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BIOMETRIC PROPERTIES AND DIET OF COMMON PANDORA, *PAGELLUS ERYTHRINUS* (OSTEICHTHYES: SPARIDAE), FROM THE EASTERN ADRIATIC SEA

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Abstract - Biometric properties and diet composition were examined in 120 specimens of the common pandora caught in the eastern Adriatic Sea. Biometric analysis of the morphometric and meristic characteristics indicate a homogenous morphology stock of *P. erythrinus* in the eastern Adriatic Sea. Changes in some of the morphometric characteristics obtained in conjunction with an increase in body length showed that smaller specimens have a longer dorsal fin, standard length, eye diameter and postorbital distances than larger specimens. The meristic characteristics of the common pandora from Italian waters and the Black Sea are mostly in agreement with data in our study. The prey species identified in the stomachs belong to five groups: Decapoda, Bivalvia, Polychaeta, Teleostei and Euphausiacea. Decapods were the most important ingested prey group while bivalves were second in importance. Various prey groups and species found in the stomach indicate that the common pandora could be an opportunistic predator.

Key words: *Pagellus erythrinus*, morphometric and meristic characteristics, diet, Adriatic Sea

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INTRODUCTION

The common pandora, *Pagellus erythrinus* (Linnaeus, 1758) is distributed throughout the Mediterranean and the north-eastern Atlantic (Jardas, 1996). It is common in the Adriatic Sea, more in channels than in open sea (Jardas, 1996). This species inhabits depths up to 150 m, mostly among sandy-muddy sediments (Jukić and Arneri, 1984). The common pandora is a protogynous hermaphroditic fish. In the Adriatic Sea, bottom trawlers actively exploit this species. There are no reliable statistics on *P. erythrinus* landing in the eastern Adriatic but rough estimates of the annual catch are around 50 tons (FAO, 2009). In the Mediterranean Sea, annual landings are about 1500 tons (FAO, 2009).

Although different aspects of its biology have been examined in the Adriatic Sea (Rijavec and Županović, 1965; Jukić and Arneri, 1984; Vrgoč, 2000), studies of its diet have been rare and are generally not up to date. Only two studies have provided some observation of the diet of the common pandora in the Adriatic Sea (Rijavec and Županović, 1965; Jukić, 1972). Jukić and Županović (1965) noted the feeding intensity of this species. However, the biometric properties of the common pandora from the Adriatic Sea have not been thoroughly studied. Only Jardas (1996) noted some meristic observations.

The goal of this paper is to analyze the biometric properties and diet composition of the common pandora in the eastern Adriatic Sea.

MATERIALS AND METHODS

During 2009 a total of 120 common pandora specimens were sampled to study their biometric characteristics and diet composition. The fish were collected by commercial bottom trawls (using a 22 mm

stretched mesh size cod-end) from four different trawling grounds in the eastern Adriatic Sea (Fig. 1). The duration of each haul was 2 – 3 h and the trawling speed fluctuated from 2 to 3 knots. The investigated areas are situated on the circalittoral shelf mostly at depths from 60 to 100 m. Biometric measurements were performed on fresh fish. Twelve morphometric and four meristic characteristics were measured. The analyzed morphometric characteristics analyzed are (Fig. 2): total length (Lt), standard length (Ls), head length (C), lengths of dorsal (Ld) and anal fins (La), lengths of pectoral (Lp) and ventral fins (Lv), maximum (T) and minimum body heights (Tpc), eye diameter (O), preocular (Po) and postocular distance (Olo).

The analyzed meristic characteristics are: number of rays in dorsal (D), ventral (V), anal (A) and pectoral (P) fins.

The total and standard lengths were measured with a fish meter to the nearest 0.1 cm. The rest were measured with a caliper to the nearest 0.01 mm. The entire sample was sorted into centimeter length classes. Measurements of the head were expressed as percentages of head length, whereas the other body measurements were expressed as percentages of the standard length (Ls). The standard length was expressed as a percentage of the total length (Ls/Lt) and minimum height was expressed as a percentage of maximum body height (Tpc/T).

