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Observations on the diet of the Starry skate, *Raja asterias* Delaroche, 1809 (Elasmobranchii: Rajidae) in the Adriatic Sea

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Abstract

The diet of immature specimens of the Starry skate (*Raja asterias*) was investigated in three different parts of the northern Adriatic Sea. Decapod crabs were found to be the primary food source of skates, followed by teleost fishes and cephalopods. An ontogenetic shift in the diet towards teleost fishes was observed. No significant differences were noted when comparing the diet of 22 females and 63 males, 81 juveniles and 4 adults, and different size groups. The prey species preferences were different for the specimens feeding on the Italian side of the northern Adriatic, but nonetheless decapods remained the preferred food source.

Keywords: Starry skate; diet; feeding habits; northern Adriatic.

Introduction

The Starry skate, *Raja asterias* Delaroche, 1809 occurs mainly in the Mediterranean Sea, although it is also found in the Atlantic and near the southern coast of Portugal (Serena *et al.*, 2005). It dwells on sandy and muddy bottoms, up to 500 m depth, but is mostly found in shallower areas, up to 150 m (Jardas, 1984). Genetic research indicates that there may be two subpopulations in the Mediterranean; one in the Adriatic and another in the Tyrrhenian/Ligurian Sea (Valsecchi *et al.*, 2005). Previously, the species was recorded only in the southern part of the Adriatic (Jardas, 1984); today its distribution includes the entire Adriatic Sea, especially the western side (Jardas *et al.*, 2008). The Starry skate is not a commercially important species. It is caught mainly by bottom trawls and longline, as bycatch (Jardas *et al.*, 2008). It is listed on the IUCN Red list; locally (Croatia) as of least concern (LC) (Jardas *et al.*, 2008), while globally it was listed as LC until 2007, when the status changed to near threatened (NT) (Serena *et al.*, 2015). Its populations are declining, especially in shallow areas where deep-water shelters are not easily accessible, such as the northern Adriatic and Gulf of Lion (Serena *et al.*, 2015). Cartilaginous fishes of the Adriatic Sea are poorly studied, so the aim of this paper is to bring new insights into the ecology of the Starry skate. The diet of the Starry skate was studied from different parts of the Mediterranean; such as Tunisian coastal areas (Capapé & Quignard, 1977), the Tyrrhenian Sea (Minervini & Rimbaldi, 1985; Romanelli *et al.*, 2007) and the Catalan Sea (Navarro *et al.*, 2013).

Materials and Methods

A total of 88 Starry skates were collected between November 2011 and November 2016 in the northern Adriatic, mostly in the Slovenian Sea (Fig. 1). The majority (73) was caught by local fishermen, as bycatch. Fifteen samples were obtained as part of the SoleMon Research from the Italian part of the Adriatic Sea. In both cases, skates were caught by bottom trawling, on sandy and muddy bottoms between 15 and 30 m depth. Immediately after capture, the specimens were labelled, frozen and stored in deep freeze chambers at the Marine Biology Station, Piran (Slovenia).

Biometry and diet analysis

Prior to freezing and storing, the specimens were photographed, sexed (based on the presence of claspers), weighed and measured to the nearest millimetre (Jardas, 1996). All measured specimens were discriminated into size groups depending on total length (TL; centimetres) according to Romanelli *et al.*, 2007 (Table 1) or, in one

