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Research article

Biological assessment of common eagle ray, *Myliobatis aquila* (Linnaeus, 1758) from the Northeastern Mediterranean (Saros Bay), Türkiye

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Abstract: In this research, total length-frequency distribution, length-weight relationships, sex ratios, age, growth, reproduction, and feeding habits of the common eagle ray (*Myliobatis aqulia*) were investigated using 85 specimens from the Northern Aegean Sea. Females made up 48.2% and males 51.8% of the total individuals studied. The F:M sex ratio was determined as 1:1.07. The total length of females and males ranged between 30.7 and 121 cm (Disc width: 21.7 cm-100 cm), and between 29.5 cm and 100 cm (Disc width: 21.5 cm-56.1 cm), respectively. The total length (TL)-total weight (TW) and disc width (DW)-total weight (TW) relationships were described by the equations; $TW=0.0012TL^{3.20}$, $r^2=0.87$ and $TW=0.0081DW^{3.17}$, $r^2=0.98$, respectively. Age data derived from vertebrae readings were used to estimate the growth parameters of von Bertalanffy equation: $L_\infty=138.59$ cm, $K=0.90$ y^{-1}, $t_0=-0.09$ y for males and $L_\infty=164.08$ cm, $K=0.95$ y^{-1}, $t_0=-0.08$ y for females. The maximum age was 10 for males and 16 females. Using gonadosomatic index and gonadal macroscopic observation, the spawning period was lasted throughout the year. Stomach content analysis showed the most-preferred prey to be mollusca (47.86% IRI) and teleostei (14.02% IRI).

Keywords: *Myliobatis aquila*, Growth, Reproduction, Feeding, Saros Bay

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Introduction

Myliobatis aquila, a member of the Myliobatidae family, is a benthopelagic species and usually found motionless over sandy bottoms during daylight periods (Ponte et al., 2016). The distribution of these species, extends from South Africa to the east of the Atlantic, the Mediterranean Sea and the western Indian Ocean. In Turkish waters, it has distribution areas in the Marmara Sea, the Aegean Sea and the Mediterranean. Although they generally prefer coastal waters below 50 m, they have been reported to be up to 537 m deep in some regions (Whitehead et al., 1986a, b). *Myliobatis aquila* has no commercial value within the Mediterranean Sea, and it is caught with trawl nets, trammel nets, and longlines as bycatch. According to La Mesa et al. (2016), during the last 40 years the common eagle ray has undergone a drastic decline in the Mediterranean Sea; and it is assessed as "Critically Endangered" category by the World Union for Conservation of Nature (IUCN) (Jabado et al., 2021). With the reported decline in batoids in recent years, the importance of management and conservation strategies on this species has increased, underlining the need for better monitoring of populations worldwide and a better understanding of their life cycles. (Simpfendorfer et al., 2011).

Published information on the comprehensive biology, ecology and distribution of *M. aquila* from the Mediterranean Sea (Rafrafi-Nouira et al., 2017; Valls et al., 2011; Tazerouti et al., 2011), Adriatic waters (Jardas et al., 2004; La Mesa et al., 2016; Bonanomi et al., 2018; Colombelli & Bonanomi, 2022), and Atlantic waters (Ponte et al., 2016). There is some data on the length-weight relationships and diet, distribution, bycatch composition of *M. aquila* in Turkish waters, (Tunka Eronat & Özaydın, 2014; Keskin et al., 2014; Yığın & Ismen, 2009; Ceyhan et al., 2010; Ilkyaz et al., 2008; Ismen et al., 2007; Filiz & Bilge, 2004; Filiz & Mater, 2002; Yeldan et al., 2013; Bengil & Başusta, 2018; Gül & Demirel, 2020; Cabbar & Yığın, 2021).

The present work is a contribution to the knowledge on the age and size distribution, growth, sex ratio, reproduction and feeding habits of common eagle ray in Saros Bay, the Northeastern Mediterranean.

Material and Methods

Fish samples were collected by monthly intervals between September 2006 and September 2008. Specimens were captured as bottom trawler with a stretched mesh size of 44 mm at the cod-end, 50-200 m depth in the Gulf of Saros (Figure 1). In the laboratory, a total of 85 specimens were measured to the nearest centimeter for total length (TL) and disc width (DW). The total weight (TW) of each specimen was weighed to the nearest 10 g. The TL-TW and TL-DW relationships were calculated separately for each sex. The slopes of the logarithmic transformed relationships TL-TW and DW-TW among sexes were tested by t-tests (Zar, 1999). A block of 10 vertebral centra were taken from above the abdominal cavity of 85 common eagle ray, vertebrae were cleaned of extraneous tissue with a scalpel, neural, and haemal arches were removed and individual centra were separated (Kadri et al., 2014).

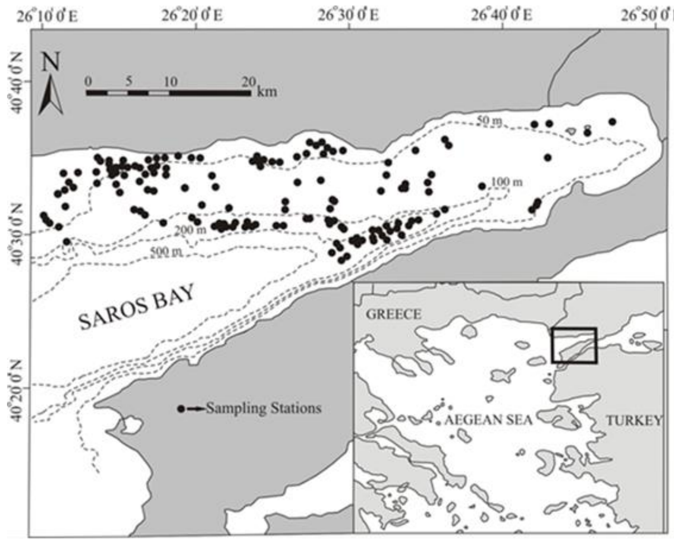

Figure 1. Sampling stations (Yığın, 2010)

The vertebrae were then embedded in epoxy resin to enable cutting. To prepare the epoxy resin, Araldite epoxy GY502 and hardener HY 956 were mixed at a ratio of 5:1 and poured over the vertebrae in silicone molds and allowed to dry for 24 h (Campana, 2014). An IsoMet low-speed diamond bladed saw was used to prepare vertebral sections. Growth bands in vertebral sections were counted using an Olympus SZX7 stereomicroscope. The age of each specimen was determined from the number of opaque and hyaline bands deposited on vertebral centra (Figure 2).

