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Biological Characteristics and Length-Weight Relationships of landed Thornback Ray (*Raja clavata*, Linnaeus 1758) in the Fishing Port of Durres, Albania

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Abstract

Elasmobranchs, mainly represented by sharks and rays, account for 0.8% of bottom trawl total landings in the South Adriatic Sea. The thornback ray (Raja clavata, Linnaeus, 1758) represents one of the most important species in terms of landing in the Mediterranean basin. Several studies have shown that k-selected species, like elasmobranchs, with low intrinsic population regeneration potential are the most impacted by harvesting. The thornback ray has been listed as near threatened by the International Union for Conservation of Nature (IUCN) (Ellis et al., 2016), which imply the need for sustainable management of this species population. In order to develop management plans for cartilaginous species (including thorback ray), it requires basic knowledge about life history traits, such as growth rate, maturity, and fecundity. Several male and female individuals of thornback ray fished in the marine area close to the fishing port of Durres were analysed in order to evaluate some biological characteristics of this species in Albanian marine waters. Our allometric measurements results suggested that the environment conditions of marine waters close to the fishing port of Durres didn't satisfy the physiological requirements of this highly migratory species, though in other studies conducted with speciemens fished in the Souther Adriatic Sea, the thornback ray growth was charachterised by positive allometry.

Keywords: Elasmobranchs, thornback ray; South Adriatic Sea; Mediterranean Sea.

1. Introduction

Elasmobranchs account for 2% of small-scale fishery and 0.8% of bottom trawl total landings in the South Adriatic Sea [15] and represent a considerable proportion of bycatch landings in the Mediterranean Basin [9]. The thornback ray (*Raja clavata,* Linnaeus, 1758) represents one of the most important species in terms of landing [10] in the Mediterranean basin. In the South Adriatic Sea, the thornback ray is caught mostly by bottom longlines targeting the European hake (*Merluccius merluccius*) and bottom trawls with mixed target fishes (mainly European hake and striped red mullets) and crustacean decapods (deep-water rose shrimp and Norway lobster) [15]. The thornback ray is accessible to different fishing métiers [12] due to the fact that it lives in a wide bathymetric range [14, 16]. Furthemore, *R. clavata* exhibits a k-selected strategy, like most elasmobranchs, which is characterized by slow growth rate, long life spans, late-age sexual maturity, and low fecundity [28, 13], which makes the species particularly vulnerable to fishing exploitation. Indeed, several studies have shown that k-selected species with low intrinsic population regeneration potential are the most impacted by harvesting [26, 8, 5].

The thornback ray has been listed as near threatened by the International Union for Conservation of Nature

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(IUCN) [6], which imply the need for sustainable management of this species population. Stock status assessment is essential for developing management plans for cartilaginous species (including thorback ray). In particular for *R. clavata*, it requires basic knowledge about life history traits, such as growth rate, maturity, and fecundity. In the South Adriatic Sea, Carbonara et al [4] validated the availability of the growth parameters for the thornback ray, which allowed to produce diagnosis of the state of the stocks and the consequent management measures for most of the Mediterranean areas, where they have not yet been implemented, especially for the study area: the South Adriatic Sea. Furthermore, the study conducted by Carbonara et al. [4] study represented the first to conduct a thornback ray tag-and-release experiment in the Mediterranean Sea. These studies are important, because they allow to asses various aspects of the life history of *R. clavata* in terms of migration, stock unit, and size and sex distribution [11, 6, 3]. Even it was impossible for us to conduct a thornback ray tag-and-release experiment, following a similar approach we analysed several male and female individuals of thornback ray fished in the marine area close to the fishing port of Durres in order to evaluate some biological characteristics of this species in Albanian marine waters.

2. Material and Methods

The study was conducted based on the fisheries landing surveys from February to September 2019 in the fishing port of Durres, where are landing most of the fishing vessels fishing along the Southern Adriatic Sea (Figure 1). Similarly to Mediterranean International Trawl Survey (MEDITS; 2014–2018) [25] 21 specimens of rays were mainly fished as bycatch by the trawlers.