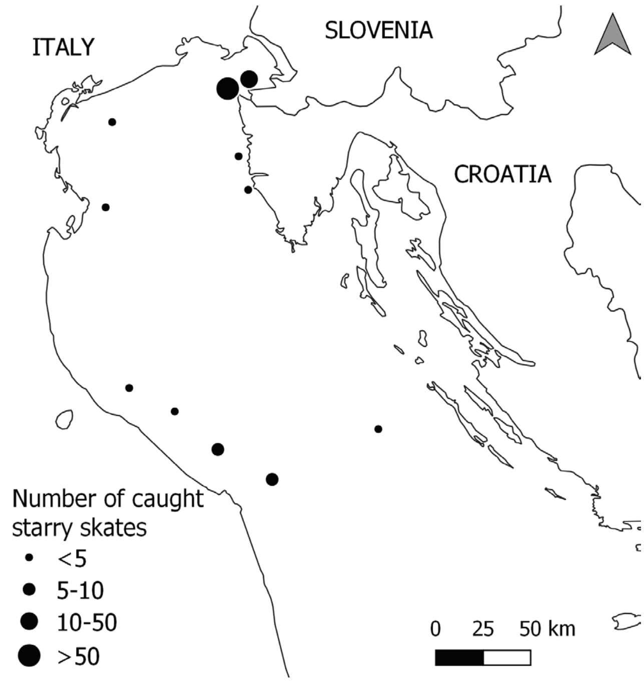

Fig. 1: Number and locations of Starry skate (*R. asterias*) specimens whose feeding habits were analyzed.

Table 1. Size categories by TL (Total length; centimetres) of Starry skates (*Raja asterias*) according to Romanelli *et al.,* 2007.

Sex/Size category	I	II	III	IV
M (TL; cm)	21-36	38-48.5	46.5-53	51>
F (TL; cm)	22-37	38-43	43-51	49.5>

case, where the tail was damaged, disc size (DS) according to Capapé *et al.*, 2007. Juveniles were considered female specimens if smaller than 56.0 cm TL, and males if smaller than 50.5 cm following Romanelli *et al*. (2007).

After measurement, the specimens were dissected to obtain the stomachs, which were cut and emptied. Stomach content was preserved in 5% alcohol solution. Prey items in each stomach were sorted and determined to the lowest possible taxonomic level following Riedel (2010), Falciai & Minervini (1992) and Francetović (2002). Prey items were analyzed using an Olympus SZX16 stereomicroscope (zoom range 0.7 x - 11.5 x, Japan) and photographed with Olympus DP-Soft SZX16 software. In most cases, the prey count was based on the number of different typical parts: foot and siphons for bivalves; beaks for cephalopods; carapaces, eyes and chelipeds for crustaceans; otoliths and whole vertebral columns for fish.

Due to damage on the body, the information on sex and size category of three skates is lacking. Thus, the calculations were conducted on 85 individuals. The diet analysis related to different areas was conducted on 87 specimens (the exact catch location of one specimen was unknown), and the overall diet analysis on the entire sample (88 individuals). Eighty five (85) of the 88 specimens were grouped into four size groups: group I = 22; group II = 27; group III = 29; group IV = 7 specimens (2).

Data analysis

In order to describe and study the feeding habits of the Starry skate, the following values were calculated: the vacuity index (VI = number of empty stomachs/total number of stomachs × 100); relative frequency of occurrence (%F = number of stomachs containing prey i/total number of filled stomachs × 100); relative numerical abundance (%N = number of prey i/total number of prey × 100) and relative gravimetric composition (%W = weight of prey i/total weight of all prey x 100). From the latter three values, we calculated the index of relative importance [IRI = %F × (%N + %W)] (Pinkas *et al.*, 1971; Hacunda, 1981), which minimizes the misinterpretations caused by analyzing only one of the given values. Prey biomass was calculated from the correlation diagrams (length/weight relationships) for various species (Özaydin & Taskavak, 2006; Dulčić *et al.*, 2008; llkyaz *et al.*, 2010; Boban *et al.*, 2013) or estimated from various sources (Ravara, 2012).

Following Rosecchi & Nouaze (1987), three different categories of food importance were assigned. We calculated the relative IRI contribution (IRI = IRI of prey i/∑IRI of all prey x100) for every prey item, listed them in decreasing order and calculated the cumulative %IRI – the %IRI of the first prey item was added to the %IRI of the second prey item, and so on until a value of 50% was obtained for the main food category. The calculation continued until another 25% was obtained to define the second food category. The remaining prey items are considered as accidental food.

Statistical differences between sexes, juveniles and adults, and location were calculated using the chi-square (χ^2) test ($p < 0.05$) (Sokal & Rohlf, 1987). Diet diversity was expressed through the Shannon–Wiener diversity index (H'). To better describe the Starry skate's feeding habits, we calculated the average prey weight (total prey weight/total number of prey items) and average prey size (total prey weight/total number of filled stomachs) for each category. To test for correlation between total size

Table 2. Starry skate (*Raja asterias*) specimens by area, sex and size group [n = 87].

