerek je meril 174 cm v dolžino in tehtal približno 35 kg. Novejši podatek o ujetju sklata v jugovzhodnem delu Marmarskega morja potrjuje prisotnost te vrste v tem majhnem in zaprtem morju. Kakorkoli že, maloštevilnost podatkov v ribiških zapisih kaže, da je vrsta v tem morju redka.*

**Ključne besede:** navadni sklat, *Squatina squatina*, Marmarsko morje, status, ogrožena vrsta, varovanje

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# FLORA IN VEGETACIJA

# FLORA E VEGETAZIONE

# FLORA AND VEGETATION

Original scientific article
Received: 2014-02-18

UDK 574.4:633.2.032(4)

# FLORISTIC AND FUNCTIONAL DIVERSITY OF MEADOWS FROM TWO NEIGHBORING BIOGEOGRAPHIC REGIONS

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## *ABSTRACT*

*Physiognomically similar meadows from two different regions, the Dinaric and the Central European, that occur in similar environments and have been subjected to relatively uniform management regimes were compared in order to test for significant differences in floristic diversity, community-weighted mean (CWM) and functional diversity (FD). We found that the Central European meadow community has higher species dominance and lower evenness, but it is less diverse than the Dinaric. Central European meadows contain more annuals, with faster rates of leaf turnover, which suggests that they are more strongly structured by disturbance than the Dinaric meadows. For most traits, diversity was highest in the Central European meadows, probably owing to more severe disturbance impact, which is known as the most potent force creating and sustaining trait divergence. We conclude that the strong evidence for divergence in functional composition between meadows from different regions suggests that functional trait composition is unlikely to be a deterministic function of similarities in environment conditions and land use in geographically disjunct communities. This may have important implications for conservation management of these meadows.*

**Key words**: plant functional traits, semi-dry grasslands, Central European meadows, Dinaric meadows

# DIVERSITÀ FLORISTICA E FUNZIONALE DEI PRATI DI DUE REGIONI BIOGEOGRAFICHE CONFINANTI

## *SINTESI*

*Prati fisiognomicamente simili in due regioni diverse, quella dinarica e quella centro-europea, che crescono in ambienti simili e sono stati sottoposti a regimi di gestione relativamente uniformi, sono stati confrontati al fine di verificare differenze significative in diversità floristica, valore medio dei tratti funzionali (CWM) e diversità funzionale (FD). I risultati della ricerca hanno evidenziato che la comunità della regione centro-europea ha una dominanza maggiore di specie, una minore uniformità nell'abbondanza degli esemplari di ogni specie, ed è meno diversificata rispetto alla comunità della regione dinarica. I prati dell'Europa centrale ospitano più specie annuali, con tassi più alti di ricambio di foglie, il che suggerisce che essi siano più fortemente strutturati da vari disturbi che i prati dinarici. Per la maggior parte dei tratti funzionali la diversità è risultata più alta nei prati dell'Europa centrale, probabilmente a causa di un impatto maggiore dei disturbi, riconosciuti come la forza più potente che crea e sostiene le divergenze tra i tratti. Gli autori concludono che la forte evidenza di divergenza nella composizione funzionale tra prati provenienti da diverse regioni suggerisce che la composizione dei tratti funzionali non sia una funzione deterministica di somiglianze in condizioni ambientali e di uso del suolo nelle comunità geograficamente disgiunte. Tale risultato può avere implicazioni importanti per la gestione e la conservazione di queste praterie.*

**Parole chiave:** tratti funzionali delle piante, prati semi-asciutti, prati centro-europei, prati dinarici

## INTRODUCTION

There is a long history in plant ecology of grouping communities from geographically disjunct regions that appear physiognomically similar (*e.g.* Cowling & Campbell, 1980). However, plant communities are increasingly classified by their functional traits as well as by physiognomy (Shipley *et al.*, 2006). The renewed interest in classifying species into groups relating to function rather than to taxonomy (*e.g.*, Keddy, 1992; Lavorel *et al.*, 1997; Westoby, 1998; Weiher *et al.*, 1999) has triggered the search for traits that express meaningful differences in ecological behaviour among plant species.

It is well known that differences in essential constraints, *e.g.*, weather, topography, soil conditions and disturbance regime, lead to different plant communities. The species combination assemblage is based on filtering plants with particular sets of functional traits from the available species pools (Lavorel *et al.,* 1997; Lavorel & Garnier, 2002; de Bello *et al.*, 2005). Morphological-functional traits are recognized as a valuable framework for describing species attributes and determining general patterns of vegetation response to disturbance and environmental gradients (McIntyre *et al.*, 1999). Furthermore, interpreting the functional trait diversity of vegetation (Mason *et al.*, 2005; Grime, 2006; Lepš *et al.*, 2006; Doležal *et al.*, 2011; Ricotta & Moretti, 2011) is emerging as a key indicator of ecosystem function (*e.g.* Scherer-Lorenzen, 2008) and also of community assembly processes (Mason & Lanoiselee, 2008; Villeger *et al.*, 2008). Functional diversity can have different definitions (Diaz & Cabido, 2001; Tilman *et al.*, 2001; Lepš *et al.*, 2006; Ricotta & Moretti, 2011) and can be quantified using a variety of indices (Ricotta, 2005; Villeger *et al.*, 2008; Doležal *et al.*, 2011). Some authors (*e.g.*, Tilman *et al.*, 2001; Petchey & Gaston, 2002) define functional diversity as the extent of functional trait variation (or differences) among the species in a community (Tilman *et al.*, 2001; Petchey & Gaston, 2002; Lepš *et al.*, 2006), whereas others define it in its broadest sense as the distribution of trait values in a community (Diaz & Cabido, 2001; Diaz *et al.*, 2007). Comparison of the functional trait means and functional diversity between communities, or groups of communities, may reveal differences in the rates of ecosystem functioning (Shipley *et al.*, 2006; Scherer-Lorenzen, 2008). These comparisons may also reveal differences in the relative influence of environmental stress, disturbance and competition on species occurrence in local communities (Grime, 2001).

Tests of whether communities that occur in similar environments and are subject to similar disturbance regimes are also similar in functional trait structure have been rare, and where such tests have been performed, they have studied a relatively small number of communities and mainly considered only the widely used community-weighted mean of a trait (CWM hereafter) (Smith *et al.*, 1994; Smith & Wilson, 2002; Watkins & Wilson, 2003).

It has already been established (Pipenbaher *et al.*, 2013a) that the semi-natural dry meadows of Slovenia provide a great opportunity for studying the ecological basis of floristic richness and community functional structure in two distinct biogeographical regions (*i.e.* the Central European and the Dinaric; biogeographical regions are used as defined in Pipenbaher *et al.* (2013a)), where these plant communities occur on similar parent rock types (calcareous loamy soils), and all have historically been subjected to a relatively uniform management regime of mowing for hay at least annually (Kaligarič, 1997; Škornik, 2000; Pipenbaher *et al.*, 2013a). The floristic distinctiveness of the Central European and Dinaric dry-meadows has already been described as substantial (Pipenbaher *et al.*, 2013a), and comparison of these communities considering only a CWM for a few plant traits revealed that the species composition of dry meadow communities in different regions may be influenced to varying degrees by stress and disturbance (Pipenbaher *et al.*, 2013a). However, the comparison of functional trait diversity between these meadows, considered as the overall difference among species in a community in terms of their traits, remains to be tested. This manuscript thus aims to interpret the functional diversity of the Central European and Dinaric dry-meadows. By calculating the functional diversity, we may reveal differences in the relative importance of complementarity or convergence in ecological strategy in community assembly. Higher functional diversity than expected by chance indicates that co-occurring species tend to differ more in ecological strategy than expected, which would provide evidence for limiting similarity.

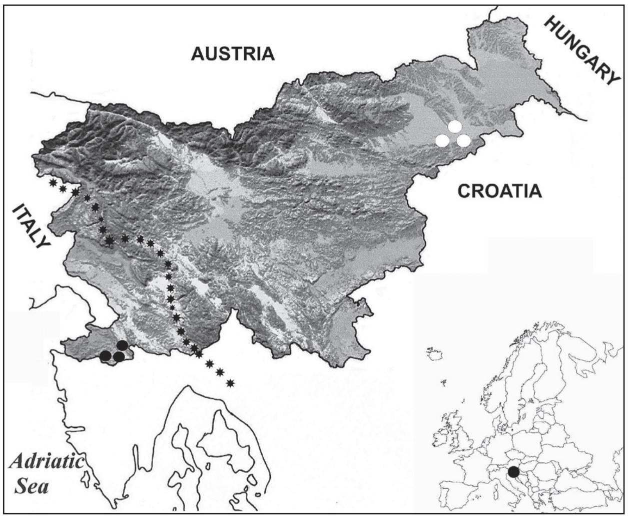

***Fig. 1: Map of study areas - Central European (○) and Dinaric (●) meadows. The stars line shows border between the biogeographic zones/ regions.***
***Sl. 1: Prikaz območij raziskave – srednjeevropski (○) in dinarski travniki (●). Linija ponazarja mejo med biogeografskima območjema.***

Lower functional diversity than expected indicates that co-occurring species tend to be more similar in ecological strategy, and provides evidence that environmental filtering is the dominant process. We used a previously published dataset with species and trait data (Pipenbaher *et al.*, 2013a) to answer the following questions: (1) Do the Slovenian Central European and Dinaric calcareous semi-dry meadows differ in their species richness and species diversity? (2) Is there any evidence that functional trait variations (*i.e.*, functional diversity) among the species differ between regions?

## MATERIAL AND METHODS

### Study area and field methods

We studied semi-dry grassland communities (class Festuco-Brometea) in two biogeographic regions in Slovenia: the Dinaric (NW Balkan, sub-Mediterranean--Illyrian) and the Central European, which meet in the pre-Alps, Dinaric and pre-Dinaric Mountains that are stretching along the eastern Adriatic to the Alps. On the basis of the typology of grasslands, we summarized the names on a biogeographic basis (Central European vs. Dinaric (NW Balkan grasslands)), based on in the distributional ranges of both types (Pipenbaher *et al.*, 2013a).

The Dinaric study area lies in Slovenia's Northern Adriatic karst zone (45° 28.38´ N, 13° 58.34´ E) and represents the most north-western part of the Balkan Peninsula (Fig. 1). The climate is transitional between Mediterranean and continental pre-Alpine, with cool, rainy winters and long, dry summers (Poldini, 1989). The mean annual temperature in the study area is 10.5 °C, the coldest in January (-2 °C) and the warmest in July (19.8 °C). The average annual precipitation is around 1400 mm (ARSO, 2009). The semi-natural, extensively managed dry grasslands in the area are still distributed over large unfragmented surfaces. There is a floristic distinction between the *Scorzonerion villosae* alliance, used as unfertilized hay meadows, and the *Satureion subspicatae* alliance, used as semi-natural pastures (Pipenbaher *et al.*, 2011).