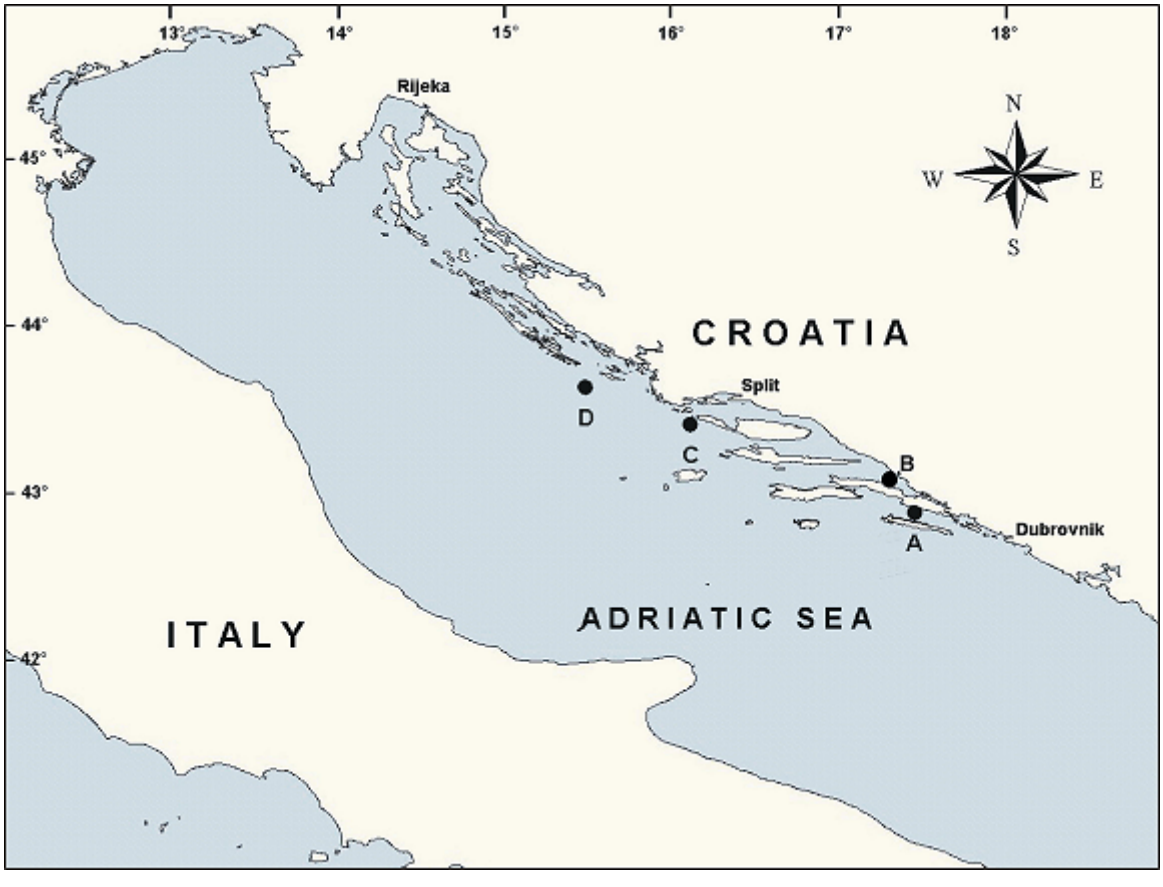

Fig. 1. Sampling localities of the common pandora from the eastern Adriatic Sea: **A** – Mljet channel, **B** – Malostonski Bay, **C** – south of Maslenica, **D** – Blitvenica fishing area.

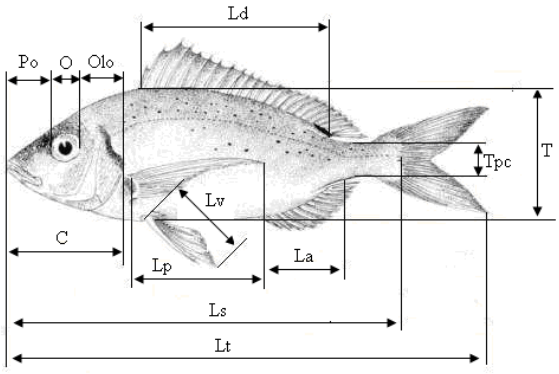

Fig. 2. Morphometric measurements of the common pandora: Lt – total length, Ls – standard length, C – head length, Ld - dorsal fin length, La – anal fin length, Lp – pectoral fin length, Lv – ventral fin length, T – maximum body height, Tpc – minimum body height, O – eye diameter, Po – preocular distance, Olo – postocular distance.

Arithmetic mean, standard deviation and variability coefficient were used to process the biometry data. Linear regression was applied to the examined morphometric relations in comparison with an increase in total length.