Figure 1. Satellite view (41º24'28''N 19º42'49''E) of the marine area of Durres (Image © 2021 DigitalGlobe)

Most of the rays were identified by using the MEDITS methodology [25] and later analysed in the Laboratory of Aquaculture and Fisheries Durres, which is one of the laboratories of the Department of Aquaculture and Fisheries at the Agricultural University of Tirana; before the detailed morphometric analyses the individuals were stored at 4ºC.
The allometric measurements were conducted by using a professional meter for applied inchtiology studies, while the applied protocols are represented by those used by McEachran and Notarbartolo di Sciara [19] (Figure 2). In addition the sub-species identification were based on the informations available about their distribution and biological characteristics [23].
For the Total Length (TL) measurement, the degree of precision 1.0 mm, while the degree of precision of 0.1 mm was applied in the other allometric measurements. The degree of precision for total weight (W) determination was 1.0 g. All the determined allometric varaibles were further categrosied according to the system provided by Fairbairn [7].

Figure 2. Identification and allometric measurements of the thornback ray in the Laboratory of Aquaculture and Fisheries Durres; photo provided by J. Kolitari (2019).

The distribution frequencies by TL were determined, while the TL difference between each of the frequencies category was 10 cm and the frequency was calculated as percentage according to the formula F% = (n * 100) / N, where 1) F% represents the frequency of the TL category, 2) n – the number of individuals corresponding to that category and N – the total number of analysed individuals.

In addition, it was evaluated the relation between the total length and weight (TL-W) as an important relations linked to the growth characteristic, though important finding have been provided by Carbonara et al. [4] in 2020 about the growth of *R. clavata* in Southern Adriatic. According to several authors (Le Cren,E.D.1951; Serena, 2005) the TL-W relations is also an important indicator for the sexual maturation and the general wellness of marine organisms. The corellations of these two parameters is represented by the formula W = aLb, where a represents the angular coefficient and b the allometric coefficient, respectively. Both coefficients values were calucalted by following the method of Rajaguru and Ramachandran [21].

If the fish individuals growth is not significant along the time, its growth is isometric and the allometric coefficient b is equal to 3 (b=3.0; [2]). If the values of b are higher or lower than 3.0, it means the growth is allometric, positive and negative, respectively [1]. When the b values are lower than 3, but higher than 2.5, it means that the growth is negatively allometric and there is a high probability that the marine environment is not satisfying the physiological requirement of the analysed population of organisms. If the b values are higher than 3.0 (up to 3.5), the growth is considered as positively allometric and there is a high probabaility that the environment conditions are satisfaing the physiological conditions of the analysed population optimally [22]. All the relative coefficient values were calculated by using Microsoft Excel 2017 for conducting a linear regressive analyses. The degree of linear correlation between length (L) and weight (W) was evaluated by calculating the linear regression coefficient (R^2) and correlation coefficient (r).

Furthermore, it was also calculated the sex ratio (SR) regarding *R. clavata* landed by the fishing vessels in the fishing port of Durres; it was simply applied the formula SR = n♂/n♀ according the method used by Vazzoler [27], where n♂ and n♀ represent the number of male and female individuals, respectively. Previosu to SR values calculations, the individuals sex identification was conducted for all the analysed *R. clavata* individuals and it was based on the presence of claspers in male individuals. This organ is formed from the posterior portion of their pelvic finm which serve to channel semen into the female's cloaca during mating.

3. Results and Discussion

Thornback ray (*Raja clavata*; Linnaeus,1758) inhabits shelf and upper slope waters, while the reported depth

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ranges varies, from 10-300 m and from 300-577 m in the eastern Ionian Sea; most common in coastal waters between 10-60 m depth [18]. It has been found on mud, sand and gravel bottoms, rarely on rougher bottoms [18]. This nocturnal species feeds on all kinds of bottom animals, preferably crustaceans and fishes [18]. In addition, it undertakes migrations with mean distances about 100 km per month; it moves from deeper offshore waters (10-30 m) in autumn and winter to shallower areas (<10 m) in spring [18]. Young individuals are non-migratory, inhabiting inshore nursery grounds.

R. clavata represents an oviparous, characterized by paired eggs alaid and deposited on shallow sand, mud, pebble or gravel bottoms [18]. Up to 170 egg cases can be laid by a single female in a year, but average fecundity is much lower (around 48-74 eggs) [18].

In Figure 3 is shown an individual of *Raja clavata* species, while the TL of all the individuals of this species ranged from 27.8 cm to 90.3 cm. According to the fishers communications, the thornback ray in marine area close to the fishing port of Durres has been mainly fished at depths from 50 m to 250 m along the mixed muddy and sandy bottoms close to the Semand and Erzen river delatas, respectively.

The encountered phenotypes of analysed thornback rays in the laboratory are represented by reticular and marbel phenotype individuals (please see [20] for more information about the phenotypes).