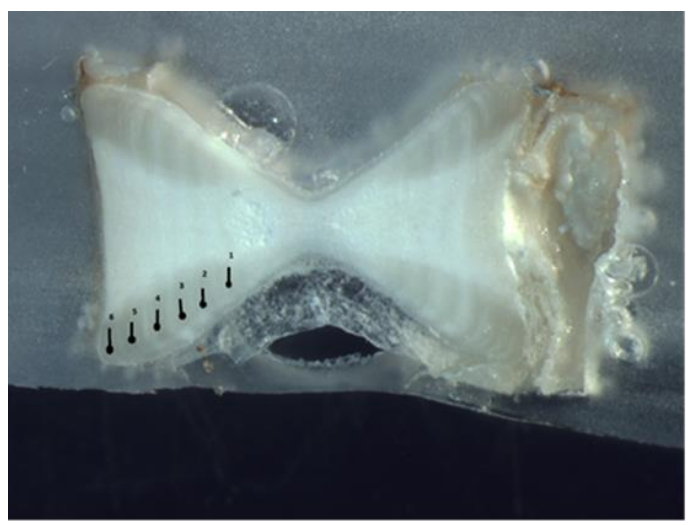

Figure 2. Photograph of a vertebral thin section of *Myliobatis aquila* in Saros Bay

The von Bertalanffy growth equation (VBGE) (von Bertalanffy, 1938) was fitted to the data: $L_t=L_\infty(1-$

$e^{-K(t-t_0)}$), where L_t = total length at age t, L_∞ = theoretical asymptotic length, K = growth rate coefficient, and t_0 = the theoretical age at zero length. The VBGE was calculated by using FISHPARM, a computer program for parameter estimation of nonlinear models with Marquardt's (1963) algorithm for least-square estimation of nonlinear parameters.

In males, the length and rigidity of claspers was recorded according to Ebert (2005) and Kadri et al. (2014b). The clasper length (CL) was measured as the distance from its tip to the pelvic girdle. Males and females were sorted into immature, maturing and mature by macroscopic inspection of the reproductive organs according to Medit (2016). Monthly variability of reproductive status in mature males and females was assigned using the the hepatosomatic index (HSI). These index were calculated as HSI=(LW/TW)*100, where LW is liver weight in "g" (Capapé & Reynaud, 2011).

Results and Discussion

Length-frequency distribution

This research study determined the sex ratios and length-frequency distributions of *M. aquila* individuals captured in the Gulf of Saros. The sex ratio of the samples was revealed to be M:F=1.07:1. The differences between the male and female individuals were not observed to be statistically significant ($\chi 2$ =0.11, df=1, P>0.05) (Schoonjans, 2017). In terms of the length-frequency distribution, the females ranging from 40 to 50 cm (43.9%) in length conspicuously prevailed the sample, whereas the males of 40-50 cm and 50-60 cm were the most common sets and accounted for 27.3% of the captured specimens (Figure 3). Başusta and Aslan (2018) have researched the disc width (cm)-frequency distributions of 94 *Aetomylaeus bovinus* individuals in the Northeastern Mediterranean Sea. They have revealed that males, females, and total with disc widths of 21-30 cm were abundantly available. In their study on Southern Brazil, Araújo et al. (2016) report 500 mm and 600 mm as the most common disc width measures in males and females of 95 *Myliobatis goodei* and 500 mm and 700 mm as the most common disc width measures in males and females of 175 *Myliobatis ridens*, respectively. The length-frequency distribution of sampled fish may vary according to fishing time, number of samples, net selectivity, and research site.

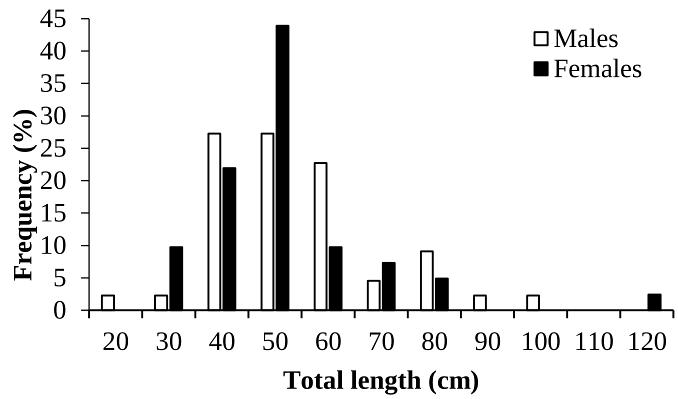

Figure 3. The length-frequency distribution for males and females of *Myliobatis aquila* from the northern Aegean Sea