The Central European study area (Fig. 1) is located in the tertiary hilly region of the NE region of Slovenia, (46° 18.74´ N, 15° 49.03´ E), at ca. 300400 m above sea level. The mean annual temperature is 9.7 °C. The coldest month is January (-2.4 °C) and the warmest July (19.4 °C). The average annual rainfall is about 1050 mm (ARSO, 2009). The landscape is characterized by a mosaic of deciduous forest, arable fields and semi-natural grasslands. Large proportions of this type of vegetation have been lost during recent decades, owing to the forest encroachment that has followed the abandonment of traditional management, which consisted of extensive mowing (12 times a year), extensive grazing and no fertilizer addition. The semi-dry *extensively used meadows* in this study occur in the area on sites with middle-deep eutric cambisols on steep slopes with dry, sunny conditions (Kaligarič & Škornik, 2002).

In this study we used a previously published dataset (Kaligarič, 1997; Škornik, 2000; Pipenbaher *et al.*, 2013a), comprising 205 species in 118 vegetation samples (relevés collected by authors of this study) that met the following criteria in both regions: (1) the sampled meadows occur on mesic eutric cambisols developed on carbonate flysch; (2) the traditional extensive management regime consists of mowing once a year. From 118 vegetation samples it is 67 relevés from Dinaric region (association *Danthonio-Scorzoneretum villosae*, alliance *Scorzonerion villosae*) and 51 relevés from Central European region (association *Onobrychido-Brometum*, alliance *Mesobromion erecti*) (Kaligarič, 1997; Škornik, 2000). In each 25 m$^2$ quadrat, vascular plants were sampled using a seven-point cover-abundance scale according to Braun-Blanquet (1964). All plant species occurring only in one relevé were removed, to exclude casual occurrences from the analysis. These species were thus not included in dataset. Taxonomic nomenclature follows by Martinčič *et al.* (2007); syntaxonomic nomenclature follows by Kaligarič & Škornik (2002) and Kaligarič (1997).

### Species richness and diversity

For species by relevé matrix we calculated two indices: Species richness and Simpson diversity index. Species richness was noted as the number of species recorded on each plot. For calculation Simpson diversity index we followed de Bello *et al.* (2006). For species richness we used present/absence data.

### Selected plant functional traits

In choosing key traits, we followed different literature sources (Hodgson *et al.*, 1999; Kahmen *et al.*, 2002; Cornelissen *et al.*, 2003). We selected 14 traits for each species. Traits were chosen from our own database (protocol standardized by Cornelissen *et al.* (2003). Information on species traits was also taken from two existing trait databases BiolFlor (Klotz *et al.*, 2002) and LEDA (Kleyer *et al.*, 2008). Species were characterized by basic traits as well as composite traits (such as C-S-R strategy). Owing to the variety of species sets, we focused on traits that were easy to measure. The traits selected were as follows: "life cycle", "growth form", "vegetation propagation", "storage organs", "spinescence", "hairiness", "height", "specific leaf area (SLA)", leaf dry matter content (LDMC)", "flowering start", "flowering length", "leaf persistence", "leaf anatomy" and "type of reproduction".

The list of traits with the description of classes in the matrix and the sources of information are presented in Table 1. Categorical traits were all transformed into binary variables, with one for each possible level of the factor (dummy variables). In this way the number of traits in the matrix increased from 14 to 40.

***Tab. 1: Plant traits, recorded on 205 vascular plant species of Central European and Dinaric meadows. Scales of measurement were originally categorical (cat), continuous (cont) or binary (bin).***
***Tab. 1: Morfološko-funkcionalne poteze za 205 rastlinskih vrst srednjeevropskih in dinarskih travnikov. Podatki so bili v osnovi kategorični (cat), zvezni (cont) ali binarni (bin).***

| **Traits** | **Abbreviation and description** | **Data source** |
|---|---|---|
| Life cycle | LC_Annu = annual; LC_Bien = biennial; LC_Pere = perennial | Hegi, 1958, 1963, 1964, 1965, 1966, 1974, 1987; Martinčič *et al.*, 2007 |
| Growth form | GF_Tuss = tussocks; GF_Rose = rosette; GF_le_st = leafy stem; GF_ro_le = rosette and leafy stem; GF_clim = climb | Hegi, 1958, 1963, 1964, 1965, 1966, 1974, 1987; Rothmaler, 1995; Martinčič *et al.*, 2007 |
| Vegetation propagation | Veg_0 = absent; Stolon = stolons; Rhizom = rhizomes; Bulb_il = Bulb and Bulbil; Root_sho = root shoot; Tuber = bud with root and shoot tuber; Fragment = Fragmentation | BiolFLor (Klotz *et al.*, 2002); own measurements; |
| Storage organs | Sto_org = present; Sto_org0 = absent | own measurements |
| Spinescence | Spi_pres = present; Spine_0 = absent | Hegi, 1958, 1963, 1964, 1965, 1966, 1974, 1987; Martinčič *et al.*, 2007 |
| Hairiness | Hair_low = low; Hair_hig = high; Hair_0 = absent | Hegi, 1958, 1963, 1964, 1965, 1966, 1974, 1987; Poldini, 1991; Martinčič *et al.*, 2007 |
| Height | Plan_hig = cm | own measurements |
| Specific leaf area | SLA = mm$^2$/mg | LEDA database (Kleyer *et al.*, 2008); own measurements |
| Leaf dry matter content | LDMC = mg/g | LEDA database (Kleyer *et al.*, 2008); own measurements |
| Flowering start | Flo_star = months | Hegi, 1958, 1963, 1964, 1965, 1966, 1974, 1987; Poldini, 1991; Martinčič *et al.*, 2007 |
| Flowering length | Flo_peri = months | Hegi, 1958, 1963, 1964, 1965; 1966, 1974, 1987; Poldini, 1991; Martinčič *et al.*, 2007 |
| Leaf persistence | LP_1 = spring green; LP_2 = summer green; LP_3 = overwintering green; LP_4 = persistent green | BiolFLor (Klotz *et al.*, 2002); own measurements |
| Leaf anatomy | LA_1= succulent; LA_2 = scleromorphic; LA_3 = mesomorphic; LA_4 = hygromorphic | BiolFLor (Klotz *et al.*, 2002); own measurements |
| Type of reproduction | Repr_1 = by seed/by spore; Repr_2 mostly by seed, rarely vegetatively; Repr_3 = by seed and vegetatively; Repr_4 = mostly vegetatively, rarely by seed; Repr_5 = vegetatively | BiolFLor (Klotz *et al.*, 2002) |

### Functional trait indices

To assess the functional trait composition we are using two approaches, which are increasingly used in functional composition (Diaz *et al.*, 2007). For that we combined the species by relevé matrix with the corresponding species by trait matrix.

First was calculated the community-weighted mean trait values (CWM) for each relevé as the average of trait values weighted by the relative abundance of each species (Garnier *et al.*, 2004; Lepš *et al.*, 2006; Lavorel *et al.*, 2008; Moretti *et al.*, 2009; Ricotta & Moretti, 2010, 2011). The metric is computed simply as:

$$CWM_{jk} = \sum_{i=1}^{S} p_{ik} \times x_{ij}$$

Where $CWM_{jk}$ is the community-weighted mean value of trait j at site k, $p_{ik}$ is the relative abundance of species *i* (i = 1, 2 ... S) at site k; and $x_{ij}$ is the value of trait j for species i (Ricotta & Moretti, 2010). This operation results in a matrix of 40 new traits by 118 relevés (matrix CWM).

Secondly, the functional diversity index (FD hereafter) was proposed by Lepš *et al.* (2006) to measure the functional diversity index of single traits with the Rao

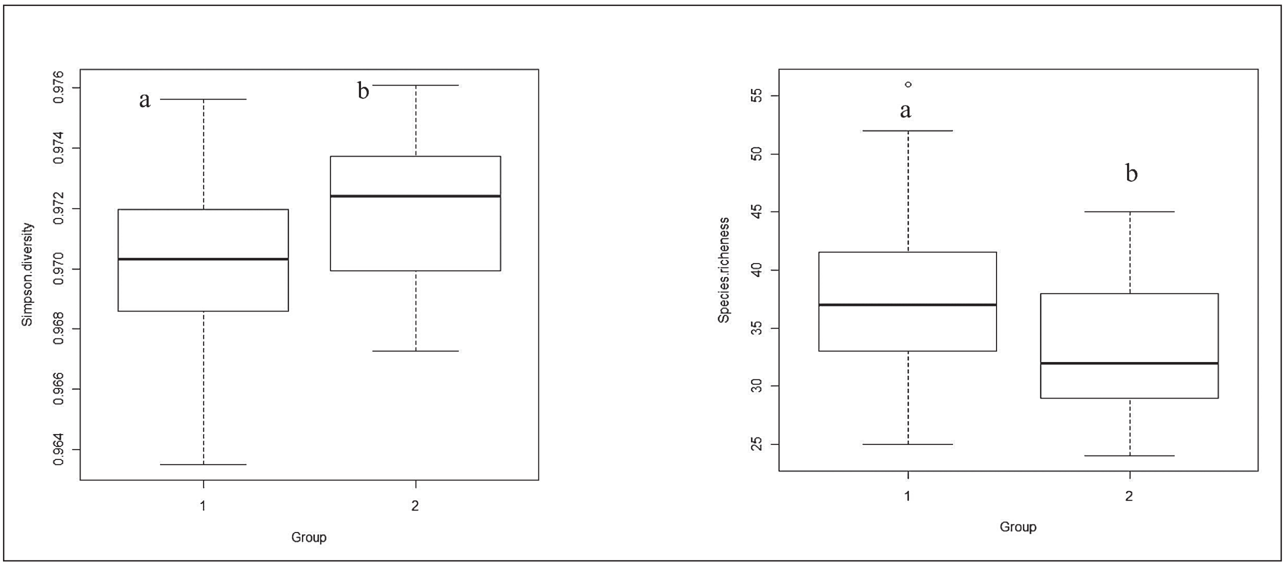

***Fig 2: Simpson diversity (left) and species richness (right) from two neighbouring biogeographic regions. Group 1 is from Central European meadows and Group 2 is from Dinaric meadows. Different letters indicate significant differences among locations (Student's* t*-test,* p *< 0.05).***

***Sl. 2: Simpson diverzitetni indeks (levo) in vrstna pestrost (desno) iz dveh sosednjih biogeografskih območij. Skupina 1 so srednjeevropski travniki, Skupina 2 pa dinarski travniki. Črke prikazujejo statistično značilne razlike med območjema (Studentov* t*-test,* p *< 0,05).***

(1982) quadratic diversity. If the proportion of i-th species in a community is $p_i$ and the dissimilarity of species i and j is $d_{ij}$, the Rao coefficient takes the form:

$$FD = \sum_{ij}^{S} d_{ij} \times p_i \times p_j$$

S is the number of species in the community. Calculations were performed using an Excel macro (Lepš *et al.*, 2006). This operation results in a matrix of 14 FD indices for each trait by 118 relevés (matrix FD).

