

# Distribution and morphometric characters of the Mediterranean thornback ray, *Raja clavata* (Chondrichthyes: Rajidae) in the Gulf of Gabès (Tunisia, Central Mediterranean)

Distribution et caractères morphométriques de la raie bouclée de la Méditerranée, *Raja clavata* (Chondrichthyens : Rajidae) dans le golfe de Gabès (Tunisie, Méditerranée centrale)

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## Abstract

Kadri H., S. Marouani, M.N. Bradaï, A. Bouaïn, E. Morize – Distribution and morphometric characters of the Mediterranean thornback ray, *Raja clavata* (Chondrichthyes: Rajidae) in the Gulf of Gabès (Tunisia, Central Mediterranean). *Mar. Life*, 18: 9-16.

Population structure and distribution of the thornback ray, *Raja clavata*, L. 1758, in the Gulf of Gabès are described on the basis of data from bottom trawl surveys conducted in the area between 2006 and 2007. *Raja clavata* was caught at depths between 30 and 180 m; highest abundance and density indices were recorded at a depth stratum 30 - 80 m.

The status of the species is still poorly known and there is a knowledge gap regarding its distribution and morphometric characters.

The aim of this study was to investigate the distribution and the relationships between the morphometric characters and total length, defined separately for males and females, and meristic counts of these species were carried out along the Gabès coast.

A total of 1 280 *Raja clavata* were examined, of which 750 were females ranging from 14 to 110 cm TL and 10 - 8 500 g TM and 530 were males ranging from 14.6 to 89 cm TL and 10 - 4 380 g TM. Sexual dimorphic differences were evident in these species, the total length (TL) to total mass (TM) relationship was significantly different.

But there was no significant difference in the regression slopes between sexes for the TL and DW relationship.

### KEY-WORDS :

*Raja clavata*, distribution, morphometric characters, numerical characters, Gulf of Gabès, Mediterranean Sea.

## Résumé

Kadri H., S. Marouani, M.N. Bradaï, A. Bouaïn, E. Morize – [Distribution et caractères morphométriques de la raie bouclée de la Méditerranée, *Raja clavata* (Chondrichthyens : Rajidae) dans le golfe de Gabès (Tunisie, Méditerranée centrale)]. *Mar. Life*, 18: 9-16.

La structure de la population et la distribution de la raie bouclée, *Raja clavata*, L. 1758, dans le golfe de Gabès ont été décrites à partir des données provenant de pêche au chalut de fond dans la région entre 2006 et 2007. *Raja clavata* a été capturé à des profondeurs comprises entre 30 et 180 m ; l'indice d'abondance et la densité les plus élevés ont été enregistrés à une profondeur comprise entre 30 et 80 m.

Le statut de l'espèce est encore mal connu et il y a un manque de connaissances sur la répartition et les caractères morphométriques.

Le but de ce travail est d'étudier la distribution et les caractères morphométriques en relation avec la longueur totale pour les mâles et les femelles séparément, les caractères numériques ont été comptés pour cette espèce le long de la côte du golfe de Gabès.

Au total, 1 280 *Raja clavata* ont été examinés : 750 étaient des femelles allant de 14 à 110 cm TL et de 10 à 8 500 g TM et 530 étaient des mâles allant de 14,6 à 89 cm TL et de 10 à 4 380 g TM. Le dimorphisme sexuel est évident pour cette espèce, en considérant la relation longueur totale (TL) / masse totale (TM) qui est significativement différente, mais il n'y a pas de différence significative dans les pentes de régression entre les sexes pour la relation TL / DW.

### MOTS CLÉS :

*Raja clavata*, distribution, caractères morphométriques, caractères numériques, golfe de Gabès, mer Méditerranée

## Introduction

The thornback ray, *Raja clavata* L. 1758 (Rajiformes: Rajidae), is a medium-sized skate, widely distributed in the Mediterranean and Black Seas (Massuti, Moranta, 2003; Serena *et al.*, 2010), as well as in the eastern Atlantic and all around the coasts of Africa (Stehmann, Burkel, 1986), inhabiting a wide variety of bottoms from very shallow waters down to 700 m (Serena *et al.*, 2010). *Raja clavata* is rather frequently landed at Tunisian fishing sites, even if it is locally considered as by-catch species (Bradai *et al.*, 2004). *Raja clavata* is very common along the Tunisian coasts, mainly in the Gulf of Gabès (Kadri *et al.*, 2014).

*Raja clavata* is one of the most commercially valuable rays, although the economic value of their total catch is small in comparison to other demersal species and as such they have not been the focus of fisheries management. Given especially their low fecundity, slow growth rate, and late maturity, which makes them potentially vulnerable to exploitation (Bottari *et al.*, 2013), *R. clavata* is considered as “near threatened” in the Red List of IUCN (2011) and consequently, specific local management strategies are required.