Morphometric relationships

In this study, 44 (51.8%) and 41 (48.2%) of the captured common eagle rays were male and female, respectively. The minimum total lengths, disc widths, and weights of the specimens were 29.5 cm, 21.5 cm, and 120 g, while the maximum values were 121.0 cm, 100 cm, and 12990 g, respectively. The statistical analyses showed that the relationships between the length-weight and the disc width-weight did not vary between the male and female individuals (P>0.05). The total length-weight relationship was calculated to be $TW=0.0012*TL^{3.20}$, and $TW=0.0022*TL^{3.07}$ for the females and $TW=0.0006*TL^{3.36}$ for the males. Positive allometric growth (P<0.05) was observed in the males, while isometric growth (P>0.05) in the females. The total disc width-weight relationship of the common eagle rays was calculated to be $TW=0.0081*DW^{3.17}$ for pooled data, $TW=0.0115*DW^{3.06}$ for the females and $TW=0.0056*DW^{3.28}$ for the males. In terms of disc width-weight relationships, positive allometric growth (P<0.05) was observed in males, while isometric growth (P>0.05) in females. The studies on the length-weight and disc width-weight relationships of the Myliobatiformes specimens in other regions are provided in Table 1. As clear in Table 1, the "*b*" values of *M. aquila* vary across the species with high or low length and disc width. The differences in the length-weight relationship parameters can be accounted for by the annual variations in seasons, locations, sampling time, population size, and environmental conditions (Moutopoulos & Stergiou, 2002; Froese, 2006; Al Nahdi et al., 2016).

Table 1. Length–weight relationship parameters of *Myliobatis* species obtained by other authors and the present study

Species	Region	Sex	N	Length (cm)		Weight (g)		Parameters			Reference
				Min.	Max.	Min.	Max.	a	b	r^2	
Myliobatis aquila	North Aegean Sea (Edremit Bay)	M+F	12	41.5	58.5	179.2	645	0.0014	3.18	0.87	Türker et al. (2018)
Myliobatis aquila	North Aegean Sea	M+F	14	47.5	76.5	274.09	1500.00	0.0008	3.34	0.93	Filiz & Bilge (2004)
Rhinoptera javanica	Oman Sea	M	4	33.7*	81	400	7840	0.0024	3.42	0.99	Rastgoo et al. (2016)
		M	5	32.0*	42.0*	510	950	0.1305	2.38	0.97	
Aetobatus flagellum	Oman Sea	F	9	31.5*	66.0*	360	5420	0.0027	3.43	0.99	Rastgoo et al. (2016)
		M+F	14	31.5	66.0*	360	5420	0.0036	3.36	0.98	
		M+F	54	41.1	179.5	67.65	15800	0.0005	3.42	0.95	
Myliobatis aquila	Aegean Sea	M	14	41.1	87.5	67.65	2260	0.0009	3.29	0.78	Tunka Eronat & Özaydın (2014)
		F	40	43.5	179.5	168.6	15800	0.0004	3.5	0.96	
Rhinoptera marginata	İskenderun Bay	M+F	17	13*	92*	172	11000	0.0100	2.13	0.75	Başusta et al. (2012)
Pteromylaeus bovinus	İskenderun Bay	M+F	22	32*	86*	730	7864	0.0194	2.90	0.90	Başusta et al. (2012)
Myliobatis freminvillei	North Carolina	M+F+U	222	28	129	-	-	0.0768	3.29	0.99	Wigley et al. (2003)
Rhinoptera bonasus	North Carolina	M+F+U	78	34	103	-	-	0.1821	3.23	0.98	Wigley et al. (2003)
		M+F+U	5	43	51	-	-	0.8913	2.09	0.96	
Myliobatis aquila	Aegean Sea	M+F	39	23.5	54.4	-	-	0.0058	3.28	0.99	İlkyaz et al. (2008)
Myliobatis aquila	North Aegean Sea, Saros Bay	M+F	85	29.5	121	120	12990	0.0012	3.20	0.87	Present study
		M	44	29.5	100	120	3140	0.0006	3.36	0.93	
		F	41	30.7	121	146	12990	0.0022	3.07	0.81	

*Disc width (DW, cm)

n, sample size; M, male; F, female; U, unsexed; Min., minimum; Max., maximum; a and b, intercept and slope of length–weight relationship; r^2, coefficient of determination

Age and Growth

Başusta and Aslan (2018) have determined the ages of 94 *Aetomylaeus bovinus* species in the Northeastern Mediterranean Sea based on vertebral sections from the captured specimens. They calculated the maximum age to be 14 years. The von Bertalanffy growth equation parameters were DW_∞ = 242.59 cm, K = 0.056 $year^{-1}$ and t_0 = -1.904 year for the females and DW_∞ = 238.43 cm, K = 0.044 $year^{-1}$ and t_0 = -2.982 years for the males. Martin and Cailliet (1988) have determined the age and growth parameters of the *Myliobatis californica* species in the Californian waters. They have performed two methods on the vertebrae. They have enhanced the growth bands on the vertebral centra by using oil-clearing and x-radiography. X-radiography was found to yield the most realistic growth curve for the males, while oil-clearing for the females. The von Bertalanffy growth curves harvested by these methods have shown that female eagle rays reach a greater asymptotic size (DW = 1587 mm) and exhibit a lower growth rate (K = 0.0995 $year^{-1}$) than males do (DW = 1004 mm, K = 0.229 $year^{-1}$). In a study carried out in Argentine, the maximum ages for *M. goodei* and *M. ridens* were determined to be 23 years and 17 years, respectively (Ruocco et al., 2012).

In the present study conducted in the Northern Aegean Sea, the asymptotic sizes and the growth rates were calculated to be 164.08 cm and K=0.08 $year^{-1}$ for the female *M. aquila* individuals and 148.09 cm and K=0.11 $year^{-1}$ for the males (Table 2). The maximum age was ten years for the males and 16 years for the females. Age distribution of *M. aquila* according to size class was presented in Table 3. Holden (1974) have made some suggestions concerning the K growth rates of batoids. Despite their similar body forms, the reproductive biology, global distributions, taxonomic relationships of the species of the Myliobatidae and Rajidae families can be operationalized to account for the differences in growth rates. Ryland and Ajayi (1984) have found the K values for three Rajas to range between 0.086 and 0.152. The differences in these species' growth rates are great although they look similar. Smith and Merriner (1987) report similar variations. Further research is required for more precise age analyses.