### Data analysis

Changes in species composition (Species richness and Simpson diversity) between Central European and Dinaric meadows was analysed with a Student's *t*-test for independent samples (R Development Core Team, 2008) (Fig. 2).

To test differences in the CWM and FD indices between Central European and Dinaric meadows, we analysed data with a Student's *t*-test for independent samples (R Development Core Team, 2009) (Tab. 2). Type error I was controlled by Bonferonni correction of significance values (Rice, 1989).

The CWM and FD indices was further analysed by means of Principal Component Analysis (PCA) (Goodall, 1954). Only traits with significant differences in their CWM and FD values between Central European and Dinaric meadows (Student's *t*-test) were used for PCA. Gradient length for the first PCA axis of ordination was in both cases lower than three, indicating that linear ordination methods are suitable for the analysis. The ordination method (PCA) and visualization of their result was carried out using the Canoco and CanoDraw programs (ter Braak & Šmilauer, 2002).

## RESULTS

Across 118 plots (relevés) we recorded and included in dataset 205 vascular plant species with 68 species common to both regions, 83 species exclusive to the Dinaric and 54 exclusive to the Central European meadows. Student's *t*-test revealed strongly significant differences in both Species richness ($p < 0.001$) and Simpson diversity ($p < 0.001$) of meadows between regions. There was evidently higher species richness in Central European region (37 ± 6) in comparison to Dinaric region (33 ± 5). By contrast, Simpson species diversity was higher for Dinaric region (0.97 ± 0.003) than for the Central European region (0.96 ± 0.002). This indicates that Dinaric semi-dry meadows have lower species dominance and higher evenness than the Central European meadows.

In order to identify the predominant plant traits for studied vegetation, the (CWM) were analyzed with PCA. The ordination graph is presented in Figure 3, where only traits with significant differences in their CWM values (n = 25) between both type of meadows are shown.

***Tab. 2: Results of Student's t-test for aggregated traits (CWM community-weighted means) values and functional trait diversity (FD) between Central European (n = 67) and Dinaric (NW Balkan) meadows (n = 51). CWM values for binary and categorical plant traits are in percentages.***

***Tab. 2: Rezultati Studentovega t-testa za CWM (srednje vrednosti morfološko-funkcionalne poteze) vrednosti in funkcionalne pestrosti (FD) med srednjeevropskimi (n = 67) in dinarskimi (S Balkan) travniki (n = 51). CWM vrednosti za binarne in kategorične morfološko-funkcionalne poteze so v procentih.***

| **Plant functional traits** | **Abbreviation of specific plant** | **Abbreviation of specific plant** | **CWM** | | | **FD** | | |
|---|---|---|---|---|---|---|---|---|
| | | | Central European | Dinaric | *p* | Central European | Dinaric | *p* |
| Life cycle | LC | LC_Annu | 5.09 | 3.83 | / | 0.181 | 0.102 | *** |
| | | LC_Bien | 4.81 | 1.51 | *** | | | |
| | | LC_Pere | 90.10 | 94.67 | *** | | | |
| Growth form | GF | GF_Tuss | 30.74 | 26.10 | *** | 0.665 | 0.626 | *** |
| | | GF_Rose | 8.56 | 12.43 | *** | | | |
| | | GF_le_st | 44.65 | 51.24 | *** | | | |
| | | GF_ro_le | 15.41 | 10.23 | *** | | | |
| | | GF_clim | 0.64 | 0 | / | | | |
| Vegetation propagation | Veg | Veg_0 | 8.34 | 11.04 | *** | 0.710 | 0.625 | *** |
| | | Stolo | 23.50 | 10.90 | *** | | | |
| | | Rhizom | 41.30 | 54.94 | *** | | | |
| | | Bulb_il | 0.33 | 0.19 | / | | | |
| | | Root_sho | 5.34 | 5.46 | / | | | |
| | | Tuber | 4.27 | 1.24 | *** | | | |
| | | Fragment | 16.92 | 16.23 | / | | | |
| Storage organs | Sto_Org | Sto_org | 91.97 | 92.70 | / | 0.143 | 0.128 | / |
| | | Sto_org0 | 7.84 | 7.11 | / | | | |
| Spinescence | Spine | Spi_pres | 1.91 | 4.50 | *** | 0.036 | 0.085 | *** |
| | | Spine_0 | 98.09 | 95.50 | *** | | | |
| Hairiness | Hairness | Hair_low | 33.62 | 42.18 | *** | 0.658 | 0.635 | *** |
| | | Hair_hig | 35.06 | 23.42 | *** | | | |
| | | Hair_0 | 31.33 | 34.40 | / | | | |
| Plant height | Plant_he | Plan_hig = cm | 38.01 | 36.84 | / | 0.182 | 0.176 | / |
| Specific leaf area | SLA | SLA = mm$^2$/mg | 17.38 | 14.54 | *** | 0.153 | 0.118 | *** |
| Leaf dry matter content | LDMC | LDMC = mg/g | 283.95 | 304.82 | *** | 0.177 | 0,179 | / |
| Phenology | Phenolog | | | | | 0.445 | 0.474 | *** |
| | | Flo_star = months | 5.35 | 5.45 | / | | | |
| | | Flo_peri = months | 3.66 | 3.44 | *** | | | |
| Leaf persistence | LP | LP_1 | 1.54 | 1.47 | / | 0.504 | 0.451 | *** |
| | | LP_2 | 57.96 | 66.93 | *** | | | |
| | | LP_3 | 1.41 | 1.04 | / | | | |
| | | LP_4 | 39.09 | 30.56 | *** | | | |
| Leaf anatomy | LA | LA_1 | 0 | 0.05 | / | 0.424 | 0.486 | *** |
| | | LA_2 | 30.89 | 47.78 | *** | | | |
| | | LA_3 | 68.73 | 52.33 | *** | | | |
| | | LA_4 | 0.71 | 0.19 | *** | | | |
| Type of reproduction | Repr | Repr_1 | 34.00 | 35.40 | / | 0.674 | 0.628 | *** |
| | | Repr_2 | 20.88 | 16.61 | *** | | | |
| | | Repr_3 | 39.56 | 44.69 | / | | | |
| | | Repr_4 | 5.05 | 2.78 | / | | | |
| | | Repr_5 | 0.51 | 0.52 | / | | | |

*** $p < 0.001$

/ not significant

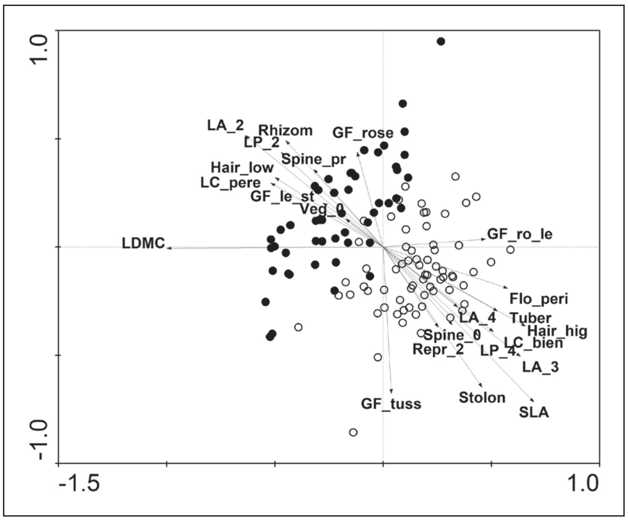

***Fig. 3: PCA ordination diagram of matrix CWM with 118 relevés and 23 plant functional traits. Only traits (n = 23) with significant differences in their CWM values between Central European and Dinaric meadows (Student's* t*-test) are shown. Eigenvalues: axis 1 = 0.993, axis 2 = 0.006. Relevés divided in two groups according to region: ● – Dinaric, ○ – Central-European. Abbreviations of plant traits are explained in Table 1.***

***Sl. 3: PCA-ordinacija matrike CWM s 118 popisi in 23 morfološko-funkcionalnimi potezami. Prikazane so samo tiste morfološko-funkcionalne poteze (n = 23), pri katerih so statistično značilne razlike (Studentov* t*-test) med srednjeevropskimi in dinarskim travniki. Lastne vrednosti: os 1 = 0,993, os 2 = 0,006. Popisi so ločeni v dve skupini glede na območje: ● – dinarski travniki, ○ – srednjeevropski travniki. Razlage okrajšav za morfološko-funkcionalne poteze so v tabeli 1.***

Relevés of both vegetation types are again clearly divided, which indicates that the Central European and Dinaric meadows differ in community trait composition. Analysis of plant life form and cycle showed that the Dinaric meadows had significantly higher CWM for perennials (LC_pere), whereas that of annuals (LC_annu) was significantly higher in the Central European meadows. The Dinaric meadows also had significantly higher CWM for spinescens present (Spin_pres), rosette and leafy stem growth form (GF_rose, GF_le_st), while the Central European meadows had more tussock (*e.g.* grasses) (GF_tuss) and hairy plants (Hair_low, Hair_hig). There were no significant differences in CWM for plant height (Plan_hei).

The two meadow communities differed in most foliar traits. Compared to Central European meadows, Dinaric meadows had significantly greater CWM values for LDMC and summer green and scleromorphic leaves (LP_2, LA_2) and consequently lower CWM values for SLA, persistent green (LP_4) and mesomorphic (LA_3) leaves. Analysis of flower phenology showed that the onset of flowering was significantly earlier and the flowering period longer in the Central European meadows. Analysis of clonality revealed that non-clonal plants (Veg_0) and clonal plants with rhizomes (Rhizom) were proportionally higher in Dinaric meadows, while plants with stolons (Stolon) and tubers (Tuber) were more common in the Central European region (Tab. 2).

The Central European and Dinaric meadows differed significantly in FD (Fig. 4) of most analysed traits or trait groups (Tab. 2). FD for the flower phenology, spinescence and leaf anatomy was significantly greater in the Dinaric semi-dry meadows, when compared to the central European semi-dry meadows, while the diversity in SLA, life cycle, growth form, vegetation propagation, hairiness, leaf persistence and type of reproduction was significantly higher in the Central European sites. There were no significant differences in FD for storage organs, plant height and LDMC between the floristic regions ($p < 0.001$) (Tab. 2).