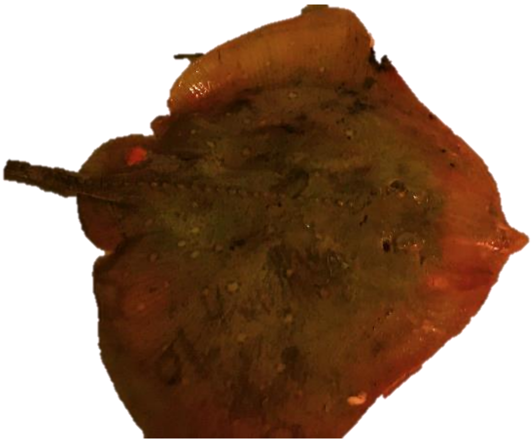

Figure 3. Photo showing thornback ray (*Raja clavata*; Linnaeus,1758) provided by A. Lleshaj (2019).

In the Table 1 are shown the some of the morphometric measurements (mean and standard devidation values corresponding to all analysed individuals) conducted on *R. clavata*, while later were calculated the rates between the mean values of these morphometric measurements; the morphometric parameter rates are shown in Table 2.

Table 1. Some of the morphometric measurements conducted on *R. clavata*.

Abbreviation (Description)	Mean ± SD (Standard Deviation) in mm
TL (Total Length)	638 ± 207
DW (Disc Width)	412 ± 132
DL (Disc Length)	306 ± 64
DCC or CL (distance from the cloaca to the end of the tail)	353 ± 79
DSC (distance from cloaca to mouth)	319 ± 37
D1GO (Distance between first gill openings)	102 ± 18
D5GO (Distance between fifth gill openings)	52 ± 8
MW (Mouth Width)	55 ± 10
PORAL (Preoral Length)	77 ± 12
PORBL = (Preorbital Length)	86 ± 14

Table 2. The morphometric parameters rates calculated based on the mean values of each morphometric measurement conducted on the individuals of *R. clavata*.

Morphometric Parameters Rate	Value

DW/TL	0.645
DL/TL	0.479
DCC/TL	0.553
OD (Orbital Diameter)/TL	0.031
PORBL/TL	0.121
IOD (Interorbital Distance)/TL	0.039
SL (Spiracel Length)/TL	0.027
ISD (Interspiracular Distance)/TL	0.081
PORAL/TL	0.118
MW/TL	0.075
D1GO/TL	0.136
D5GO/TL	0.072
DPF (Maximum distance between pelvic fins)/TL	0.226
APELL (Anterior pelvic lobe length)/TL	0.114
PIPL (Posterior internal pelvic lobe length)/TL	0.044
DSC/TL	0.443

Serra-Pereira and colleagues [24] have shown that *R.clavata* individuals along the Portuguese coast of of Atlantic Ocean that the DW/TL ranged from 0.63 to 0.78, while DL/TL ranged from 0.48 to 0.55; the values of DCC/TL ranged from 0.50 to 0.56. The calculated values of our analyses parameters rates of DW/TL and DL/TL show to be close to the minimal values calculated by Serra-Pereira and colleagues [24]. Contrary happened with the DCC/TL values, which resulted to be closer to the maximal value calculated by the same group of authors for the speciemens catched along the Atlantic Coast of Portugal.

The values of the coefficients calculated according to the linear equation of allometric correlations between the TL and each of the allometric parameter values of thornback ray (*R.clavata*) individuals fished in the marine area close to the fishing port of Durres (Albania).

Table 3. Calculated coefficients values according to the linear equation of allometric correlations between the TL and each of the allometric parameter values of *R.clavata* individuals fished in the marine area close to the fishing port of Durres.

Correlations	**Coefficients**			
	a	b	R^2	r
TL-DW	0.5797	52.997	0.889	0.942
TL-DL	0.5272	-28.94	0.782	0.884
TL-MW	0.0709	4.3792	0.841	0.917
TL-DSC	0.4190	22.325	0.933	0.965
TL-PORAL	0.0963	8.8164	0.778	0.882
TL-PORBL	0.1076	9.6812	0.747	0.864
TL-D1GO	0.1994	-38.97	0.901	0.949
TL-D5GO	0.1213	-33.95	0.819	0.905
TL-DCC	0.4076	68.805	0.891	0.944
TL-DPF	0.2188	4.277	0.915	0.956

The negative (-) or positive signs (+) in front of the b coefficient values confirmed that 7 from the 10 analysed parameters correlations showed positive allometric relations, while 3 of them (TL-DL, TL-D1GO and D5GO) showed negative allometric relations.