Area	F	M	Unknown	Σ	I	II	III	IV	Σ
Slovenia	8	48	2	58	7	17	29	5	58
Croatia	6	7	1	14	5	8	0	1	14
Italy	7	8	0	15	10	2	2	1	15
Σ	22	63	3	87	22	27	29	7	87

(TL, in millimetres) and body weight (W, in grams) in *R. asterias*, log_{10}-tranformation was applied and the data were tested for normality using the Shapiro-Wilk W test. 85 individual values of body weight and total size were then correlated using nonparametric *Spearman* rank order correlation ($p < 0.05$), since the data were not normally distributed. Correlation and the normality test were performed with STATISTICA 13 (Statsoft Inc., Tulsa, OK, USA).

In order to study the trophic level of the species, the TROPH value was calculated. The trophic level for any consumer species *i* is (Pauly *et al*., 2000; Pauly & Christensen, 2000; Pauly & Palomares, 2000): TROPH*i* = 1 + ∑DC*ij* × TROPH*j*; where TROPH*j* is the fractional trophic level of prey *j*, DC*ij* represents the fraction of j in the diet of the consumer species *i*. The TROPH of the Starry skate was calculated using TrophLab (Pauly *et al*., 2000); a stand-alone Microsoft Access routine for estimating trophic levels, downloadable from www.fishbase.org

For 85 of the 88 collected Starry skates, the size was known while only four individuals were considered sexually mature (one female, three males), according to their size. Due to the significant discrepancy in sample size, the diet analysis between juveniles and adults did not show any significant results.

Results

Biometry

Biometrical analysis was conducted on 85 specimens (21 females, 64 males). Maximum recorded TL was 56.2 cm for females and 53.0 cm for males, minimum TL was 22.6 and 22.0, respectively. Maximum recorded specimen weight was 1180g for females and 890g for males, minimum weight was 60g and 32g, respectively (Fig. 2). The Shapiro-Wilks W test indicated that scores for TL and W were not normally distributed (W= 0.86 and 0.87 for TL and W, respectively). Therefore, we applied nonparametric *Spearman* correlation and found a positive linear relationship between TL and W (*Spearman* rank order correlation $r_s = 0.93$, $p < 0.05$) (Fig. 3).

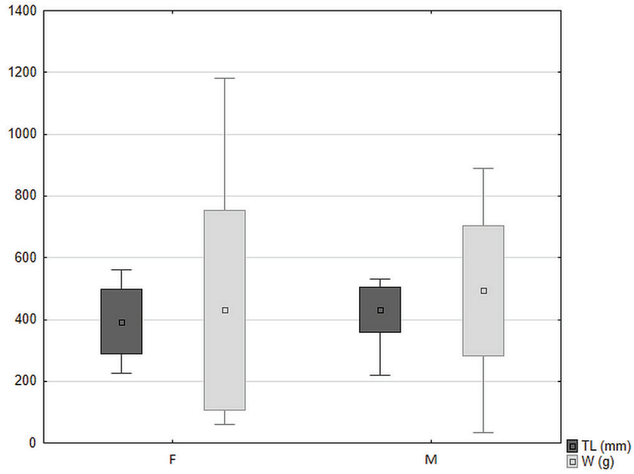

Fig. 2: Starry skate (*Raja asterias*) average total length (TL) and weight (W) [n = 83]. (Sex: M - male, F - female).