## DISCUSSION

Semi-natural dry grasslands are the main remnants of the traditional agricultural landscape in Europe, and they are among the most species-rich habitats in terms of the number of plant species they support per unit area (Zobel *et al*., 1996; Wallis DeVries *et al*., 2002; Kaligarič *et al*., 2006; Purschke *et al*., 2012). Therefore, many studies on plant biodiversity have been concerned with these plant communities (Pärtel & Zobel, 1999; Eriksson *et al*., 2002; Johansson *et al*., 2011; Vitasović-Kosić *et al*., 2011; Habel *et al*., 2013; Pipenbaher *et al*., 2013a, 2013b).

The high species richness of the Slovenian Central European and Dinaric semi-dry meadows has already been confirmed by previous studies (Kaligarič *et al*., 2006; Škornik *et al*., 2010; Pipenbaher *et al*., 2013a). This study supports these findings. Additionally, we found greater species richness per plot for the Central European meadow community. Focusing on species richness, could, however mask important differences among species in abundance (or evenness), and since the Central European meadow community has higher species dominance and lower evenness (*Briza media, Bromus erectus, Salvia pratensis,* etc.) it is less diverse than the Dinaric, in which several different species have a similar abundance.

In most studies linking biodiversity to ecosystem functioning, species richness has been used as the main index (Lepš, 2004; Schmidt & Hector, 2004). However, since it is generally understood that species make a difference in the functioning of ecosystems because of their differences in traits, measures of community trait composition and functional diversity tend to correlate more strongly than those of traditional species-diversity with ecosystem functions (Petchey & Gaston, 2006; Ricotta & Moretti, 2010, 2011). According to our results, meadow

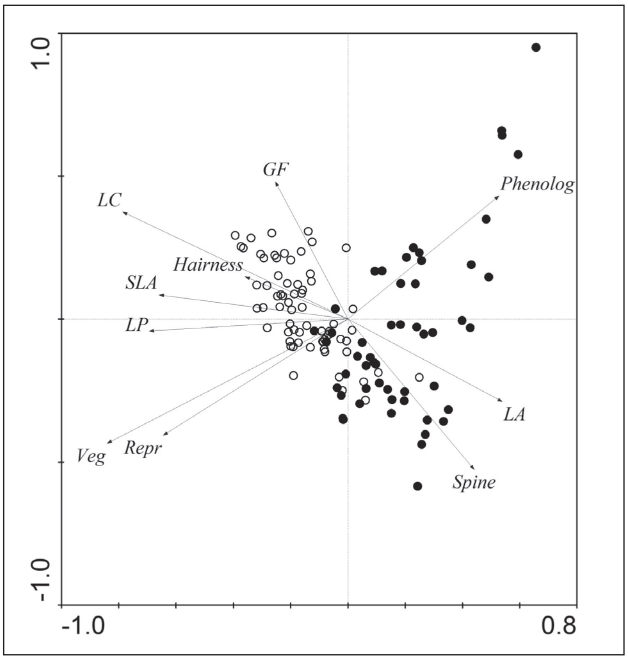

***Fig. 4: PCA ordination diagram of Functional diversity matrix with 118 relevés and 10 indices of functional diversity. Only traits (n = 10) with significant differences in their FD values between Central European and Dinaric meadows (Student's* t*-test) are shown. Eigenvalues: axis 1 = 0.412, axis 2 = 0.144. Relevés divided in two groups according to region: ● – Dinaric; ○ – Central-European. Abbreviations of plant traits are explained in Table 1.***

***Sl. 4: PCA-ordinacija matrike funkcionalne pestrosti s 118 popisi in 10 indeksi funkcionalne pestrosti. Prikazane so samo tiste morfološko-funkcionalne poteze (n = 23), pri katerih so statistično značilne razlike v funkcionalni pestrosti (Studentov* t*-test) med srednjeevropskimi in dinarskimi travniki. Lastne vrednosti: os 1 = 0,412, os 2 = 0,144. Popisi so ločeni v dve skupini glede na območje: ● – dinarski travniki; ○ – srednjeevropski travniki. Razlage okrajšav za morfološko-funkcionalne poteze so v tabeli 1.***

communities from separate regions differed markedly in community trait composition at least for the set of traits studied. This is remarkable, given that meadows in both regions occur on similar substrate types and experience similar management practices.

While some authors (Lavorel *et al.*, 2008) consider CWM to be one of the indices for "functional diversity", most authors do not (*e.g.,* Mouchet *et al.*, 2010; Schleuter *et al.*, 2010). Whereas the term "diversity" is related to the concept of variety, variability, etc., CWM is rather a measure of central tendency, like the mean or the median (Ricotta & Moretti, 2011). In our study, differences in CWM between communities are mainly associated with dominant and subdominant species with particular traits. In the Central European meadows where we found lower species diversity tussock species are dominant, whereas in the Dinaric region these meadows are dominated by species with rosettes and leafy stems. In addition, our results confirm the suggestion of Pipenbaher *et al.* (2013a) about the stronger effect of eutrophication and local disturbance on the Central European semi-dry meadows. These plant communities are distinguished not only by higher SLA and LDMC (Pipenbaher *et al.*, 2013a) but also by higher numbers of species with mesomorphic leaves and annuals. It has been shown in other studies that annuals (therophytes) are promoted by intensification of land use (Bullock *et al.*, 1994; Škornik *et al.*, 2010), as they are more tolerant of disturbance, owing to their fast growth rates and early, prolific seed set (Grime, 1974). A similar interpretation could also apply to reproductive strategies. In our study, early flowering also appears to be promoted in Central European meadows, since annuals (*Rhinanthus aristatus, Veronica arvensis,*) tend to flower early in the vegetation season.

While differences in CWM between communities are mainly associated with dominant and subdominant species with particular traits, differences in functional diversity are related to differences in the number of niches available along the ecological gradients (Ricotta & Moretti, 2011). Therefore, along gradients, environmental filters may operate with different intensities and assamble different plant communities from the available species pool (Grime, 2006; Pausas & Verdú, 2010). According to our results, the strong floristic distinctiveness of the Central European and Dinaric regions (Pipenbaher *et al.,* 2013a) is also accompanied by strong functional diversification. For most traits, the diversity was greater in the Central European meadows. In these meadows functional variation in growth form, vegetation propagation, SLA and leaf persistence, provide evidence for limiting similarity probably owing to stronger disturbance impact in this community than in the Dinaric meadows, which is consistent also with our explanation of the observed differences among regions comparing the CWM. Disturbance is known as the most potent force creating and sustaining trait divergence (Grime, 2006), although this declines at high disturbance frequencies (Grime, 1974).

The differences in functional diversity between regions suggest that communities which appear physiognomically similar (analysis of plant height confirmed a similar community vertical structure in the two meadow types) may be markedly different in the number of available niches. The strong evidence for divergence in functional composition between meadows from different regions suggests that functional trait composition is unlikely to be a deterministic function of similar environmental conditions (e.g., substrate type) and land use in geographically disjunct communities. Meadows from the Central European region had a functional trait composition typical of more ruderal communities, which may reflect the higher density of ruderal seed resources in this region, arising from increased anthropogenic disturbance. This may have important implications for conservation management of these meadows. For example, given that traits characteristic of ruderal strategists were more common in the Central European region, maintenance of species diversity in these meadows is likely to be much more dependent on the application of a regular disturbance regime, such as mowing, than for the Dinaric region. Moreover, functional composition is very likely a key factor determining the susceptibility of a grassland community to a community changes, very often in the direction of lower conservation value for the grasslands. Traditional management practices and land abandonment in general have occurred almost everywhere in the montane belt of Central and South-Eastern Europe, but within the Balkan range, meadows are still common and currently not yet endangered, as the Central European ones certainly are (Kaligarič & Škornik, 2002; Molnár *et al.*, 2008; Vitasović-Kosić *et al.*, 2011; Pipenbaher *et al.*, 2013a).

# PRIMERJAVA FLORISTIČNE IN FUNKCIONALNE PESTROSTI MED TRAVNIKI IZ DVEH SOSEDNJIH BIOGEOGRAFSKIH OBMOČIJ

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## *POVZETEK*

*V pričujočem članku smo proučevali floristično in funkcionalno pestrost sekundarnih travišč, in sicer na stičnem območju dveh biogeografskih regij – srednjeevropske in dinarske (S Balkanske). Primerjali smo dva tipa fiziognomsko podobnih travišč iz asociacij* Danthonio-Scorzoneretum *(dinarski travniki) in* Onobrychido viciifoliae-Brometum *(srednjeevropski travniki). Travišča so se v obeh regijah razvila v podobnih okoljskih razmerah (tip tal, nadmorska višina in količina padavin) in imajo podobno rabo. To so polsuhi travniki, ki so se razvili na naravno rodovitnih rjavih pokarbonatnih tleh. Primerjali smo ju glede na vrstno pestrost, srednjo vrednost funkcionalnih potez (angl. community-weighted mean, CWM) in funkcionalno pestrost (angl. functional diversity, FD). Medtem ko je CWM merjena, kot povprečna vrednost posamezne morfološko-funkcionalne poteze (MFP), predstavlja indeks funkcionalne pestrosti povezavo z raznolikostjo posamezne MFP. Baza podatkov je obsegala 118 fitocenoloških popisov omenjenih asociacij. V popisnih ploskvah smo zabeležili skupaj 205 različnih rastlinskih vrst. Ugotovili smo, da imajo srednjeevropski travniki v povprečju večje število vrst na popisno ploskev kot dinarski. Ker pa imajo srednjeevropski travniki več dominantnih vrst in manjšo enakomernost števičnosti osebkov posamezne vrste, je njihova vrstna pestrost nižja v primerjavi z dinarskimi travniki. Srednjeevropski polsuhi travniki vsebujejo več enoletnic, večje število rastlin z višjimi vrednostmi za specifično listno površino (SLA) in nižjimi vsebnostmi suhe snovi lista (LDMC). Na podlagi teh rezultatov lahko sklepamo, da so ti travniki bolj podvrženi motnjam kot dinarski travniki. Našli smo tudi velike razlike v funkcionalni pestrosti med obema tipoma travnikov. Za večino MFP je raznolikost večja na srednjeevropskih travnikih. Ti rezultati potrjujejo, da so ti travniki močneje izpostavljeni motnjam. Kot ugotavljajo avtorji različnih študij, je motnja med najpomembnejšimi dejavniki, ki ustvarjajo funkcionalno raznolikost v rastlinskih skupnostih. Naše ugotovitve so pomembne in uporabne tudi pri načrtovanju naravovarstvenih strategij za ohranjanje teh travišč. Glede na to, da motnja tako odločilno vpliva na vrstno sestavo srednjeevropskih travnikov, lahko sklepamo, da je vzdrževanje redne košnje le-teh pomembnejše kot v primeru dinarskih polsuhih travnikov. Zaključimo lahko, da je funkcionalna sestava med ključnimi dejavniki, ki odražajo občutljivost vegetacije na spremembe v okolju, posledica katerih je pogosto razvoj vegetacije nižje naravovarstvene vrednosti.*