Table 2. von Bertalanffy growth parameters for *Myliobatis aquila* (C.I.: Confidence Interval)

Sex	von Bertalanffy Growth Parameters		
	L_∞ (95% C.I.)	**K (95% C.I.)**	**t_0 (95% C.I.)**
Males	148.09 (52.11–244.09)	0.11 ((-0.02)–0.24)	-0.16 ((-1.72) –1.39)
Females	164.08 (110.64–217.52)	0.08 (0.03–0.14)	-0.65 ((-2.12) –0.82)
Total	154.15 (119.26–189.04)	0.09 (0.06–0.14)	-0.29 ((-1.10) –0.51)

Table 3. Age distribution of *Myliobatis aquila* according to size class (cm)

Size class (cm)	Age (Years)										
	1	3	4	5	6	7	8	10	14	16	**Total**
35-40	1.5										1.5
40-45		6.2									6.2
45-50		9.2	6.2								15.4
50-55			21.5	4.6							26.1
55-60				10.8	1.5						12.3
60-65				15.4							15.4
65-70				3.1							3.1
70-75					1.5						1.5
75-80					3.1						3.1
80-85						4.6	1.5				6.1
85-90						4.6					4.6
90-95								1.5			1.5
95-100									1.5		1.5
120-125										1.5	1.5
Total	1.5	15.4	27.7	33.9	6.1	9.2	1.5	1.5	1.5	1.5	100

Reproductive characteristics

Because of the inadequate number of the mature *M. aquila* individuals analyzed in the present study, the length at first sexual maturity of the species could not be determined. In the course of the research, the diameters and weights of 60 oocytes obtained from a single individual in March, measuring 121 cm and weighing 12990 g, were measured. Their ovaries were measured to have a length of 74 mm on the right and 97 mm on the left and a width of 43 mm on the right and 50 mm on the left. The minimum and maximum oocyte diameters and weights of this individual were 0.3 mm and 1.1 mm and 0.04 g and 1.4 g, respectively. 37 of 44 *M. aquila* males were identified as juveniles, while seven as mature individuals. The individuals shorter than 70 cm were observed to exhibit uncalcified claspers, whereas the ones longer than 77 cm had calcified claspers. The lengths of the claspers (CL, cm) increased with the total fish lengths (Fig. 4). Previous research on the reproduction of the *Myliobatis* species reports similar increasing patterns of clasper lengths (Martin & Cailliet, 1988; Schluessel et al., 2010; Araújo et al., 2016).

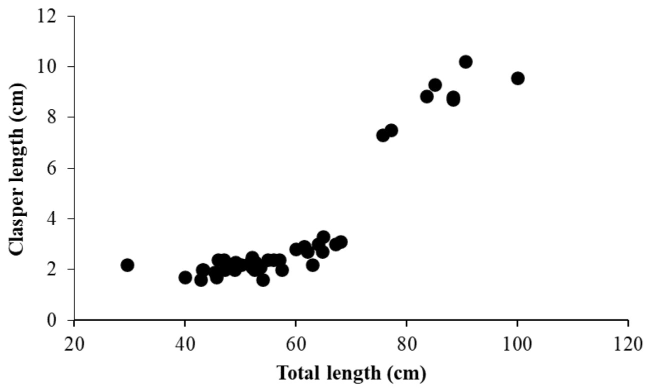

Figure 4. Relationship between total length and clasper length, for males of *Myliobatis aquila* from the northern Aegean Sea.

In the research conducted in Southern Brazil, Araújo et al. (2016) have failed to determine the first sexual maturity of *Myliobatis goodei* and *Myliobatis ridens* males due to the inadequate number of the specimens. Yet they report the length at first sexual maturity of the *M. goodei* species as 55.5 cm (DW). The ones longer than this measure have been detected to be young or mature individuals. The sigmoid form between the clasper length and disc width has been observed to be underdeveloped owing to the lower number of the specimens. The lengths of the clasper glands have been noted to range from 20 to 40 mm in the maturing and mature males. The length at first sexual maturity of *M. ridens* has been determined to be 55.8 cm (DW). The weights of the right and left testes are different in *M. goodei*. Maruska et al. (1996) report that right testicles in rays are smaller than the left ones, which is assumed to result from the placement of the other internal organs. Hamlett (2005) states that testes in rays are paired and correspond to 1–5% of body mass in adults. Males of *M. californica* and *M. longirostris* have been observed to reach maturity when they have a disc width (DW) of 55-56 cm (Villavicencio-Garayzar, 1996). Capapé et al. (2007) report 52 cm DW for the mature *M. aquila* males. Araújo et al. (2016) have found that female *M. goodei* individuals attain first sexual maturity at a DW of 68.3 cm and have identified all the females over 74 cm DW in their sample as mature. They have also determined that the *M. ridens* females reach first sexual maturity at 66.2 cm and the individuals over 73 cm are mature. In a study on the Argentinian seas (Ruocco et al., 2012), the lengths of female *M. goodei* and *M. ridens* at first sexual maturity are noted to be 59.9 cm and 55.9 cm (DW_{50}), respectively. Molina and Lopez Cazorla (2015) report 48.7 cm (DW_{50}) as the length at first sexual maturity for *M. goodei* females. In a research study (Capapé et al., 2007) on *Myliobatis* off the Mediterranean coast of Languedoc in France, females are remarked to attain sexual maturity at 73 cm (DW). Martin and Cailliet (1988) have determined the average maturity size of *M. californica* females to be 88.1 cm. Snelson et al. (2008) suggest that individuals of the same species do not necessarily mature at the same chronological age owing to different growth rates. They also express that the geographical rates of some species and size and age of sexual maturity may vary depending on their geographical distributions.