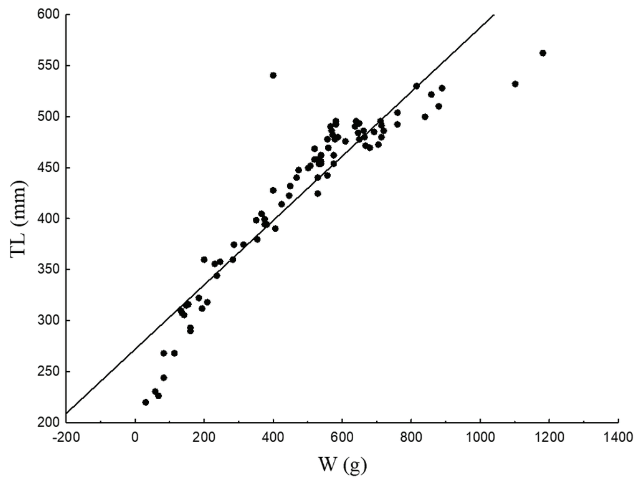

Fig. 3: Relationship between the total length (TL; millimetres) and body weight (W; grams) of the Starry skate *Raja asterias* from the Adriatic Sea. The curve was fitted by: $y = 271.98 + 0.31x$ ($r_s = 0.93$, $p < 0.05$).

Overall diet analysis

Of 88 examined stomachs, only one was found empty (VI% = 1.15). Most of the stomachs contained four to five prey items, and average prey number per stomach was 4.44. The two most represented taxonomic groups were decapods and teleost fishes (Table 3). Average prey weight was 13.82g and average meal weight 62.1 g.

Prey items belong to six taxonomic groups: bivalves (Bivalvia), gastropods (Gastropoda), polychaetes (Polychaeta), crustaceans (Crustacea) and teleost fishes (Teleostei). Of 391 prey items, 103 (26.34 %) were identified to species level. Thirteen different prey species were determined: one polychaete, two cephalopods, six crustaceans and four teleost fishes.

Decapods were the most important food category in terms of %F, %N, %W and %IRI (85.06; 59.59; 37.37; 56.94), followed by teleost fishes (63.22; 27.62; 28.78; 38.41) and cephalopods (16.09; 4.61; 28.98; 3.37). Among the identified species, *Ethusa mascarone* (Herbst, 1785) had the highest %IRI value (13.4), followed by *Liocarcinus depurator* (Linnaeus, 1758) (2.09) and *Gobius niger* Linnaeus, 1758 (0.87).

Decapods were the primary food source, teleost fishes the secondary while other prey groups are considered as accidental food. In addition, the calculated TROPH value for the Starry skate was 3.82 ± 0.64 (mean ± s.d.) .

Diet related to sex

Of 88 specimens, sex was identified for 22 females and 63 males (85 specimens). Only the stomach of one male was found empty (VI% = 1.59). Average prey weight was 14.32g and 5.38g, and average meal weight

Table 3. Diet of the Starry skate (*Raja asterias*) in the northern Adriatic [n = 88].

Taxonomic group	%F	%N	%W	%IRI
Bivalvia	**3.45**	**0.77**	**0.83**	**0.08**
Bivalvia - indeterminata	3.45	0.77	0.83	0.08
Gastropoda	**1.15**	**0.26**	**0.09**	**0.01**
Gastropoda - indeterminata	1.15	0.26	0.09	0.01
Polychaeta	**2.3**	**0.52**	**0.01**	**0**
Sternaspis scutata	1.15	0.26	0.00	0.00
Polychaeta - indeterminata	1.15	0.26	0.01	0.00
Cephalopoda	**16.09**	**4.61**	**28.98**	**3.37**
Loligo vulgaris	1.15	0.26	2.31	0.04
Sepia sp.	9.20	2.56	18.51	2.83
Sepia officinalis	3.45	0.77	5.55	0.32
Cephalopoda - indeterminata	3.45	1.02	2.61	0.18
Crustacea	**88.5**	**65.99**	**41.09**	**57.74**
Natantia	6.90	1.79	0.13	0.19
Natantia Alpheidae	6.90	2.56	0.19	0.28
Squilla mantis	4.60	1.28	3.30	0.31
Upogebia pusilla	1.15	0.51	0.05	0.01
Pagurus sp.	1.15	0.26	0.05	0.01
Decapoda	**85.05**	**59.59**	**37.37**	**56.94**
Decapoda - Brachyura	18.39	6.91	4.95	3.18
Geryon longipes	1.15	0.26	0.09	0.01
Ethusa mascarone	31.03	11.51	18.08	13.40
Liocarcinus depurator	17.24	5.37	2.95	2.09
Liocarcinus vernalis	2.30	1.02	0.56	0.05
Liocarcinus sp.	4.60	1.02	0.56	0.11
Decapoda - indeterminata	59.77	33.50	10.18	38.10
Teleostei	**63.22**	**27.62**	**28.78**	**38.41**
Buglossidium luteum	1,15	0,26	0,19	0,01
Cepola macrophthalma	3.45	1.02	1.18	0.11
Gobius niger	10.34	3.32	2.41	0.87
Gobius sp.	1.15	0.26	0.37	0.01
Serranus hepatus	2.30	0.51	0.39	0.03
Teleostei – indeterminata	55.17	22.51	24.43	37.39