**Ključne besede**: morfološko-funkcionalne poteze, polsuhi travniki, srednjeevropski travniki, dinarski travniki

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# DELA NAŠIH ZAVODOV IN DRUŠTEV

# ATTIVITÀ DEI NOSTRI ISTITUTI E DELLE NOSTRE SOCIETÀ

# ACTIVITIES BY OUR INSTITUTIONS AND ASSOCIATIONS

## 4. SLOVENSKI ENTOMOLOŠKI SIMPOZIJ Z MEDNARODNO UDELEŽBO

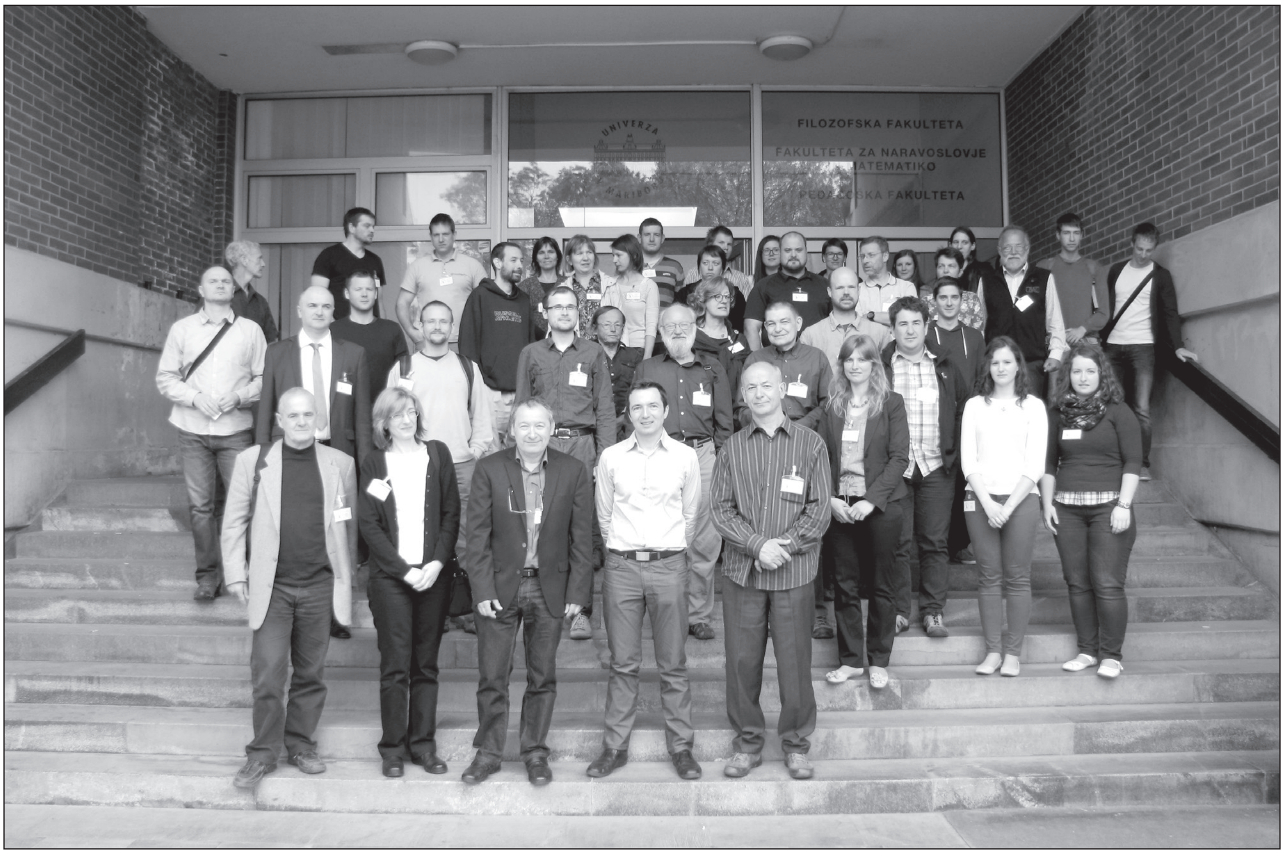
### 9. in 10. maj 2014, Maribor

Na Fakulteti za naravoslovje in matematiko Univerze v Mariboru je letos potekal Četrti slovenski entomološki simpozij z mednarodno udeležbo, ki so ga organizirali zoologi Oddelka za biologijo in Inštituta za biologijo, ekologijo in varstvo narave Fakultete za naravoslovje in matematiko, skupaj s Slovenskim entomološkim društvom Štefana Michielija. Simpozija se je udeležilo več kot 50 entomologov iz Slovenije, Avstrije, Bosne in Hercegovine, Italije, Nizozemske, Srbije in Velike Britanije. Uradna jezika simpozija sta bila slovenski in angleški.

Simpozij je potekal dva dni. Po začetnih pozdravnih nagovorih dekanice gostiteljske fakultete, prof. dr. Nataše Vaupotič, glavnega organizatorja simpozija prof. dr. Dušana Devetaka in predsednika Slovenskega entomološkega društva Štefana Michelija, mag. Slavka Polaka, sta sledili predavanji vabljenih predavateljev. Dr. Gerd Leitinger z Medicinske univerze v Gradcu je predaval o uporabi vrstične elektronske mikroskopije pri ugotavljanju povezav med nevroni in receptorskimi celicami v očesu kobilic. V drugem vabljenem predavanju je dr. Predrag Jakšić z Univerze v Nišu predstavil zoogeografske značilnosti razporeditve dnevnih metuljev v višjih predelih Panonske nižine. Po vabljenih predavanjih so prišla na vrsto predavanja iz ekologije, fiziologije, morfologije in vedenja žuželk.

Naslednji dan se je začel z vabljenim predavanjem dr. Mirze Dautbašića z Univerze v Sarajevu. Tema predavanja so bile ksilofagne žuželke, ki naseljujejo vrsto bora *Pinus heldreichii,* ki je endemit dela Balkana. Sledila so predavanja s področja naravovarstva, aplikativne entomologije, sistematike in favnistike žuželk.

V dveh dneh se je zvrstilo 32 predavanj, štirje avtorji pa so predstavili tudi pet posterjev. V knjigi povzetkov, ki je dostopna na spletni strani simpozija (http://4ses.fnm.uni-mb.si/), so zbrani povzetki vseh prispevkov, ki so jih pripravili udeleženci.



***Udeleženci 4. slovenskega entomološkega simpozija.***
***Participants of the 4th Slovenian Entomological Symposium.***

Zaključimo lahko, da je bil simpozij uspešno izveden in je potekal v prijetnem vzdušju ter druženju. K temu so prispevali predvsem udeleženci s predstavitvami najnovejših rezultatov raziskav z različnih področij entomologije.

## 4th SLOVENIAN ENTOMOLOGICAL SYMPOSIUM WITH INTERNATIONAL ATTENDANCE

### 9th and 10th May 2014, Maribor

The 4th Slovenian entomological symposium with international attendance was organized by the Faculty of Natural Sciences and Mathematics of the University of Maribor. The organizers were zoologists from the Department of Biology and the Institute for Biology, Ecology and Nature Conservation of the Faculty of Natural Sciences and Mathematics, with help of the Slovenian Entomological Society of Štefan Michieli. More than 50 entomologists from Slovenia, Austria, Bosnia and Herzegovina, Italy, the Netherlands, Serbia and the United Kingdom attended the symposium. The official languages of the symposium were Slovenian and English.

The symposium was carried out in two days. After the introductory speeches of the Dean of the host institution, Prof. Dr. Nataša Vaupotič, the chief organizer, Prof. Dr. Dušan Devetak and the president of the Slovenian Entomological Society of Štefan Micheli, Mag. Slavko Polak, invited lectures followed. Dr. Gerd Leitinger from the Medical University of Graz presented the use of serial block face scanning electron microscopy for discovering the synapses between photoreceptors and neurons in locust eye. Dr. Predrag Jakšić from the University of Niš presented zoogeographic distribution of butterflies in higher regions of the Panonian plain. Lectures about ecology, physiology, morphology and ethology of insects followed.

The second day begun with another invited lecture. Dr. Mirza Dautbašić from the University of Sarajevo presented the xylophagous insects on *Pinus heldreichii,* an endemic pine for part of the Balkan Peninsula. The following lectures covered topics about nature conservation, applied entomology, faunistics and systematics of insects.

Over the two days 32 presentations took place. Also, five posters were presented by four authors. All contributions are included in the book of abstract, which is available on the web page of the symposium (http://4ses.fnm.uni-mb.si/).

In conclusion, the symposium was successfully executed and was held in a pleasant atmosphere, especially on account of participants, who presented their latest results from different fields of entomology.

**Jan Podlesnik**

# IN MEMORIAM

# V SPOMIN PROFESORJU, MENTORJU, SODELAVCU IN PRIJATELJU PROF. DR. JURIJU PIŠKURJU

Prof. dr. Jurij Piškur je bil vrhunski znanstvenik, biolog, biokemik, molekularni biolog in genetik. Živel je za znanost in je pustil velik pečat na področju genetike in molekularne biologije kvasovk. Živel pa je tudi za ljudi v znanosti, premikal je meje v razmišljanju in bil s svojo energijo in zagnanostjo navdih mnogim. Bil je izreden pedagog in mentor – v znanosti, pa tudi v življenju na sploh. Številni študenti in sodelavci, tako v tujini kot doma, bodo njegove zamisli razvijali tudi v prihodnje.