As example (Figure 4) is shown the linear correlation between the Disc Width (DW) and the TL, while in the graphic are shown the a and b coefficient values, respectively. According to Serra-Pereira et al. [24], the coefficient a is known as the initial growth coefficient or the condition factor, while the b coefficient indicate the growth rate. Generally it was shown a stong correlation between TL and each of the considered parameters (r = 0.85 ~ 0.95).

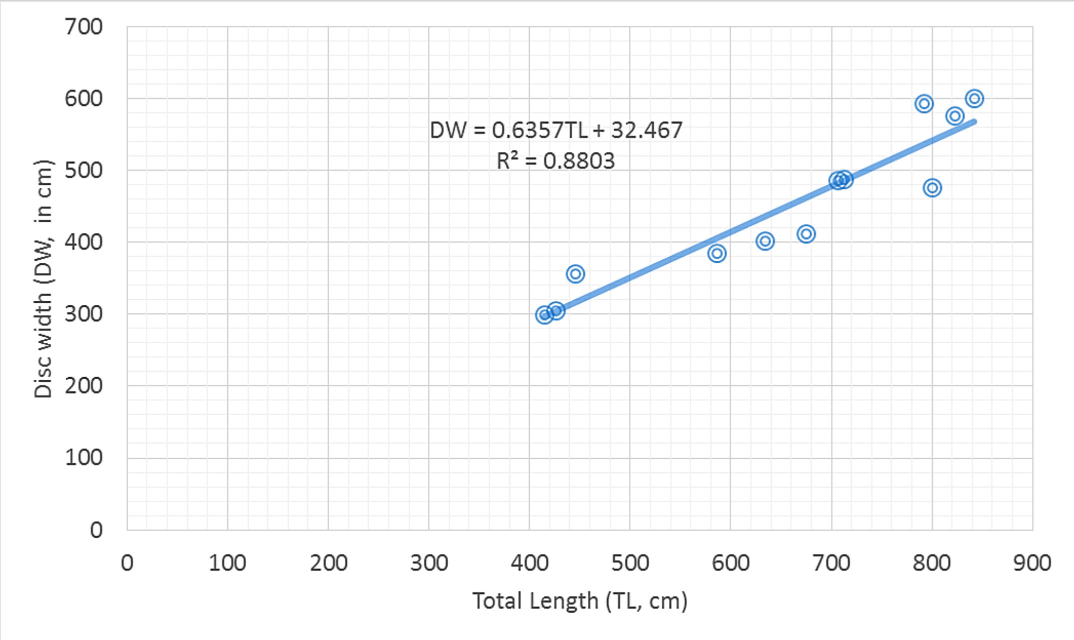

Figure 4. Graphical presentation of the TL and Disck Width (DW) relations for the analysed individuals of thornback ray fished close to the fishing port of Durres (R^2 = 0.880; r = 0.938)

In addition, these coefficients were calculated for the correlation between the TL and Weight (W), which resulted to be a logarithmic correlations, as it is shown in Figure 5, where are also shown the linear regression coefficients (R^2 and r), after analyzing the samples without previosu sex identification of the thornback ray individuals, manily fished by the trawlers close to the fishing port of Durres.