There is very little information on the morphometric characters of *R. clavata*, though this status in the Gulf of Gabès is unclear. In fact, the aim of the present study was to define the total length and other morphometric characters relationships of the *R. clavata* population. The results derived from this study provide very important and useful information for the conservation and management of this species.

## Material and methods

### Study area

The Gabès region is located in southern Tunisia and in the southern Mediterranean Sea. It includes 750 km of coastline, from 35° N to the Libyan border (33° 10' N) (Ben Othman, 1973), representing 58% of the Tunisian coast (Bradai *et al.*, 1992).

This region is the most important Tunisian fishing area, involving more than 50% of the local fishing fleet (Bradai *et al.*, 2004).

The salinity remains fairly stable throughout the year. High concentrations have been recorded in summer (47–48‰) and often in winter (40–42‰). The data set obtained was recorded and maps of population distribution were drawn.

### Sampling

Samples of *Raja clavata* (750 females and 530 males) were landed monthly by the commercial fleets in the Gulf of Gabès (Figure 1). All specimens were sexed and sized as shown in Figure 2: total length (TL, cm), disc width (DW, cm), distance measured from snout tip to eye (SE, cm), width of the mouth (WM, cm) and distance from snout tip to first dorsal (SD1, cm). The sex ratio was analyzed by using a Chi-square test (?2).

Length-frequency distribution of females and males were compared using the Kolmogorov–Smirnov two-sample test. The total length (TL) was measured to the nearest centimeter. The total body mass (TM) of each specimen was weighed to the nearest 10 and 0.01g respectively for large and small specimens.

### Morphometric characters measurement

The length-total mass relationships of all collected samples were determined by the expression  $TM = aL^b$ , where TM is the derived weight (g), L is the total length (cm). The parameters a and b of the length-weight relationships were estimated by the least squares regression method. The significance of the regression was different from the predictions for isometric growth ( $b = 3$ ). Equations expressing the length/total mass relationships were calculated for sex.

The allometric equation  $Y = aX^b$  was used to define the relationship between the total length (TL, cm) and disc width (DW, cm), distance measured from snout tip to eye (SE, cm), width of the mouth (WM, cm), distance from snout tip to first dorsal (SD1, cm) where Y is the various dimensions (DW, SE, WM, SD1 respectively), and X is the total length.

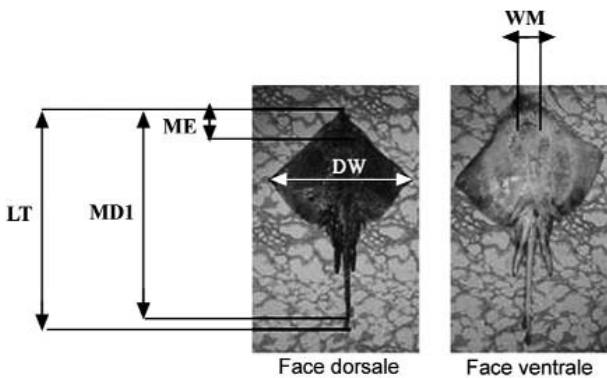
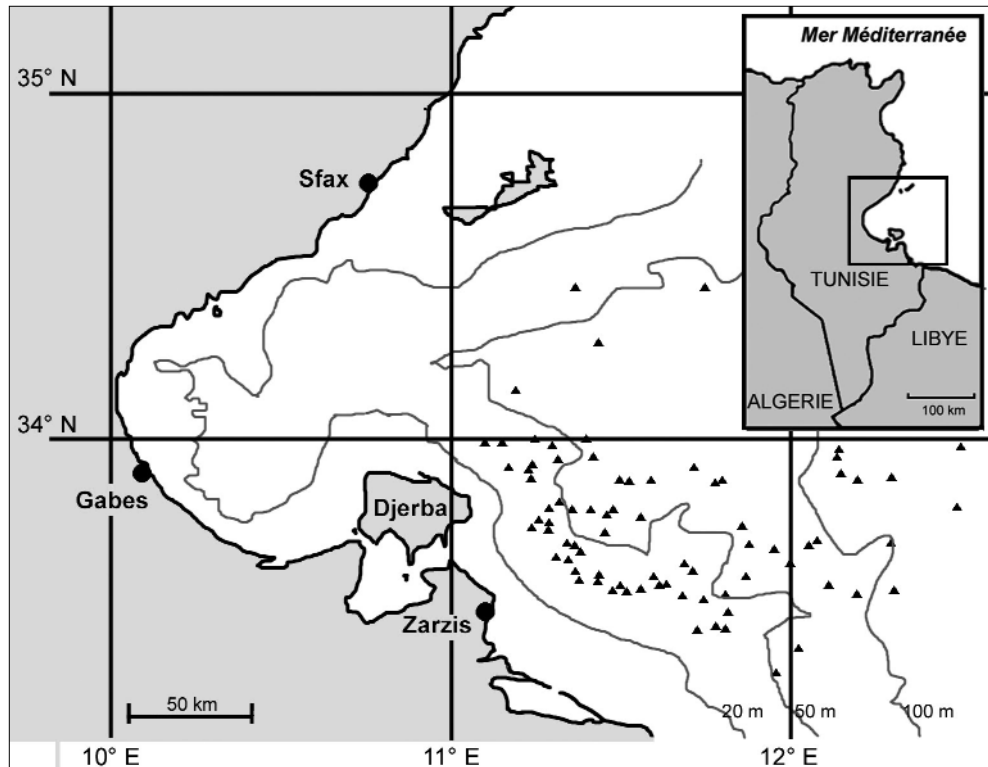
Parameters a and b were estimated by linear regression analysis (least-squares method) of log-transformed data. To count numeric characters, tooth rows were counted directly on specimens by making incisions at the jaw angles to expose the teeth. The tooth shape was noted (NT), number of the tooth rows on lower and upper jaws as well as the number of pectoral fin rays (NP), the number of nictitating lamellae (NL), the number of pseudobranchial lamellae (NPL) and the number of the trunchal vertebrae (NV) were recorded.