Prof. dr. Jurij Piškur je polovico svojega življenja preživel v tujini, ob tem pa je ves čas vzdrževal strokovne in osebne stike z domovino. Gimnazijo je končal v svojem rodnem kraju Celju, nadaljeval študij na Univerzi v Ljubljani in leta 1984 prejel Prešernovo nagrado s področja bakterijske genetike. Po končani diplomi s področja biofizike DNA na Oddelku za biologijo Biotehniške fakultete Univerze v Ljubljani je študij nadaljeval v Avstraliji. Leta 1989 je na Avstralski nacionalni Univerzi v Canberri doktoriral s področja molekularne biologije in genetike kvasovk. Po doktoratu se je vrnil v Evropo in se zaposlil na Oddelku za genetiko kvasovk laboratorija v Carlsbergu na Danskem. Znanstveno pot je nadaljeval kot docent za molekularno genetiko na Oddelku za genetiko na Univerzi v Köbenhavnu, kjer je osnoval svojo prvo raziskovalno skupino v starosti 31 let. Od leta 2004 je bil redni profesor molekularne genetike na Oddelku za biologijo Univerze v Lundu (LU) na Švedskem. V sklopu lundske univerze je sodeloval tudi pri izvedbi doktorskega študijskega programa Geneco in pri ustanovitvi platforme za produkcijo proteinov za potrebe sinhrotrona MAX IV in ESS (European Spallation Source) centra za raziskave materialov, z najzmogljivejšim virom nevtronov na svetu. Bil je tudi vodja raziskovalnega konzorcija Cornucopia (2009–2015), ki ga financira evropska unija in ga sestavlja enajst akademskih in industrijskih partnerjev. V zadnjih dvajsetih letih je redno obiskoval Slovenijo, kjer je imel številna predavanja v raziskovalnih organizacijah ter na konferencah. Posebej intenzivno je sodeloval z Morsko biološko postajo Nacionalnega inštituta za biologijo ter z Univerzo v Novi Gorici, kjer je bil od leta 2010 delno zaposlen kot redni profesor.

Glavna raziskovalna področja prof. dr. J. Piškurja pokrivajo metabolizem prekurzorjev nukleinskih kislin, gensko zdravljenje, primerjalno genomiko in molekularno evolucijo kvasovk. Njegova glavna odkritja so novi encimi, kot je multisubstratna deoksiribonukleozid kinaza (EC 2.7.1.145), ki predstavlja model za biokemijsko razumevanje aktivacije zdravil proti raku. Encim je uporaben pri »zeleni« sintezi nukleozidnih učinkovin in ga od leta 1998 dalje proizvaja podjetje Roche Diagnostics. Pomemben je tudi njegov doprinos k odkritju samomorilskih genov za gensko terapijo raka. Na področju vinarstva in študija kvasovk je veliko prispeval k uvedbi, razvoju in popularizaciji novih modelnih organizmov, kot so kvasovke *Saccharomyces kluyveri*, *S. castellii* in *Dekkera/Brettanomyces bruxellensis*, ter postavitvi hipoteze o neenaki evoluciji podvojenih genov in evoluciji kvasovk. V sklopu evropskega projekta Cornucopia je preučeval, kateri geni so ključni za kvaliteto vina, piva in hrane. Svoje raziskave je opisal v več kot 120 znanstvenih člankih, med katerimi so številni objavljeni v vrhunskih revijah, kot je skupina Nature in PNAS, ter drugih znanstvenih revijah, kot so EMBO J., J. Mol. Biol., J. Biol. Chem., TIG, TIBS, Genetics itd. Bil je urednik znanstvenih revij FEMS Microbiol. Rev., FEMS Yeast Research in Trends in Evolutionary Biology ter urednik in soavtor znanstvenih knjig in obširnega učbenika o strukturni biologiji. Pred kratkim je izšla tudi knjiga o metabolizmu ogljika pri kvasovkah, pri kateri je bil sourednik. Poleg znanstvenih člankov je napisal veliko poljudnih člankov, nekatere tudi s svojo ženo Judito, posebno v času, ko je delal v Avstraliji in na Danskem. Prof. dr. J. Piškur je bil soustanovitelj več spin-off biotehnoloških podjetij (Jubile kinase, Jubi in ZGene), nekatera njegova odkritja s področja molekularne biologije in genetike pa so bila tudi patentirana. Intenzivno je sodeloval z industrijo, med drugim s svetovno znanimi podjetji, kot sta Carlsberg in Roche Diagnostics ter z Novo, Neurosearch, NsGene, Adorkem in Inbev. Posebno priznanje njegovim raziskovalnim dosežkom pred-

***(Vir: Univerza v Novi Gorici)***

stavlja njegova izvolitev v Kraljevo fiziografsko društvo v Lundu, eno od švedskih kraljevih akademij, leta 2005. Od leta 2010 dalje je deloval tudi v Odboru za znanost, pri Svetu za Slovence po svetu, ki je posvetovalno telo Vlade RS. Je prejemnik nagrade Miroslava Zeia Nacionalnega inštituta za biologijo v letu 2011 in prejemnik državnega priznanja Ambasador znanosti RS v okviru Zoisovih nagrad v letu 2012. Žal se je življenjska pot Jureta Piškurja sklenila sredi velikih načrtov za prihodnost – prav v teh dneh naj bi se ponovno zaposlil na Univerzi v Kopenhagnu, kjer je dobil mesto profesorja za področje živilske mikrobiologije.

Prof. dr. J. Piškur je bil mentor številnim dodiplomskim ter podiplomskim študentom in je sodeloval pri pisanju dodiplomskih študijskih programov na področju napredne evkariotske molekularne biologije in genetike, molekularne biologije kvasovk, biotehnologije in inovacij tako na danski tehnični univerzi (DTU) kot na lundski univerzi (LU). V njegovem laboratoriju so bili slovenski raziskovalci, mladi raziskovalci in študentje vedno dobrodošli, pa tudi on je pogosto predaval v domovini, zato bo za njim ostala praznina tudi v našem raziskovalnem prostoru. Bil je eden tistih izjemnih Slovencev, ki mu v tujini, kjer je vseskozi izredno uspešno znanstveno deloval, ni bilo vseeno, kaj se dogaja z znanostjo doma.

Iz izbranih odlomkov njegovega pisma je razvidno razmišljanje prof. dr. J. Piškurja o življenju in njegovem koncu, ljubezni do domovine, ljudi, predanosti znanosti in boju z boleznijo. Iz njega nas nagovarjajo njegov genialni um, visoka stopnja zavedanja in vse njegovo dobro.

*Rodili smo se na ta svet za določen čas, ki ga lahko zapolnimo z veseljem, delom, ambicijami, žalostjo, ljubeznijo in sovraštvom,…če smo zmožni čustvovati. Vse to lahko delimo z drugimi ljudmi, toda potem pride čas, ko se moramo umakniti. To je zakon narave. Prej ali slej nas posesa nazaj v ta veliki reciklirni stroj in postanemo deli in energija novih molekularnih kompleksov in celo novih bitij. Tako jaz kot znanstvenik, ki nisem religiozen, razumem svoj obstoj. In hvaležen sem da je bilo moje življenje dovolj dolgo, da sem lahko doživel močna čustva, kakor na primer biti ljubljen, ljubiti, uživati v življenju in sodelovati z drugimi ljudmi, biti del intenzivnega družinskega življenja, občudovati naravo in izpolniti znanstveno radovednost … Še vedno doživljam svoje otroštvo v domovini kot nekaj najlepšega. Slovenija mi vedno prinaša nove inspiracije, izzive in radost. Ko stojiš pred cerkvijo Svetega Jurija v Piranu in se zvonik in njegovi angeli dotikajo modrega neba in oči počivajo na Jadranskem morju … Ali si lahko bliže nebes? To je eno mojih najljubših mest, polno spiritualnosti, kjer se različne energije mešajo in lahko plavaš v času naprej in nazaj in srečaš kogar želiš, pra pra dedke in pra pra otroke… neskončna mešanica ljudi ...*

Jure, bil si profesor in mentor, vendar tudi izreden prijatelj. S svojim delom, zagnanostjo in energijo si se za vedno zapisal v naša srca.

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in Valentina Turk**

## NAVODILA AVTORJEM

**1.** Revija ANNALES (*Anali za istrske in mediteranske študije* Series historia naturalis) objavlja **izvirne znanstvene** in **pregledne članke** z naravoslovnimi vsebinami, ki obravnavajo posebnosti različnih podpodročij sredozemskega naravoslovja: morska biologija in ekologija, ihtiologija, geologija s paleontologijo, krasoslovje, oljkarstvo, biodiverziteta Slovenije, varstvo narave, onesnaževanje in varstvo okolja, fizična geografija Istre in Mediterana idr. Vključujejo pa tudi **krajše** znanstvene prispevke o zaključenih raziskovanjih., ki se nanašajo na omenjeno področje.

**2.** Sprejemamo članke v angleškem, slovenskem in italijanskem jeziku. Avtorji morajo zagotoviti jezikovno neoporečnost besedil, uredništvo pa ima pravico članke dodatno jezikovno lektorirati.

**3.** Članki naj obsegajo do 48.000 znakov brez presledkov oz. 2 avtorski poli besedila. Članek je mogoče oddati na e-naslov annales@mbss.org (zaželjeno) ali na elektronskem nosilcu (CD) po pošti na naslov uredništva.

Avtor ob oddaji članka zagotavlja, da članek še ni bil objavljen in se obvezuje, da ga ne bo objavil drugje.

**4. Naslovna stran** članka naj vsebuje naslov članka, ime in priimek avtorja (avtorjev), ime in naslov inštitucije, kjer je (so) avtor(ji) zaposlen(i) oz. domači naslov in naslovom elektronske pošte (samo prvi oz. korespondenčni avtor).

**5.** Članek mora vsebovati **povzetek** in **izvleček.** Izvleček je krajši (cca. 10 vrstic) od povzetka (cca. 30 vrstic).

V *izvlečku* na kratko opišemo namen, metode dela in rezultate. Izvleček naj ne vsebuje komentarjev in priporočil.

*Povzetek* vsebuje opis namena in metod dela ter povzame analizo oziroma interpretacijo rezultatov. V povzetku ne sme biti ničesar, česar glavno besedilo ne vsebuje. V povzetku se avtor ne sklicuje na slike, tabele in reference, ki so v članku.

**6.** Avtorji naj pod izvleček članka pripišejo ustrezne **ključne besede** (največ 6). Zaželjeni so tudi angleški (ali slovenski) prevodi izvlečka, povzetka, ključnih besed, podnapisov k slikovnemu in tabelarnemu gradivu. V nasprotnem primeru bo za prevode poskrbelo uredništvo.

**7. Glavni del besedila** naj vključuje sledeča poglavja: Uvod, Material in metode, Rezultati, Razprava ali Rezultati in razprava, Zaključki (ali Sklepi), Zahvala (če avtor želi), Literatura. Dele besedila je možno oblikovati v podpoglavja (npr. Pregled dosedanjih objav v Uvodu, Opis območja raziskav v Material in metode). Podpisi k slikam so priloženi posebej za poglavjem Literatura.