60.17 g and 30.83 g, for females and males, respectively (Fig. 2).

%IRI values, for females and males, are highest for decapods [70.46 (f); 53.54 (m)], followed by teleost fishes [21.48 (f); 42.47(m)] and cephalopods [5.07 (f); 3.12 (m)] (Fig. 4).

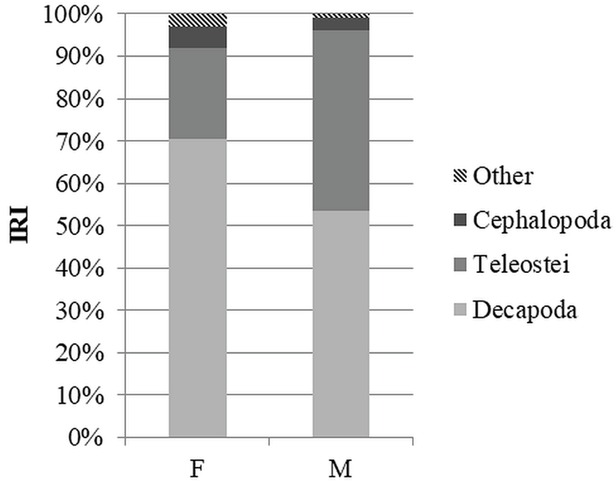

Fig. 4: Diet of Starry skates (*Raja asterias*) in relation to sex [n = 85]. (IRI - relative index of relative importance; Sex: M - male, F - female).

For both sexes, decapods constituted the main food source, teleost fishes the secondary ehile other prey groups are considered accidental food. Of the identified species, the most important food source for females (%IRI = 10.93) and males (%IRI = 12.92) was *E. mascarone*.

Although there are some visible differences in the diet of females and males, they are not statistically significant (χ^2 = 31.79, $p < 0.05$, df = 24). The Shannon–Wiener diversity index showed that females (H'=1.9) have a more uniform diet than males (H'=2.2).

Diet of different size groups

Only one specimen in the IV size group had an empty stomach (VI=14%). Group III had the highest average prey weigh (17.6 g) and average meal weight (67.05 g) (Table 4).

Decapods were the most abundant food group for all four size groups in terms of %N (I = 66.92; II = 60.48; III = 49.12, IV = 76.47) and % IRI (I = 66.8; II = 52.62; III = 48.31; IV = 84.62), followed by teleost fishes (%N; I = 16.92; II = 29.03; III = 40.35; IV = 11.77 and %IRI; I = 26.18; II = 42.3; III = 40.35; IV = 11.76) (Fig. 5). Cephalopods were found only in the stomachs of the first three size groups (%N; I = 4.62; II = 3.22; III = 7.01 and %IRI; I = 4.88 II = 3.78; III = 5.18). All size groups were frequently (%F) feeding on decapods, i.e. *E. mascarone* and *Liocarcinus* sp. Teleost fishes were also a frequent prey, especially *Cepola macropthalma* and *G. niger*.

The Shannon–Wiener diversity index decreased with the increasing size groups of the skates (I = 2.04, II = 2.03, III = 1.98, IV = 1.59). The analysis of the diet all four size groups (χ^2 = 119.00, $p < 0.05$, df = 72) or individually one to another, revealed significant statistical differences.

Table 4. Diet parameters of Starry skates (*Raja asterias*) by size group (I, II, III, IV) [n = 85].