After taking the biometric measurements, the fish were dissected and the stomach contents were analyzed. Preys were identified to the species level whenever possible. Species abundance and blotted wet weight (±0.001 g) were recorded.

In the present study, the following indices were used:

Vacuity index (VI) = number of empty stomachs divided by total number of stomachs × 100;

Percentage frequency of occurrence (%F) = number of stomachs in which a food item was found, divided by the total number of non-empty stomachs, × 100;

Percentage numerical abundance (%Cn) = number of each prey item in all non-empty stomachs, divided by the total number of food items in all stomachs, × 100;

Percentage gravimetric composition (%Cw) = wet weight of each prey item, divided by the total weight of stomach contents, multiplied by 100.

The main food items were identified using the Index of Relative Importance (IRI) (Hacunda (1981):

$$IRI = \%F \times (\%Cn + \%Cw)$$

The index was expressed as:

$$\%IRI = (IRI / \sum IRI) \times 100$$

Prey species were sorted in decreasing order according to IRI and then cumulative %IRI was calculated.

RESULTS

Overall, 120 specimens of *P. erythrinus* were examined for biometric properties and diet composition. The total length (Lt) of the samples ranged from 10.0 to 26.1 cm.

Biometric properties

Range of morphometric characters, arithmetic mean, standard deviation and variability coefficient are presented in Table 1. Morphometric relations indicate relatively low values of variability coefficient. The high values of variability coefficients were found only for morphometric characteristics in the relation between eye diameter and head length as well as between postocular distance and head length. The coefficients of linear regressions for morphometric characters are shown in Table 2.

Table 3 displays the meristic data of the common pandora. In all specimens, the ventral fin ray was composed of six rays and anal fin constituted 12 rays. The number of pectoral fin rays ranged between 14 and 15.

Table 1. *Pagellus erythrinus*. Relative relations of the morphometric characters (n = 120).

Relation	Range (%)	Mean ± SD	V (%)
Ls /Lt	76.67 - 84.86	80.18 ± 1.63	2.03
C/Ls	22.12 – 40.36	30.97 ± 2.23	7.20
Ld/Ls	32.19 – 52.41	48.39 ± 2.40	4.95
La/Ls	12.68 – 22.07	18.03 ± 1.08	5.99
Lp/Ls	26.81 – 39.60	33.45 ± 2.52	7.53
Lv/Ls	11.92 – 25.57	19.31 ± 1.15	5.17
T /Ls	27.37 – 36.05	32.40 ± 1.86	5.74
Tpc/Ls	4.13 – 11.68	7.68 ± 0.51	6.64
Po/C	25.82 – 37.01	31.49 ± 2.53	8.03
O/C	18.14 – 43.80	33.49 ± 3.01	8.98
Olo/C	26.25 – 45.68	35.03 ± 3.13	8.93
Tpc/T	14.45 – 32.39	25.58 ± 2.06	8.05

SD = standard deviation
V = variability coefficient

Table 2. *Pagellus erythrinus*. Regression (a, b) and determination coefficients (R^2) of linear regression (n = 120).

Relation	a	b	R^2
Ls /Lt	81.129	- 0.051	0.012
C/Ls	22.682	0.452	0.135
Ld/Ls	50.075	- 0.091	0.174
La/Ls	14.827	0.174	0.124
Lp/Ls	24.696	0.477	0.424
Lv/Ls	12.693	0.360	0.229
T /Ls	26.729	0.309	0.327
Tpc/Ls	5.353	0.126	0.078
Po/C	32.030	0.079	0.003
O/C	34.920	- 0.187	0.064
Olo/C	34.696	- 0.018	0.004
Tpc/T	20.241	0.182	0.023

Table 3. Meristic characters of *Pagellus erythrinus* (n = 120). Explanations: D = number of rays in dorsal fin, A = number of rays in anal fin, P = number of rays in pectoral fin, V = number of rays in ventral fin.