**8. Tabele** avtor priravi posebej na ločenih straneh v programu Word, tako kot rokopis, jih zaporedno oštevilči in opremi z naslovom – kratkim opisom. V glavnem delu besedila se sklicuje na tabele tako, da jih na ustreznem mestu označi z npr. "(Tab. 1)".

**9. Slikovno gradivo** (grafi, zemljevidi, fotografije, table) avtor posreduje v ločenih datotekah (jpeg, tiff) z najmanj 300 dpi resolucije pri želeni velikosti. Največja velikost slikovnega gradiva je 17x20 cm. Vsa potrebna dovoljenja za objavo slikovnega gradiva (v skladu z Zakonom o avtorski in sorodnih pravicah) priskrbi avtor sam in jih predloži uredništvu pred objavo članka. Slike je potrebno tudi podnasloviti in zaporedno oštevilčiti (glej točko 7). V glavnem delu besedila se avtor sklicuje na slike tako, da jih na ustreznem mestu označi z npr. "(Sl. 1)".

**10**. Bibliografske opombe, s čimer mislimo na **citat** – torej sklicevanje na druge publikacije, sestavljajo naslednji podatki v oklepaju: *avtor* in *leto izida*; npr. (Novak, 2007). Če sta dva avtorja, se izpišeta oba (Novak & Kranjc, 2001), če so trije ali več pa se izpiše samo prvi, ki mu sledi okrajšava *et al.* (Novak *et al.*, 1999). Več citatov je med seboj ločenih s podpičjem in si sledijo kronološko - z naraščajočo letnico izdaje, npr. (Novak *et al.*, 1999; Adamič, 2001; Kranjc & Zupan, 2007). Osebno informacijo (ustno, pisno) izpišemo prav tako v oklepaju z navedbo kratice imena in priimka posredovalca informacije, za vejico pa dodamo "osebno sporočilo", npr. (J. Novak, *osebno sporočilo*).

**11.** Celotni **bibliografski podatki** so navedeni v poglavju Literatura v abecednem vrstnem redu. Pri tem avtor navede izključno dela, ki jih je v članku citiral. Če ima isti avtor več bibliografskih podatkov, se najprej kronološko izpišejo tisti, kjer je edini avtor, sledijo dela v soavtorstavu še z enim avtorjem in dela v soavtorstvu z več avtorji. Imena revij, v katerih so izšla citirana dela, se izpišejo okrajašano (splošno priznane okrajšave revij). Članki, ki še niso bili publicirani, se lahko citirajo le, če so bili dokončno sprejeti v tisk, pri čemer se na koncu bibliografskega podatka doda beseda "v tisku". Člankov, ki so šele bili poslani v recenzijo, se ne sme citirati.

Primeri navajanje različnih tipov bibliografskih podatkov:

*članki v revijah:*

**Klock, J.-H., A. Wieland, R. Seifert & W. Michaelis (2007):** Extracellular polymeric substances (EPS) from cyanobacterial mats: characterisation and isolation method optimisation. Mar. Biol., 152, 1077-1085.

*Knjige in druge neserijske publikacije (poročila, diplomska dela, doktorske disertacije):*

**Wheeler, A. (1969):** The fishes of the British Isles and North-West Europe. McMillan, London, 613 p.

*Poglavje v knjigi:*

**McEachran, J. D. & C. Capapé (1984):** Myliobatidae. In: Whitehead, P. J. P., M. L. Bauchot, J.-C. Hureau, J. Nielsen & E. Tortonese (eds.): Fishes of the North-eastern Atlantic and the Mediterranean, Vol. 1. Unesco, Paris, pp. 205-209.

**12. Drugo:** latinski izrazi kot npr. *in vivo*, *in situ*, *e.g.*, *i.e.*, ter rodovna (*Myliobatis* sp.) in vrstna (*Myliobatis aquila*) imena se izpišejo v fontu italic. Kadarkoli je možno, se uporabljajo enote iz sistema SI (Système international d'unités).

**13.** Prvi odtis člankov uredništvo pošlje avtorjem v **korekturo.** Avtorji so dolžni popravljeno gradivo vrniti v enem tednu. Besedilo popravljamo s korekturnimi znamenji, ki jih najdemo na koncu Slovenskega pravopisa (2001), Ljubljana, ZRC SAZU, 24–25.

Širjenje obsega besedila ob korekturah ni dovoljeno. Druge korekture opravi uredništvo.

**14.** Za dodatna pojasnila v zvezi z objavo člankov je uredništvo na voljo.

UREDNIŠTVO

## ISTRUZIONI PER GLI AUTORI

**1.** La rivista ANNALES (*Annali per gli studi istriani e mediterranei*, Series historia naturalis) pubblica **articoli scientifici originali** e **compendii** dai contenuti scientifici relativi ai vari settori della storia naturale e pertinenti l'area geografica del Mediterraneo: biologia marina, ecologia, ittiologia, geologia, paleontologia, carsologia, olivicoltura, biodiversità della Slovenia, tutela della natura, inquinamento e tutela dell'ambiente, geografia fisica dell'Istria e del Mediterraneo ecc. La rivista pubblica anche articoli scientifici **brevi** relativi a ricerche concluse pertinenti a tali settori.

**2.** La Redazione accetta articoli in lingua inglese, slovena e italiana. Gli autori devono garantire l'ineccepibilità linguistica dei testi, la Redazione si riserva il diritto di una revisione linguistica.

**3.** Gli articoli devono essere di lunghezza non superiore alle 48.000 battute senza spazi, ovvero 2 fogli d'autore. Possono venir recapitati all'indirizzo di posta elettronica annales@mbss.org (preferibilmente) oppure su supporto elettronico (CD) per posta ordinaria all'indirizzo della Redazione.

L'autore garantirà l'originalità dell'articolo e si impegnerà a non pubblicarlo altrove.

**4.** Ogni articolo deve essere corredato da: **titolo**, nome e cognome dell'autore (autori), denominazione ed indirizzo dell'ente di appartenenza o, in alternativa, l'indirizzo di casa, nonché l'indirizzo di posta elettronica (solo del primo autore o dell'autore di corrispondenza).

**5.** I contributi devono essere corredati da un **riassunto** e da una **sintesi**. Quest'ultima sarà più breve (cca. 10 righe) del riassunto (cca 30 righe).

Nella *sintesi* si descriveranno brevemente lo scopo, i metodi e i risultati delle ricerche. La sintesi non deve contenere commenti e segnalazioni.

Il *riassunto* riporterà in maniera sintetica lo scopo, i metodi delle ricerche e l'analisi ossia l'interpretazione dei risultati. Il riassunto non deve riferirsi alle tabelle, figure e alla bibliografia contenuta nell'articolo.

**6.** Gli autori sono tenuti ad indicare le **parole chiave** adeguate (massimo 6). Sono auspicabili anche le traduzioni in inglese (o sloveno) della sintesi, del riassunto, delle parole chiave, delle didascalie e delle tabelle. In caso contrario, vi provvederà la Redazione.

**7. Il testo principale** deve essere strutturato nei seguenti capitoli: Introduzione, Materiali e metodi, Risultati, Discussione o Risultati e discussione, Conclusioni, Ringraziamenti (se necessari), Bibliografia. Il testo può essere strutturato in sottocapitoli (ad es. sottocapitolo Rassegna delle pubblicazioni nell'Introduzione; sottocapitolo Descrizione dell'area di ricerca nel capitolo Materiali e metodi). Le didascalie devono essere presentate separatamente, a seguito del capitolo Bibliografia.

**8. Le tabelle** saranno preparate in forma elettronica come il manoscritto (formato Word) e allegate in fogli separati alla fine del testo. Gli autori sono pregati di contrassegnare ogni tabella con un numero e il titolo ossia una breve descrizione. Nel testo la tabella viene richiamata come segue: (Tab. 1).

**9. Il materiale grafico** (grafici, carte geografiche, fotografie, tavole) va preparato in formato elettronico (jpeg o tiff) e consegnato in file separati, con una definizione di 300 dpi alla grandezza desiderata, purché non ecceda i 17x20 cm. Prima della pubblicazione, l'autore provvederà a fornire alla Redazione tutte le autorizzazioni richieste per la riproduzione del materiale grafico (in virtù della Legge sui diritti d'autore). Tutto il materiale grafico deve essere accompagnato da didascalie (vedi punto 7) e numerato.. Nel testo i grafici vengono richiamati come segue: (ad es. Fig. 1).

**10. I riferimenti bibliografici (citazioni)** richiamano un'altra pubblicazione (articolo). La nota bibliografica, riportata nel testo, deve contenere i seguenti dati tra parentesi: *cognome dell'autore*, *anno di pubblicazione*, ad es. (Novak, 2007). Se gli autori sono due, verranno indicati entrambi (Novak & Kranjc, 2001), nel caso di tre o più autori verrà indicato soltanto il primo, seguito dall'abbreviazione *et al.* (Novak *et al.,* 1999). Vari riferimenti bibliografici in una stessa nota vanno divisi dal punto e virgola e segnalati in ordine cronologico, ad. es. (Novak *et al.*, 1999; Adamič, 2001; Kranjc & Zupan, 2007). La testimonianza (orale, scritta) verrà indicata tra parentesi con l'abbreviazione del nome e con il cognome di chi l'ha trasmessa, seguiti dalla virgola e la dicitura "informazione personale", ad es. (J. Novak, *informazione personale*).

**11. La bibliografia** completa va inserita in ordine alfabetico nel capitolo Bibliografia. L'autore indicherà esclusivamente i lavori e le edizioni citati nell'articolo. Se si citano più lavori dello stesso autore, verranno indicati prima in ordine cronologico i lavori in cui l'autore appare solo, poi quelli in cui l'autore compare assieme ad un secondo coautore, seguiti infine da quelli in cui egli compare tra più coautori. I nomi delle riviste in cui sono pubblicati i lavori citati saranno indicati nella forma abbreviata (abbreviazioni ufficialmente riconosciute). Gli articoli inediti si possono citare soltanto se sono in corso di pubblicazione, facendo loro seguire la dicitura "in corso di pubblicazione". Gli articoli, non ancora recensiti non possono essere citati.

Esempio di lavoro bibliografico:

*Articoli in riviste:*

**Klock, J.-H., A. Wieland, R. Seifert & W. Michaelis (2007):** Extracellular polymeric substances (EPS) from cyanobacterial mats: characterisation and isolation method optimisation. Mar. Biol., 152, 1077-1085.