Parameters	I	II	III	IV
Average prey weight [g]	11.8	14.54	17.06	12.21
Average meal size [g]	65.47	66.78	67.05	34.6
Shannon-Weiner diversity index (H')	2.04	2.03	1.97	1.59

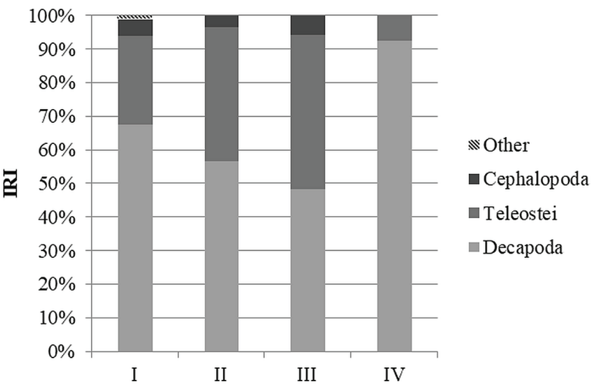

Fig. 5: Diet of Starry skates (*Raja asterias*) in relation to size group (I, II, III, IV) [n = 85]. (IRI - relative index of relative importance; Sex: M - male, F - female).

Table 5. Diet of the Starry skates (*Raja asterias*) by area where Starry skates (*Raja asterias*) were caught [n = 87].

Parameters	Slovenia	Croatia	Italy
Average prey weigh [g]	16.12	14.48	7.25
Average meal size [g]	71.53	64.46	40.14
Shannon-Wiener diversity index (H')	2.02	1.95	1.93

Diet differences between sampling locations

The majority of the skates were caught from the Slovenian Sea (58), mostly males belonging to size groups II and III. Skates caught from the Slovenian Sea had the highest average prey weight (16.12 g) and highest average meal value (71.53 g) (Table 5).

In terms of %N and %IRI, decapods were the main prey items in all three studied areas; Slovenia: %N = 55.33%, %IRI = 51.03; Croatia: %N = 70.49, %IRI = 72.15; Italy: %N = 63.86, %IRI = 66.86 (Fig. 6). Teleost fishes were the second most represented group: Slovenia: %N = 34.84, %IRI = 43.81; Croatia: %N = 18.03 %IRI = 21.72; Italy: %N = 15.66, %IRI = 25.83, followed by cephalopods on a much smaller scale: Slovenia: %N = 6.15, %IRI = 4.91; Croatia: %N = 3.28 %IRI = 2.36; Italy: %N = 1.2, %IRI = 0.54. Decapods were the most frequent prey items in all three locations

In line with those results, decapods constituted the primary food source of skates at all three locations, with

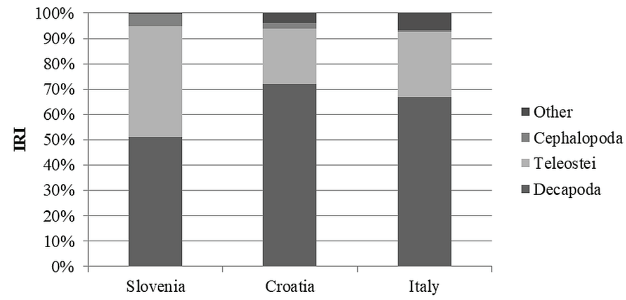

Fig. 6: Diet of Starry skates (*Raja asterias*) caught in three different areas of the Northern Adriatic [n = 87]. (IRI - relative index of relative importance)

teleost fishes being the secondary source and other prey groups being accidental food.

Of the identified species, *E. mascarone* (%IRI = 15.78) was the most important prey for skates caught in the Slovenian and Croatian (%IRI = 28.92) part of the Adriatic, but was not consumed by any of the skates caught on the Italian side. They were mainly feeding on *L. depurator* (%IRI = 18.19), which was also consumed by the skates in other areas, but in much smaller quantities.

The analysis of the diet of skates from all three areas (χ^2 = 134.8, df = 48, $p < 0.05$), or one to another, showed that the statistical differences are significant. The Shannon–Wiener diversity index showed that skates caught in the Slovenian Sea (H' = 2.06) had the largest prey diversity, while those from the Croatian (H' = 1.95) and Italian (H' = 1.93) side had a slightly smaller diet range.