Relation	Range (%)	Mean ± SD	V (%)
D	21 - 22	21.75 ± 0.44	0.19
A	12	12.00 ± 0	0
V	6	6.00 ± 0	0
P	14 - 15	14.87 ± 0.84	0.70

Diet composition

The prey items identified in the stomachs belong to five major groups: Decapoda, Bivalvia, Polychaeta, Teleostei and Euphausiacea (Table 4). Decapods were the most important ingested prey group, constituting 66.7% of the total IRI, followed by bivalves (%IRI = 17.8) while other prey groups such as polychaetes (%IRI = 7.8), teleosts (%IRI = 5.1) and euphausiids (%IRI = 2.5) were comparatively less and of less importance. Due the advanced degree of digestion, identification to the species level was often impossible. The m,ost common identifiable prey were the decapods *Alpheus dentipes* (%IRI = 6.6), *Processa canaliculata* (%IRI = 3.6), and polychaetes *Aphrodite aculeata* (%IRI = 2.1).

Of the 120 common pandora stomachs examined, 20 were empty (16.6%).

DISCUSSION

Available literature data about the morphometric characteristics of the common pandora are very scarce. Only Banarescu (1964) noted some comparable morphometric data of the *P. erythrinus* from the Black Sea. In the Black Sea, the maximum body lengths of this species make 28-37% of the standard body length, which is in agreement with the range in the present study. According to Banarescu (1964) the head constitutes 24-38% of the standard body length while the eye diameter constitutes 24-35% of

Table 4. Diet composition of *Pagellus erythrinus* (%F is frequency of occurrence; %Cn is percentage numerical composition; %Cw is percentage gravimetric composition; IRI is index of relative importance).

Food items:	%F	%N	%W	IRI	%IRI
Bivalvia					
Cardium edule	13.0	5.0	6.2	145.6	1.9
Modiolus sp.	11.0	4.3	5.4	106.7	1.4
Chlamys sp.	9.0	3.4	4.8	73.8	0.9
neidentified Bivalvia	13.0	6.2	6.4	163.8	2.1
Total Bivalvia	32.0	18.9	22.8	1334.4	17.8
Polychaeta					
Aphrodite aculata	17.0	5.3	4.1	159.8	2.1
Nephthys sp.	10.0	3.1	3.2	63.0	0.8
Neidentified Polychaeta	12.0	3.7	3.2	82.8	1.1
Total Polychaeta	26.0	12.1	10.5	587.6	7.8
Crustacea					
Decapoda					
Alpheus dentipes	26.0	10.9	8.3	499.2	6.6
Alpheus sp.	19.0	6.8	7.7	275.5	3.6
Processa canaliculata	16.0	6.8	7.5	228.8	3.0
Palaemon sp.	10.0	3.4	4.8	82.0	1.0
Alpheus glaber	8.0	3.1	4.1	57.6	0.7
Galathea strigosa	7.0	2.8	4.6	49.7	0.6
Upogebia sp.	6.0	2.5	3.5	36.0	0.5
Processa sp.	6.0	2.2	3.2	32.4	0.4
Neidentified Decapoda	25.0	9.0	6.9	397.5	5.3
Total Decapoda	51.0	47.5	50.6	5003.1	66.7
Euphausiacea					
Nyctiphanes couchii	10.0	5.9	2.4	83.0	1.1
Neidentified Euphausiacea	8.0	5.3	2.0	58.4	0.8
Total Euphausiacea	12.0	11.2	4.4	187.2	2.5
Teleostei					
Gobius sp.	10.0	3.1	3.3	64.0	0.8
Callyonimus maculatus	7.0	2.2	3.0	36.4	0.5
Neidentified Teleostei	9.0	4.3	4.5	79.2	1.0
Total Teleostei	19.0	9.6	10.8	387.6	5.1

Table 5. Meristic characters of *Pagellus erythrinus* from the Adriatic Sea, Italian coast and Black Sea.

Area and data of authors	D	A	V	P
Eastern Adriatic,				
our result	21 - 22	12	6	14 - 15
Eastern Adriatic				
Jardas (1996)	21 - 23	12 - 13	6	15
Italian coast				
Bini (1968)	22	12 – 13	6	15
Tortonese (1975)	22 - 23	12	6	-
Black Sea				
Banarescu (1964)	22- 23	12 – 13	6	15
Svetovidov (1964)	22	11 - 12	-	-

the head length, respectively. Generally, these data are very close to the data in our study.

The relatively low values of variability coefficient suggest that possibly there is no morphological difference between the collected specimens. High values of variability coefficients were found only for the morphometric relations O/C and Olo/C. In fish, the values of this coefficient within populations are usually far greater than 10% (Carvalho, 1993). Probably the results in our study indicate the possibility of a homogenous morphology stock of common pandora in the eastern Adriatic Sea. The low values of variability coefficient indicate a minimal or very low intrapopulation variation of *Mullus barbatus* and *Leiopotherapon plumbeus* (Mamuris et al., 1998; Quilang et al., 2007).