*Libri ed altre pubblicazioni non periodiche (relazioni, tesi di laurea, dissertazioni di dottorato):*

**Wheeler, A. (1969):** The fishes of the British Isles and North-West Europe. McMillan, London, 613 p.

*Capitoli di libro:*

**McEachran, J. D. & C. Capapé (1984):** Myliobatidae. In: Whitehead, P. J. P., M. L. Bauchot, J.-C. Hureau, J. Nielsen & E. Tortonese (eds.): Fishes of the North-eastern Atlantic and the Mediterranean, Vol. 1. Unesco, Paris, pp. 205-209.

**12. Altro:** Le espressioni latine come ad es. *in vivo*, *in situ*, *e.g.*, *i.e.*, i nomi dei generi famiglie (*Myliobatis* sp.) e delle specie (*Myliobatis aquila*) si scrivono con il carattere italic. Quando possibile saranno utilizzate le unità del sistema SI (*Système international d'unités*).

**13.** Gli autori ricevono le **prime bozze** di stampa per la revisione. Le bozze corrette vanno quindi rispedite entro una settimana alla Redazione. In questa fase, i testi corretti con segni adeguati (indicazioni in merito si trovano alla fine della pubblicazione "Slovenski pravopis" (2001), Ljubljana, ZRC SAZU, 24-25, non possono essere più ampliati. La revisione delle bozze è svolta dalla Redazione.

**14.** La Redazione rimane a disposizione per eventuali chiarimenti.

LA REDAZIONE

## INSTRUCTIONS TO AUTHORS

**1.** The journal ANNALES (*Annals for Istrian and Mediterranean Studies,* Series historia naturalis) publishes **original scientific** and **review articles** in the field of natural studies related to the specifics of various subfields of Mediterranean natural studies: marine biology and ecology, ichthyology, geology with paleontology, karst studies, olive growing, biodiversity of Slovenia, nature protection, pollution and environmental protection, physical geography of Istria and the Mediterranean, etc. It also publishes **short** scientific papers on completed research projects related to the above-mentioned subfields.

**2.** The articles submitted can be written in the English, Slovene or Italian language. The authors should ensure that their contributions meet acceptable standards of language, while the editorial board has the right to have them language edited.

**3.** The articles should be no longer than 48,000 characters (spaces excluded) or 32 typewritten double-spaced pages. They can be submitted via e-mail annales@mbss.org (preferably) or regular mail, with the electronic data carrier (CD) sent to the address of the editorial board.

Submission of the article implies that it reports original unpublished work and that it will not be published elsewhere.

**4.** The **title page** should include the title of the article, the name and surname of the author(s), their affiliation (institutional name and address) or home address, and e-mail address (of the first author or the corresponding author only).

**5.** The article should contain the **summary** and the **abstract,** with the former (c. 30 lines) being longer than the latter (c. 10 lines).

The *abstract* contains a brief description of the aim of the article, methods of work and results. It should contain no comments and recommendations.

The *summary* contains the description of the aim of the article and methods of work and a brief analysis or interpretation of results. It can contain only the information that appears in the text as well. It should contain no reference to figures, table and citations published in the main text.

**6.** Beneath the abstract, the author(s) should supply appropriate **keywords** (max 6) and, if possible, the English (or Slovene) translation of the abstract, summary, keywords, and captions to figures and tables. If unprovided, the translation will be provided by the editorial board.

**7.** The **main text** should include the following chapters: Introduction, Material and Methods, Results, Discussion or Results and Discussion, Conclusion, Acknowledgement (not obligatory), References. Individual parts of the text can form a sub-chapter (e.g. Survey of Previous Studies under Introduction; Description of Research Area under Material and Methods). Captions to figures should appear on a separate page beneath References.

**8.** Each **table** should be submitted on a separate page in Word programme (just like the main text). It should be numbered consecutively and supplied with the title – brief description. When referring to the tables in the main text, use the following style: (Tab. 1).

**9. Illustrative matter** (diagrams, maps, photographs, plates) should be submitted as separate files (in jpeg or tiff format) and saved at a minimum resolution of 300 dpi per size preferred, with the maximum possible publication size being 17x20 cm. Prior to publication, the author(s) should obtain all necessary authorizations (as stipulated by the Copyright and Related Rights Act) for the publication of the illustrative matter and submit them to the editorial board. All figures should be captioned and numbered consecutively (cf. Item 7). When referring to the figures in the main text, use the following style: (Fig. 1).

**10**. **Bibliographic notes** or **citations** – i.e. references to other articles or publications – should contain the following data: *author* and *year of publication,* e.g. (Novak, 2007). If there are two authors, include both surnames (Novak & Kranjc, 2001); if there are more than two authors, include the surname of the first author followed by a comma and the abbreviation *et al.* (Novak *et al.*, 1999). If there is more than one reference, separate them by a semicolon and list them in ascending chronological order, e.g. (Novak *et al.*, 1999; Adamič, 2001; Kranjc & Zupan, 2007). When citing information obtained through personal communication (oral, written), provide the initial letter of the name and full surname of the informant followed by a comma and the phrase *personal communication,* e.g. (J. Novak, *personal communication*).

**11.** The entire list of **bibliographic data** should be published under References in alphabetical order. The author(s) should list only the works cited in the article. If you are listing several works by the same author with some of them written in co-authorship, first list those written by the author him/herself, then those written in co-authorship with another author, and finally those written in co-authorship with more than one author, with the entries listed in chronological order. The names of journals in which the works cited were published should be abbreviated (cf. list of official journal abbreviations). Unpublished articles can be cited only if they have been approved for publication, which should be indicated by adding the phrase *in press* to the end of the relevant bibliography entry.

Some examples of how to cite different types of bibliographical data:

*Articles published in serial publications:*

**Klock, J.-H., A. Wieland, R. Seifert & W. Michaelis (2007):** Extracellular polymeric substances (EPS) from cyanobacterial mats: characterisation and isolation method optimisation. Mar. Biol., 152, 1077-1085.

*Books and other non-serial publications (reports, diploma theses, doctoral dissertation):*

**Wheeler, A. (1969):** The fishes of the British Isles and North-West Europe. McMillan, London, 613 p.

*Chapters published in a book:*

**McEachran, J. D. & C. Capapé (1984):** Myliobatidae. In: Whitehead, P. J. P., M. L. Bauchot, J.-C. Hureau, J. Nielsen & E. Tortonese (eds.): Fishes of the North-eastern Atlantic and the Mediterranean, Vol. 1. Unesco, Paris, pp. 205-209.

**12. Miscellaneous:** Latin phrases such as *in vivo*, *in situ*, *e.g.*, *i.e.*, and names of genera (*Myliobatis* sp.) and species (*Myliobatis aquila*) should be written in italics. Whenever possible, use the SI units (Système international d'unités).

**13.** The authors are sent the **first page proofs**. They should be returned to the editorial board within a week. When reading the proofs, the authors should use the correction signs listed at the end of the book Slovenski pravopis (2001), Ljubljana, ZRC SAZU, 24–25.

It is not allowed to lengthen the text during proof-reading. Second proof-reading is done by the editorial board.

**14.** For additional information regarding article publication contact the editorial board.

EDITORIAL BOARD

## KAZALO K SLIKAM NA OVITKU

SLIKA NA NASLOVNICI:
Sredozemska kamena korala (*Cladocora caespitosa*) je endemična vrsta koralnjakov v Sredozemskem morju. Je pomemben biogradnik, v zadnjem času ji pripisujejo pomembno vlogo kot pokazatelju podnebnih sprememb. Na bližinskem posnetku je prikazan polip tega kolonijskega ožigalkarja. (Foto: B. Furlan)
Sl. 1: Sredozemsko kameno koralo najdemo tudi v slovenskem delu Jadrana, kjer se ponekod pojavlja v velikem številu. To velja še posebej za biogeno formacijo v akvatoriju naravnega rezervata Strunjan, ki jo tvorijo koraliti odmrlih koral. (Foto: B. Furlan)
Sl. 2: Kolonije sredozemske kamene korale tvorijo posamezni polipi. Ti imajo v svojem telesu endosimbiontske alge, s katerimi živijo v sožitju. (Foto: B. Furlan)
Sl. 3: Kolonije sredozemske kamene korale lahko merijo v premeru od nekaj centimetrov do 50 cm, v nekaterih okoljih, kot npr. v Velem jezeru na otoku Mljetu, pa lahko tudi do več metrov. (Foto: B. Furlan)
Sl. 4: Javorkov rdeči koren (*Onosma javorkae*) uspeva v najbolj suhih in kamnitih oblikah kraških travišč. (Foto: M. Kaligarič)
Sl. 5: V bližini otoka Lastova se nahaja predel z orjaškimi kolonijami sredozemske kamene korale, ki tvorijo posebno življenjsko okolje. (Foto: B. Furlan)
Sl. 6: Kolonije sredozemske kamene korale nudijo bivalne niše za številne pridnene nevretenčarje, med katerimi so tudi črvasti mnogoščetinci. (Foto: B. Furlan)
Sl. 7: Kraški črnilec (*Melampyrum carstiense*) je s svojimi barvami pravi okras kraških travnikov asociacije *Danthonio-Scorzoneretum villosae*. (Foto: M. Kaligarič)

## INDEX TO IMAGES ON THE COVER

FRONT COVER:
The Mediterranean stony coral (*Cladocora caespitosa*) is an anthozoan coral endemic to the Mediterranean Sea. This important bioconstructor was recently described as valid as a relevant bioindicator of climate change. The close-up photograph shows the polyp of this colonial cnidarian. (Photo: B. Furlan)
Fig. 1: The Mediterranean stony coral is also present in the Slovenian part of the Adriatic Sea, where it can be found in large numbers. This is especially true for the biogenic formation in the acquatory of the nature reserve at Strunjan, which is created from the corallites of dead corals. (Photo: B. Furlan)
Fig. 2: Colonies of the Mediterranean stony coral are made up of numerous polyps. Their bodies are inhabited by endosymbiothic algae. (Photo: B. Furlan)
Fig. 3: Colonies of the Mediterranean stony coral measure from a few to fifty centimetres in diameter. Though in certain localities, such as in the Velo Jezero on the island of Mljet, they can grow up to a few metres in diameter. (Photo: B. Furlan)
Fig. 4: *Onosma javorkae* is a flowering species inhabiting very dry and rocky types of karstic meadows. (Photo: M. Kaligarič)
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Fig. 6: Colonies of the Mediterranean stony coral offer habitats and shelter for many benthic invertebrates such as sedentary polychaetes. (Photo: B. Furlan)
Fig. 7: A colourful species of cow-wheat *Melampyrum carstiense* is a true decoration for karstic meadows of the association *Danthonio-Scorzoneretum villosae*. (Photo: M. Kaligarič)