Discussion

The diet of *R. asterias* indicates that the skate mainly feeds on species inhabiting muddy and sandy bottoms, such as *E. mascarone* (Gusso *et al.*, 2001), *L. depurator* (Rufino *et al.*, 2005) and *G. niger* (Boban *et al.*, 2013), which is in accordance with the Starry skate habitat preferences (Heithaus, 2004).

A low vacuity index (1.18%) shows that *R. asterias* is a voracious feeder, which has been additionally indicated by the strong correlation between total size and body weight. Small cartilaginous fishes often inhabit shallow, productive areas at different life stages (Heithaus, 2004). Therefore, the northern Adriatic, especially the Slovenian Sea, where most of the specimens were caught, could be a suitable area for their growth and development. Since most of the analyzed skates were juveniles, it can be presumed that they use it as a nursery area. It has been reported that the sandbar shark [*Carcharhinus plumbeus* (Nardo, 1827)] uses this area as a nursery (Costantini & Affronte, 2003). This insight supports the hypothesis of the function of the northern Adriatic as a nursery area (Soldo, 2006). Analyzing all four calculated parameters (N%, F%, W% and IRI%), decapods displayed the highest values. They are the primary food source of the Starry skate in the northern Adriatic, although a slight decrease in its importance, i.e. %IRI, can be noted with increasing age and size. Through their ontogenetic development, Starry skates tend to prey on teleost fishes more frequently. Teleost fishes are a more nutritious food source, hence preferred by the older, more agile and experienced individuals (Wetherbee & Cortés, 2004). Also, smaller individuals, due to their size, can more efficiently hunt in small crevices and cracks, which are inaccessible to larger skates.

Due to decomposition and the poor state of the prey items, only 26% of the prey items were identified to species level, which is why no definite conclusions regarding prey species preferences can be reached. The relatively large prey species count indicates that *R. asterias* is an opportunistic predator (Wetherbee & Cortés, 2004). Prey item diversity decreased with age, which may indicate that skates specialize in certain prey species with age and increasing hunting experience. Our results show that the carrier crab, *E. mascarone*, is the most important prey species for the Starry skates in the northern Adriatic. The carrier crab inhabits sandy and muddy bottoms up to 30 m depth (Gusso *et al.*, 2001), which overlaps with the habitat of *R. asterias.* The increase of the relative importance index value for *E. mascarone* is proportional to the increase in size of the skates. As the crab uses camouflage as a method of avoiding predators, it may imply that the skates learn how to recognize it and catch it with age.

It is interesting to note that *E. mascarone* was not found in any of the stomachs of skates caught on the Italian side; while it was the dominant prey species in the eastern Adriatic, it was completely absent in the stomachs of skates from the western part. Therefore, the diet analysis regarding different areas showed significant differences in the skate's diet, i.e. prey species composition and their %IRI. This might be due to pure coincidence, limited distribution of *E. mascarone* on the Italian side of the Adriatic, or to the fact that the skates found other decapods that are an easier and more accessible prey. Due to the small sample size (15), it is difficult to draw any definite conclusions. Nevertheless, in all investigated areas, decapods were shown to be the primary food source of skates and teleost fishes the secondary one. The largest Shannon–Wiener diversity index value was calculated for skates from the Slovenian Sea but, given that that most specimens were caught in that area, it was to be expected.

Remains of the only deep-water prey species (Company *et al.*, 2008), *Geryon longipes* A. Milne-Edwards, 1882, were found in the stomach of a skate whose exact catch location remains unknown. Therefore, it can be assumed that either the skate was caught in deeper waters of the Middle Adriatic or that it recently arrived in the northern Adriatic from deeper waters.

Although it has been noted that males have sharper teeth than females (Jardas *et al.*, 2008), and the Shannon-Wiener diversity index showed that the females have a slightly wider prey species spectrum than males, no significant differences were noted in the diet in relation to sex, possibly because the morphological differences in the teeth are not as strongly expressed in juveniles**.** Regarding the diet of juveniles and adults, sample discrepancy was too large to draw valid conclusions.