Meristic characteristics of the common pandora from the eastern Adriatic Sea were compared with the available literature data (Table 5). The number of rays in the ventral fin (6) is the same for all compared locations (Adriatic, Italian waters, Black Sea). However, variations of in the range of dorsal, pectoral and anal fins were very small. The meristic characteristics of the common pandora from the different areas are mostly in agreement with data obtained in our study.

The coefficients of linear regressions indicate that fish with a smaller body length have longer dorsal fins (Ld/Ls) and standard length (Ls/Lt). Also, smaller specimens have bigger eye diameter (O/C) and postorbital distances (Olo/C) than larger *P. erythrinus* specimens. At the same time they have shorter heads (C/Ls), anal (La/Ls), pectoral (Lp/Ls) and ventral (La/Ls) fins as well as shorter preorbital distances (Po/C). The positive correlation recorded for the maximum (T/Ls) and minimum body depth (Tpc/Ls) points to the fact that the body progressively shortened.

The presented results of diet indicate that the *P. erythrinus* living in the eastern Adriatic Sea are essentially carnivorous fish. Decapods were the most abundant prey group, representing more than 50% of the total IRI and therefore can be classified as the main food source for common pandora in this area (Rosecchi and Nouaze, 1987). Bivalves are secondary prey while polychaetes, teleosts and euphausiids were of less importance and they indicate occasional food. Our study indicates that *P. erythrinus* mainly feed on bottom fauna. These results confirm those given by Larraneta (1964) for the Castellon coast; Rijavec and Županović (1965), Jukić (1972) for Adriatic Sea; Caragitsou and Papaconstantinou (1988) for Greek waters.

The pattern of the stomach contents of the common pandora in the present study agrees well with the field distribution of several decapod species. For instance, in the eastern Adriatic Sea, decapods

from the *Alpheus* and *Processa* genus are common on the sandy-muddy seabeds (Milišić, 2008). Similar to the result of present study, Jukić (1972) reported that decapods dominated in the stomach contents of common pandora in the eastern Adriatic Sea. Also, in Egyptian Mediterranean waters, decapods were the most abundant prey (Rizkalla et al., 1999). Rijavec and Županović (1965) recorded decapods and polychaetes as the main food of this species in the central Adriatic. Taken together, the results of these studies confirm the importance of decapods in the diet of the common pandora. In the other hand, Gurgel (1971) and Caragitsou and Papaconstantinou (1988) found that polychaetes dominated the diet of *P. erythrinus* in the Gulf of Marseille and Greek waters. The differences in food habits are mainly due to different distribution, abundance, density, and availability of the prey.

In our study, the stomach contents of the common pandora suggest that the species could be an opportunistic predator, feeding on different prey items, including zooplanktonic organisms, benthic invertebrates and teleosts, of a wide range of prey sizes and morphologies. The food composition of the common pandora collected from the central Adriatic by Jukić (1972) confirms the presumption of its general behavior. Namely, in 253 of the fish examined, prey items consisted of 35 different prey species (decapods, bivalves, gastropods, scaphopods, zooplanktonic crustaceans, polychaetes, ophiuroids and teleosts).

A relatively low percentage of empty stomachs (16.6%) were found in the collected samples. Also, in the Adriatic Sea a low percentage of empty stomachs (14.4%) of this species was noted by Jukić and Županović (1965). Similarly to *P. erythrinus*, high degrees of stomach fullness were reported for other demersal fish in the eastern Adriatic Sea, such as *Scorpaena porcus* (Pallaoro and Jardas, 1991), *Chromis chromis* (Dulčić, 1996), *Spondyliosoma cantharus* (Dulčić et al., 2006) and *Diplodus puntazzo* (Dulčić et al., 2006) indicating an abundance of feed organisms in this region. The abundance of feed organisms in this region is connected with upwelling in the area of Palagruža, which is in vicinity of the studied area (Regner et al., 1987).

In conclusion, biometric analysis indicated changes in some morphometric characteristics during fish growth as well as the possibility of the existence of a homogenous morphology stock in the common pandora from the eastern Adriatic. Decapods were the most important prey while bivalves were second in importance. Various prey groups in the stomachs indicate that *P. erythrinus* could be an opportunistic predator.

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