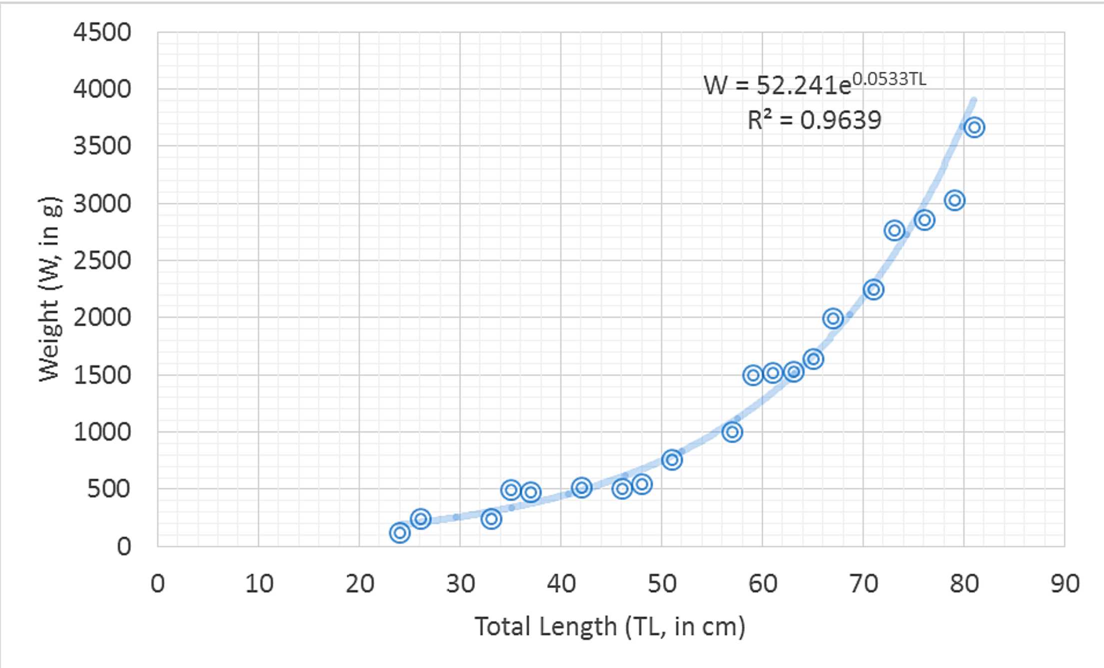

Figure 5. Graphical presentation of the TL and Weight (W) relations for the analysed individuals of thornback ray fished close to the fishing port of Durres (R^2 = 0.964; r = 0.981).

In the case of mixed sex population the condition factor a = 0.0233, the allometric coefficient b = 2.716, while the correlation coefficients R^2 = 0.964 and r = 0.981. After the identification of the sex for each of the thorback ray individuals, all these coefficients were calculated separately for males (a = 0.0321; b = 2.640; R^2 = 0.9753; r = 0.9875) and females (a = 0.0185; b = 2.780; R^2 = 0.9804; r = 0.9901), respectively.

The calculated value of allometric coefficient (b = 2.716) for the 21 thornback ray individuals was included inside the recommended interval values according to Beverton and Holt [2] or Ricker [22], which included values lower than 3.0 and higher than 2.5; it states that for these b value, the these individuals growth is definded as negative allometric growth. Futhermore, it indicates that the environment conditions are not satisfying the physiological requirements of the thornback individuals, at least at the moment these individuals have been fished by the fishing vessels.

By comparing these results with other pubished results about biological charachterization of *R.clavata* population in the Mediterranean basin and Northern Atlantic [17, 13], similarly to these autors conclusions, it resulted that the female individuals were characterized by a higher rate of weight increase in relations to TL compared to male individuals of thornback rays fished in the marine area close to the fishing port of Durres (females: b = 2.780; males: b = 2.640). It is interesting to note that differenclty from the analysed thornback populations of thorback rays along the coasts of Tunisia, Algeria and Great Britain [17, 13] (charachterised by a positive allometric growth), due to the b values lowere than 3 for the thornback rays fished close to the fishing port of Durres, their growth was allometrically negative.

In addition to the environment conditions, it is important to consider the used fishing gears, the relative efficiency and selectivity. The difference between our speciemens and thouse corresponding to the scientific works published by the other authors can also be linked to the fishing of the individuals in fishing areas characterized by a different depth, difference in the efficiency and selectivity of the used fishing gears and methodology (rays can be fished by trammel nets, gill nets and trawl nets, [15, 16]).

In Figure 6 is shown the frequency distribution of the length classes for the analysed individuals of thornback. The dimensions structure of the sampled thornback ray individuals seems to indicate the possibilities and selectivity offered by bottom trawl nets, because at least 65% of the individuals correspond to individuals, which TL ranged from 50 to 80 cm.