Hepatosomatic index (HSI) and Maturity stages

In this study in the Gulf of Saros, no significant difference was observed between the male and female *M. aquila* individuals in terms of hepatosomatic indices (HSI) ($F=0.43$, $df=1$, $P>0.05$). The highest HSI in the males was calculated in the individual with a length of 88.4 cm (TL) (8.14%). HSI has been observed to increase when males enter maturation and start to grow larger and reaches the highest value in mature individuals (Capapé et al., 2008). The highest HSI in the females was calculated in the individual with total length of 121 cm (17.56%) (Fig. 5). The highest HSI values in the present study were generally retrieved in spring, autumn, and winter.

Araújo et al. (2016) have observed that mature *M. goodei* and *M. ridens* females are more widely found in spring and summer and prefer to populate the shallow waters in Southern Brazil to give birth. Molina and Lopez Cazorla (2015) have discovered that *M. goodei* adults migrate to the shallow coastal areas in the Anegada Bay, Argentina, during spring and summer. A similar behavior is reported in *M. aquila* species in the coastal waters of Languedoc, and pregnant females have been observed to swim near warmer coastal areas to deliver their youngs in certain periods of the year (Capapé et al., 2007, 2008) Araújo et al. (2016) note that the relationship between the hepatosomatic index and gonadosomatic index and months for *M. goodei* and *M. ridens* males show no clear correlation due to the small sample size. Maruska et al. (1996) have studied *Dasyatis sabina* (Lesueur 1824) males on the eastern coast of Florida to indicate that hepatosomatic indices increase in summer but decrease in autumn and winter and to report maximum gonadosomatic indices at the onset of mating in autumn. There is a linear relationship between liver and ovaries and that vitellogenesis is triggered by the liver. Hamlett (2005) has detected the highest HSI value in *Galeorhinus galeus* (L. 1758) females during pregnancy and reports that liver weight and lipid content increase before gestation. The liver mass of mature *Atlantoraja cyclophora* (Regan, 1903) females is correlated with energy consumption during vitellogenesis, oocyte maturation, and pregnancy (Oddone & Velasco, 2006), which is also reported by Capapé et al. (2008) for *M. aquila*. *M. goodei* has been determined to give birth in December off the coast of Southern Brazil and to mate again a few months later (Araújo et al., 2016). Colonello et al. (2013) note that *M. goodei* individuals undergo a replenishing or recovering process prior to a new reproductive cycle and then enter a gestation of a short time (4-6 months). Previous research also provides the accounts of pregnant females during spring and summer.

Feeding habits

The analysis of the *M. aquila* specimens' stomach contents showed that their primary source of food was mollusca (%IRI=47.86). The examination revealed a great amount of digested material (%IRI=33.61), which is followed by teleostei (%IRI=14.02), annelida (%IRI=2.99), and crustacea (%IRI=1.52) (Table 4).

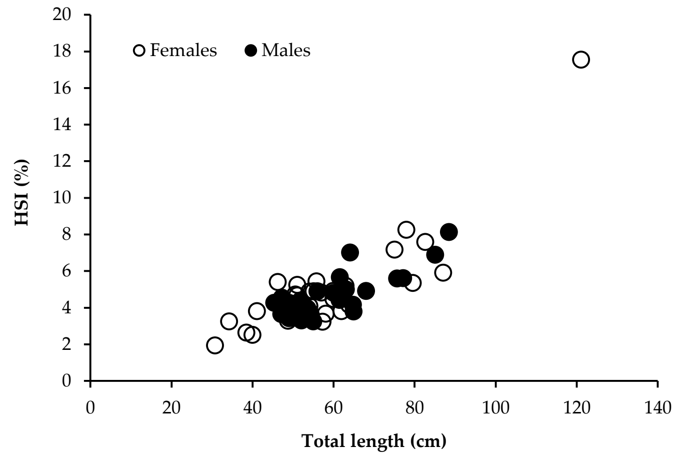

Figure 5. Variations in hepatosomatic index (HSI) versus total length in male *Myliobatis aquila*

Table 4. Diet composition of *Myliobatis aquila* presented as percentage numerical composition (%N), percentage weight of prey items (%W), percentage frequency of occurrence (%F) and percentage index of relative importance (%IRI)

Prey item	%N	%W	%F	%IRI
Annelida				
Polychaeta*	6.10	6.98	8.33	2.99
Mollusca				
Gastropoda*	34.15	15.43	20.83	28.38
Turitella communis	31.71	10.15	16.67	19.17
Cephalopoda*	1.22	1.47	4.17	0.31
Crustacea				
Decapoda*	8.54	1.54	4.17	1.15
Natantia*	1.22	1.99	4.17	0.37
Teleostei				
Fishes*	9.76	20.86	16.67	14.02
Other	7.32	41.60	25.00	33.61

*Unidentified

Gray et al. (1997) have analyzed the stomach contents of 503 *M. californica* individuals from the Humboldt Bay to find clams as the primary prey. Based on the index of relative importance and Shannon-Weiner diversity index, they have shown that the feeding habits of *Myliobatis* species change with increasing size. *Myliobatis* specimens smaller than 40 cm in particular feed on small clams (%IRI=56.89), whereas ones larger than 90 cm primarily prey Cancer crabs (%IRI=21.98). As rays get larger in size, they eat larger and varied preys. Jacobsen and Bennett (2013) have shown that Myliobatoidei species predominantly feed on decapod crustaceans (%IRI=31.71) and teleosts fishes

(%IRI=16.45). Jardas et al. (2004) have examined the food composition of *M. aquila* specimens in the Eastern Adriatic Sea. Among the most prominent preys of 165 individuals in total are molluscs (e.g., scaphopods, gastropods, bivalves, and cephalopods) (%IRI=57.1), which are followed by sipunculids (%IRI=23.1). Among the molluscs, bivalves account for %IRI=33.7 and gastropods for %IRI=20.6. Schluessel et al. (2010) have investigated the dietary habits of *Aetobatus narinari* from Queensland, Australia and the Penghu Islands, Taiwan. Molluscs numerically and gravimetrically correspond to the most crucial prey items in both regions. Their IRIs was calculated to be 85.9% in Australia and 99.9% in Taiwan. Minor dietary composition in *A. narinari* has been discovered to become less gastropod–crustacean-based and more gastropod–bivalve-based as they attain larger body sizes.