Diet analysis has been conducted on Starry skates from various parts of the Mediterranean (Capapé & Quignard, 1977; Minervini & Rimbaldi, 1985; Romanelli *et al.*, 2007; Navarro *et al.*, 2013); all results are similar to those of this research. The results emphasize that decapod crabs are the primary food source of the starry skate, but its importance, as far as ontogeny is concerned, decreases as the skate grows and begins to feed increasingly on teleost fishes. Cephalopods constitute the third most important prey group, which is in accordance with our research. Preyed species varied between three different areas, due to different ecological conditions. In our research, no diet differences between sexes were noted, as previously reported in other studies (*e.g.* Romanelli *et al.*, 2007; Navarro *et al.*, 2013).

Similar research has been conducted on other cartilaginous fishes in the Adriatic (Table 6). Although crustaceans are the primary food source of *Mustelus punctulatus* Risso, 1827 (Jardas *et al.*, 2007b; Lipej *et al.*, 2011), *Mustelus mustelus* (Linnaeus, 1758) (Jardas *et al.*, 2007a), *Raja miraletus* Linnaeus, 1758 and *Raja clavata* Linnaeus, 1758 (Jardas, 1972ab), the low %VI of the Starry skate indicates that intraspecific and interspecific competition is not excessive. The feeding habits of *Myliobatis aquila* (Linnaeus, 1758) (Jardas *et al.*, 2004) and *Pteroplatytrygon violacea* (Bonaparte, 1832) (Lipej *et al.*, 2012) have been proven to differ from those of *R.*

Table 6. Diet composition of various cartilaginous fishes in the Adriatic.

Species	*Myliobatis aquila*	*Mustelus mustelus*	*Mustelus punctulatus*	*Mustelus punctulatus*	*Pteroplatytrygon violacea*	*Raja asterias*
Author(s)	Jardas *et al.*	Jardas *et al.*	Jardas *et al.*	Lipej *et al.*	Lipej *et al.*	This research
Area in the Adriatic	Middle and southern	Middle	Middle	Northern	Northern	Northern
Year	2004	2007a	2007b	2011	2011	-
Cephalopoda	1.6 %	3.5 %	3.3 %	19.5 %	4.42 %	3.41 %
Crustacea	14.5 %	64.0 %	65.0 %	56.6 %	0.03 %	57.94 %
Teleostei	0.00 %	30.70 %	30.0 %	9.2 %	95.5 %	37.76 %
Other	83.9 %	1.8 %	1.7 %	14.7 %	0.05 %	0.89 %
Stomachs analysed	165	139	145	151	84	88

asterias; hence, these species do not compete for food with the Starry skate.

The calculated TROPH value (3.82 ± 0.64) is rather high and indicates that the Starry skate could be considered as a top predator in its environment. Our results show that mainly juveniles prey mainly on benthic crustaceans, but as the species ages it preys increasingly on coastal fishes, which contributes to the high TROPH value. The value is very close to the TROPH values of another two Mediterranean skates, *R. miraletus* and *R. radula*, Delaroche, 1809, both with a TROPH value of 3.90 (Stergiou & Karpouzi, 2002). The diet of some other cartilaginous bottom dwelling consumers was closely studied recently in the northern Adriatic Sea. The calculated TROPH value for *Mustelus punctulatus* was 3.70 (Lipej *et al*., 2011), while for the pelagic stingray *Pteroplatytrigon violacea* it was 4.50 (Lipej *et al*., 2012). The high value of the latter is related to a high percentage of fishes in its diet.

Conclusion

This paper supports previous research conducted on the feeding habits of the Starry skate (*R. asterias*), and confirms that decapods constitute the primary food source in the Adriatic, shifting towards teleost fishes with age. No significant differences were observed in the diet either, relating to sex or size group. The diet composition of the skates on the Italian part of the Adriatic slightly differs compared to the Slovenian and Croatian side, but further research is needed to elucidate those differences between the two sides of the Adriatic. The low vacuity index indicates that the skate is a voracious and opportunistic feeder. Further studies should try to elucidate whether the prevalence of small, subadult specimens is a result of overfishing or could be related to the fact that the area is considered as a nursery area for the Starry skate and many other cartilaginous fish species.

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