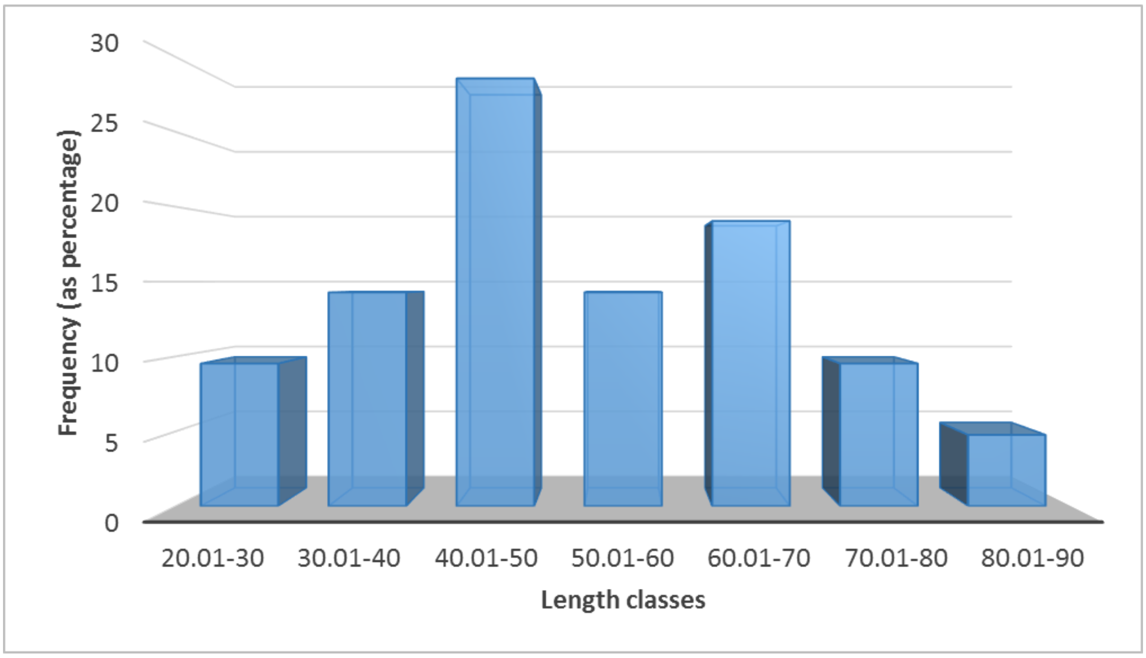

Figure 6. Graphical presentation of the frequency distribution per length classes for the analysed individuals of thornback ray fished close to the fishing port of Durres (South-eastern Adriatic Sea).

The length class of 40.01-50.0 cm constitutes about 30% of the total number of sampled individuals, while the length class of 80.01-90.0 cm was charachterised by the lowest number of individuals (1 individual or 5% of all sampled individuals). The average length of all sampled individuals was 55.1 ± 17.195 cm.

Kadri et al. [13] publication showed that the fished thornback ray female individuals fished along the coasts of Tunisia presented an average TL of 61.4 ± 5.5 cm, while the average length of male individuals was 41.4 ± 3.5 cm. Furthermore, regarding female thornback rays, the highes distribution frequency (12%) was reached for the length class of 65-70 cm, while regarding male, this length class constitutes 18% of the sampled individuals. Carbonara et al., [4] sampled a total of 291 individuals of *R. clavata* (168 females and 123 males), while the TL ranged between 14.1 and 89.0 cm in females and between 13.6 and 79.9 cm in males. They also did a calculation of the relative rays age based on the TL and most of the individuals with a TL of at least 70 cm represented individuals, which age was 8 years old and almost all were represented by females. Furthermore, according to Carbonara et al. [4] all the individuals with a TL of at least 50 cm would be at least 3 years old. In our sampled individuals, almost 65% of them presented dimensions 50-80 cm, which means that the relative ages were 3-8 years.

In addition, in our study it was applied the methodology of Vazzoler [27], which showed that the sex ratio (calculated as the percentage of males in comparison to females) per the group of ray individuals with TL<50 cm was equal to 0.642. Regarding the rays group with TL>50 cm the value of the sex ratio resulted equal to 0.919. For both length groups, the number of female individuals resulted to be higher in comparison to the male individuals of all fished thorback rays in the marine area close to the fishing port of Durres. It is also important to note that with increasing dimensions of the rays, the difference in number of females and males diminished gradually. Differently happened in the case of the analysed samples from Souther Adriatic [4], where the number of male individuals with TL>50 cm was even higher than the number of females (up to TL equal to 70 cm), while the individuals with TL>70 cm were mostly females (no males with TL from 81 to 87 cm). It can also be confirmed by the other results of Carbonara et al. [4], which showed that the maximal age of the males was 8 years, while the females could reach an age of 12 years old.

Our study is the second (after Carbonara et al. [4]) regarding the Adriatic Sea and other investigations need to be performed for a better evaluation of thornback rays status, which still is considered a bycatch species, though mostly preferred for local consumption in several countries of Mediterranean basin, including Albania.

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