Cartilaginous fish are biologically characterized to be long-lived and to exhibit late maturity. Because of the inadequate number of the mature *M. aquila* individuals analyzed in the present research study, their lengths at first sexual maturity could not be determined. Capapé et al. (2007) report that *M. aquila* males attain maturity at 520 mm DW. In this context, it could be concluded that the examined species were mostly captured prior to their first sexual maturity. Given that this will not be the case only in this study but also hold true for commercial fishing, it can be suggested that this situation will lead to fishing pressure on the respective species. Further research is needed for a better understanding of the biology of these species, which are categorized as "Critically Endangered" by the IUCN (Jabado et al., 2021). Understanding the life history and mitigating the fishing pressure on these critically endangered species is of paramount importance for their conservation and long-term survival.

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Ethical Approval

The study was conducted by collecting the fish samples in dead conditions. An ethical approval is not required for the period during which the study was conducted.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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References

Al Nahdi, A., Garcia de Leaniz, C., & King, A. J. (2016). Spatio-temporal variation in length weight relationships and condition of the ribbonfish *Trichiurus lepturus* (Linnaeus, 1758): implications for fisheries management. *PloS one*, 11(8), e0161989. https://doi.org/10.1371/journal.pone.0161989

Araújo, P. R. V., Oddone, M. C., & Velasco, G. (2016). Reproductive biology of the stingrays, *Myliobatis goodei* and *Myliobatis ridens* (Chondrichthyes: Myliobatidae), in southern Brazil. *Journal of Fish Biology*, 89, 1043–1067. https://doi.org/10.1111/jfb.13015

Başusta, A., Başusta, N., Sulikowski, J. A., Driggers, W. B., Demirhan, S. A., & Çiçek, E. (2012). Length-weight relationships for nine species of batoids from the Iskenderun Bay, Turkey. *Journal of Applied Ichthyology*, 28(5), 850-851. https://doi.org/10.1111/j.1439-0426.2012.02013.x

Başusta, N., & Aslan, E. (2018). Age and growth of bull ray *Aetomylaeus bovinus* (Chondrichthyes: Myliobatidae) from the northeastern Mediterranean coast of Turkey. *Cahiers de Biologie Marine*, 59, 107-114. https://doi.org/10.21411/CBM.A.5F77152E.

Bengil, E. G. T., & Başusta, N. (2018). Chondrichthyan species as by-catch: A review on species inhabiting Turkish waters. *Journal of the Black Sea/Mediterranean Environment*, 24(3), 288-305.

Bertalanffy, Lv. (1938). A quantitative theory of organic growth (Inquiries on growth laws. II.). *Human Biology*, 10, 181-213.

Bonanomi, S., Pulcinella, J., Fortuna, C. M., Moro, F., & Sala, A. (2018). Elasmobranch bycatch in the Italian Adriatic pelagic trawl fishery. *PloS one*, 13(1), e0191647. https://doi.org/10.1371/journal.pone.0191647

Cabbar, K., & Yığın, C. Ç. (2021). Length–Weight Relationships of Elasmobranch Species from Gökçeada Island in the Northern Aegean Sea. *Thalassas*, 37, 497-504.

Campana, S. E. (2014). Age determination of elasmobranchs, with special reference to Mediterranean species: a technical manual. Studies and Reviews. *General Fisheries Commission for the Mediterranean*, No. 94. Rome, FAO 2014, 38 p.

Capapé, C., Guelorget, O., Siau, Y., Vergne, Y., & Quignard J.P. (2007). Reproductive biology of the thornback ray *Raja clavata* (Chondrichthyes: Rajidae) from the coast of Languedoc (Southern France, Northern Mediterranean). *Vie Milieu*, 57, 83–90. https://hal.sorbonne-universite.fr/hal-03234935

Capapé, C., Vergne, Y., & Quignard, J. P. (2008). New biological data on the eagle ray *Myliobatis aquila* (Chondrichthyes: Myliobatidae), off the Languedocian Coast (Southern France, Northern Mediterranean). *Annales, Series Historia Naturalis*, 18, 167–172.

Capapé, C., & Reynaud, C. (2011). Maturity, reproductive cycle and fecundity of the spiny dogfish *Squalus acanthias* (Chondrichthyes: Squalidae) off the Languedocian coast (southern France, northern Mediterranean). *Journal of the Marine Biological Association of the United Kingdom*, 91(8), 1627-1635. https://doi.org/10.1017/S0025315411000270

Ceyhan, T., Hepkafadar, O., & Tosunoğlu, Z. (2010). Catch and size selectivity of smallscale fishing gear for the smooth-hound shark *Mustelus mustelus* (Linnaeus, 1758) (Chondrichthyes: Triakidae) from the Aegean Turkish coast. *Mediterranean Marine Science,* 11(2), 213-223. https://doi.org/10.12681/mms.73

Colombelli, A., & Bonanomi, S. (2022). Length–weight relationships for six elasmobranch species from the Adriatic Sea. *Journal of Applied Ichthyology*, 38(3), 328-332. https://doi.org/10.1111/jai.14305

Colonello, J., Christiansen, H. E., Cousseau, M. B., & Macchi, G. J. (2013). Uterine dynamics of the southern eagle ray *Myliobatis goodei* (Chondrichthyes: Myliobatidae) from the southwest Atlantic Ocean. *Italian Journal of Zoology*, 80(2), 187-194. https://doi.org/10.1080/11250003.2012.742146

Ebert, D. A. (2005). Reproductive biology of skates, *Bathyraja* (Ishiyama), along the eastern Bering Sea continental slope. *Journal of Fish Biology*, 66(3), 618-649. https://doi.org/10.1111/j.0022-1112.2005.00628.x

Filiz, H., & Bilge, G. (2004). Length-weight Relationships of 24 Fish Species from the North Aegean Sea, Turkey. *Journal of Applied Ichthyology*, 20, 431-432.

Filiz, H., & Mater, S. (2002). A Preliminary Study on Lenght-Weight Relationships for Seven Elasmobranch Species from North Aegean Sea, Turkey. *E.Ü. Su Ürünleri Dergisi*, 19(3-4), 401-409.

Froese, R. (2006). Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22(4), 241-253. https://doi.org/10.1111/j.1439-0426.2006.00805.x

Gray, A. E., Mulligan, T. J., & Hannah, R. W. (1997). Food habits, occurrence, and population structure of the bat ray, *Myliobatis californica*, in Humboldt Bay, California. *Environmental Biology of Fishes*, 49, 227–238.

Gül, G., & Demirel, N. (2020). Trophic interactions of uncommon batoid species in the sea of Marmara. *Journal of the Black Sea/Mediterranean Environment*, 26, 294-309.

Hamlett, W. C. (2005). Reproductive Biology and Phylogeny of Chondrichthyes. Sharks, Batoids, and Chimaeras, Vol. 3. Enfield, NH: Science Publishers.

Holden, M. J. (1974). Problems in the rational exploitation of elasmobranch populations and some suggested solutions. In: Harden Jones FR (ed) Sea fisheries research. John Wiley and Sons, New York, pp: 117–137.

Ilkyaz, A. T., Metin, G., Soykan, O., & Kinacigil, H. T. (2008). Length–weight relationship of 62 fish species from the Central Aegean Sea, Turkey. *Journal of Applied Ichthyology*, 24, 699–702.

Ismen, A., Ozen, A., Altinagac, U., Ozekinci, U., & Ayaz, A. (2007). Weight– length relationships of 63 fish species in Saros Bay, Turkey. *Journal of Applied Ichthyology*, 23, 707–708. https://doi.org/10.1111/j.1439-0426.2007.00872.x

Jabado, R. W., Chartrain, E., Cliff, G., Da Silva, C., Derrick, D., Dia, M., Diop, M., Doherty, P., Leurs, G. H. L., Metcalfe, K., Pacoureau, N., Porriños, G., Seidu, I., Soares, A., Tamo, A., VanderWright, W. J., Williams, A. B., & Winker, H. (2021). *Myliobatis aquila* The IUCN Red List of Threatened Species 2021: e.T161569A124508353. https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T161569A124508353.en. Accessed on 15 February 2024.

Jacobsen, I. P., & Bennett, M. B. (2013). A Comparative Analysis of Feeding and Trophic Level Ecology in Stingrays (Rajiformes; Myliobatoidei) and Electric

Rays (Rajiformes: Torpedinoidei). *PLoS ONE*, 8(8), e71348.

Jardas, I., Šantić, M., & Pallaoro, A. (2004). Diet composition of the eagle ray, *Myliobatis aquila* (Chondrichthyes: Myliobatidae), in the Eastern Adriatic Sea. *Cybium*, 28(4), 372-374.

Kadri, H., Marouani, S., Bradai, M. N., & Bouaïn, A. (2014). Diet and feeding strategy of thornback ray, *Raja clavata* (Chondrichthyes: Rajidae) from the Gulf of Gabes (Tunisia-Central Mediterranean Sea). *Journal of the Marine Biological Association of the United Kingdom*, 94(7), 1509-1516.

Keskin, Ç., Ordines, F., Ates, C., Moranta, J., & Massutí, E. (2014). Preliminary evaluation of landings and discards of the Turkish bottom trawl fishery in the northeastern Aegean Sea (eastern Mediterranean). *Scientia Marina*, 78(2), 213-225.

La Mesa, G., Annunziatellis, A., Filidei, Jr. E., & Fortuna, C. M. (2016). Bycatch of Myliobatid Rays in the Central Mediterranean Sea: the Influence of Spatiotemporal, Environmental, and Operational Factors as Determined by Generalized Additive Modeling. *Marine and Coastal Fisheries*, 8(1), 382-394. https://doi.org/10.1080/19425120.2016.1167795

Martin, L. K., & Cailliet, G. M. (1988). Aspects of reproduction of the bat ray, *Myliobatis californica*, in central California. *Copeia*, 754–762.

Maruska, K. P., Cowie, E. G., & Tricas, T. C. (1996). Periodic gonadal activity and protracted mating in elasmobranch fishes. *Journal of Experimental Zoology*, 276, 219–232.

Medit (2016). MEDITS-Handbook. Version n. 8. MEDITS Working Group: 177 pp.

Molina, J. M., & Lopez Cazorla, A. (2015). Biology of *Myliobatis goodei* (Springer, 1939), a widely distributed eagle ray, caught in northern Patagonia. *Journal of Sea Research*, 95, 106–114.

Moutopoulos, D. K., & Stergiou, K. I. (2002). Length–weight and length–length relationships of fish species from the Aegean Sea (Greece). *Journal of Applied Ichthyology*, 18(3), 200-203.

Oddone, M. C., & Velasco, G. (2006). Relationship between liver weight, body size and reproductive activity in *Atlantoraja cyclophora* (Elasmobranchii/Rajidae/ Arhynchobatinae) in oceanic waters off Riogrande do Sul, Brazil. *Neotropical Biology and Conservation*, 1(1), 12-16.

Ponte, D. D. S., Barcelos, L. M. D., Santos, C. S., Medeiros, J., & Barreiros, J. P. (2016). Diet of *Dasyatis pastinaca* and *Myliobatis aquila* (Myliobatiformes) from the Azores, NE Atlantic. *Cybium*, 40(3), 209-214. https://doi.org/10.26028/cybium/2016-403-003

Rafrafi-Nouira, S., El Kamel-Moutalibi, O., Amor, K. O. B., Amor, M. M. B., & Capapé, C. (2017). A case of hermaphroditism in the common eagle ray *Myliobatis aquila* (Chondrichthyes: Myliobatidae), reported from the Tunisian coast (central Mediterranean). *In Annales: Series Historia Naturalis*, 27(1), 43-48.

Rastgoo, A. R., Fatemi, M. R., Valinassab, T., & Mortazavi, M. S. (2016). Length–weight relationships for 10 elasmobranch species from the Oman Sea. *Journal of Applied Ichthyology*, 32, 734–736.

Ruocco, N. L., Lucifora, L. O., Astarloa, J. M. D., Mabragaña, E., & Delpiani, S. M. (2012). Morphology and DNA barcoding reveal a new species of eagle ray from the southwestern Atlantic: *Myliobatis ridens* sp. nov. (Chondrichthyes: Myliobatiformes: Myliobatidae). *Zoological Studies*, 51, 862-873.

Ryland, S. J., & Ajayi, O. T. (1984). Growth and Population Dynamics of Three *Raja* Species (Batoidei) in Carmarthen Bay, British Isles. *ICES Journal of Marine Science*, 41(2), 111-120.

Schluessel, V., Bennett, M. B., & Collin, S. P. (2010). Diet and reproduction in the white-spotted eagle ray *Aetobatus narinari* from Queensland, Australia and the Penghu Islands, Taiwan. *Marine and Freshwater Research*, 61, 1278-1289.

Schoonjans, F. (2017). MedCalc manual. ISBN: 978-1520321578, 355p.

Simpfendorfer, C. A., Heupel, M. R., White, W. T., & Dulvy, N. K. (2011). The importance of research and public opinion to conservation management of sharks and rays: a synthesis. *Marine and Freshwater Research*, 62(6), 518-527.

Smith, J. W., & Merriner, J. V. (1987). Age and growth, movements and distribution of the cownose ray, *Rhinoptera bonasus*, in Chesapeake Bay. *Estuaries*, 10, 153–164.

Snelson, F. F. Jr., Roman, B. L., & Burgess, G. H. (2008). The reproductive biology of pelagic elasmobranchs. In Sharks of the Open Ocean: Biology, Fisheries and Conservation (Camhi, M. D. & Pikintch, E. K., eds), pp. 24–45. Oxford: Blackwell Publishing.

Tazerouti, F., Neifar, L., & Euzet, L. (2011). Redescription of Monocotyle myliobatis (Monogenea, Monocotylidae) from the type host *Myliobatis aquila* (Elasmobranchii, Myliobatidae) off the Algerian coast. *Acta Parasitologica*, 56(3), 274-279.

Tunka Eronat, E. G., & Özaydın, O. (2014). Length-weight relationship of cartilaginous fish species from Central

Aegean Sea (Izmir Bay and Sığacık Bay). *Ege Journal of Fisheries and Aquatic Sciences*, 31(3), 119-125.

Türker, D., Zengin, K., & Tünay, Ö. K. (2018). Length-Weight Relationships for Nine Chondrichthyes Fish Species from Edremit Bay (North Aegean Sea). *Turkish Journal of Fisheries and Aquatic Sciences*, 19(1), 71-79. https://doi.org/10.4194/1303-2712-v19_1_08

Whitehead, P. J. P., Bauchot, M. L., Hureau, J. C., Nielsen, J., & Tortonese, E. (Eds). (1986a). Fishes of the North-Eastern Atlantic and the Mediterranean. Vol. 1. Richard Clay Ltd, UK, 511-1007.

Whitehead, P. J. P., Bauchot, M. L., Hureau, J. C., Nielsen, J., & Tortonese, E. (Eds). (1986b). Fishes of the North-Eastern Atlantic and the Mediterranean. Vol. 2. Richard Clay Ltd, UK, 1008-1474.

Wigley, S. E., McBride, H. M., & McHugh, N. J. (2003). Length-Weight Relationships for 74 Fish Species Collected during NEFSC Research Vessel Bottom Trawl Surveys, 1992-99. NOAA Technical Memorandum NMFS-NE-171, 26 pp.

Valls, M., Quetglas, A., Ordines, F., & Moranta, J. (2011). Feeding ecology of demersal elasmobranchs from the shelf and slope off the Balearic Sea (western Mediterranean). *Scientia Marina*, 75, 633-639.

Yeldan, H., Avşar, D., Mavruk, S., & Manaşırlı, M. (2013). Temporal changes in some Rajiformes species of cartilaginous fish (Chondrichthyes) from the west coast of İskenderun Bay (northeastern Mediterranean). *Turkish Journal of Zoology*, 37, 693-698.

Yığın, C. Ç., & İşmen, A. (2009). Lenght-Weight Relationship for Seven Rays from Saros Bay (North Aegean Sea). *Journal of Applied Ichthyology*, 25, 106-108.

Yığın, C. Ç. (2010). Kuzey Ege'de Avlanan Vatozların (Rajidae) Biyoekolojik Özelliklerinin Belirlenmesi. Doktora Tezi. Çanakkale Onsekiz Mart Üniversitesi. 165s.

Villavicencio-Garayzar, C. J. (1996). Tallas, proporción De sexos y reproducción de *Myliobatis californica* y *M. longirostris* (Pisces: Myliobatidae) en Baja California Sur, México. *Revista de Biología Tropical*, 44, 291–295.

Zar, J.H. (1999). Biostatistical Analysis, 4^{th} ed., Upper Saddle River, NJ: Prentice Hall.