The parameters of distribution (average) and parameters of dispersion (minimum, maximum, standard deviation, interval of confidence) of these morphometric characters were calculated.

**Figure 1**

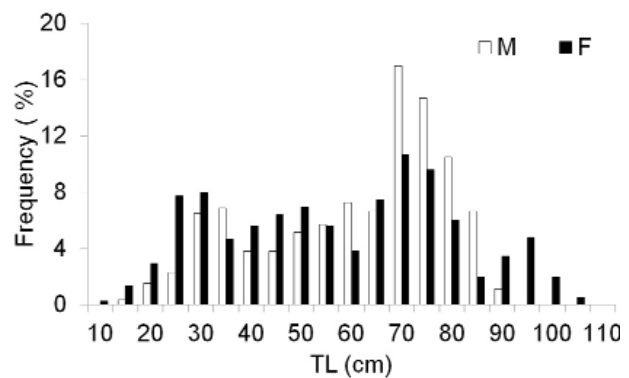
Map of the study area, indicating the sampling location (Gulf of Gabès, Southern Tunisia, Central Mediterranean).

*Carte de la zone d'étude, emplacements des stations d'échantillonnage (golfe de Gabès, Tunisie méridionale, Méditerranée centrale).*



**Figure 2**

Measurements made on *Raja clavata*.  
 Les mesures effectuées sur *Raja clavata*.



**Figure 3**

Length-frequency distribution (10 cm length classes) of female and male *Raja clavata* sampled in Gulf of Gabès (Tunisia).  
 Distribution de fréquences des longueurs (classes de 10 cm) des femelles et des mâles de *Raja clavata* collectés dans le golfe de Gabès (Tunisie).

## Results

A total of 1 280 specimens were caught during the surveys, 530 (41.41%) males and 750 (58.59%) females. The overall sex ratio (females to males) was 1.00: 1.42. The seasons that contributed to this significant difference were autumn and winter (**Table I**).

Female and male total lengths ranged from 14 to 110 cm and from 14.6 to 89 cm, respectively. A higher proportion of males were observed in the length classes between 60 and 80 cm while the proportion of females were more abundant and reached 100% in the largest individuals (**Figure 3**). The distribution of length within this ranges

was significantly different (Kolmogorov-Smirnov test,  $D = 0.088$ ,  $n = 1\ 170$ ,  $p = 0.02$ ).

The total length of the females ranged from 14 to 110 cm with a mean value of  $61.4 \pm 5.5$  cm and weight from 10 to 8 500 g (mean value  $2\ 100 \pm 568$ ); total length of the males from 14.6 to 89 cm (mean value  $41.4 \pm 3.5$  mm) and weight from 10 to 4 380 g (mean value  $1\ 325 \pm 215.7$  g). TM and other morphometric characters (DW, SE, WM, SD I) are strongly positively correlated with TL for males and females except for TL-DW and LT-SE which show negative allometric growth (**Figures 4-8, Table II**).

	Summer	Autumn	Winter	Spring	Annual
<b>Males</b>	158	109	127	136	530
<b>Females</b>	186	203	198	163	750
<b>Total</b>	344	312	325	299	1280
<b>% Males</b>	45.93	34.94	39.08	45.48	41.41
<b>% Females</b>	54.07	65.06	60.92	54.52	58.59
<b>X<sup>2</sup> cal</b>	2.48	40.53	19.85	2.68	45.66
<b>P</b>	0.12	< 0.001	< 0.001	0.10	< 0.001
<b>Significance</b>	NS	SS	SS	NS	SS

**Tableau I**

Variation in the proportion of male and female *Raja clavata* according to season in the Gulf of Gabès (Tunisia), and comparison through a t-Student test ( $p < 0.05$ ; bold values: statistically different). NS: not significant, SS: significant).

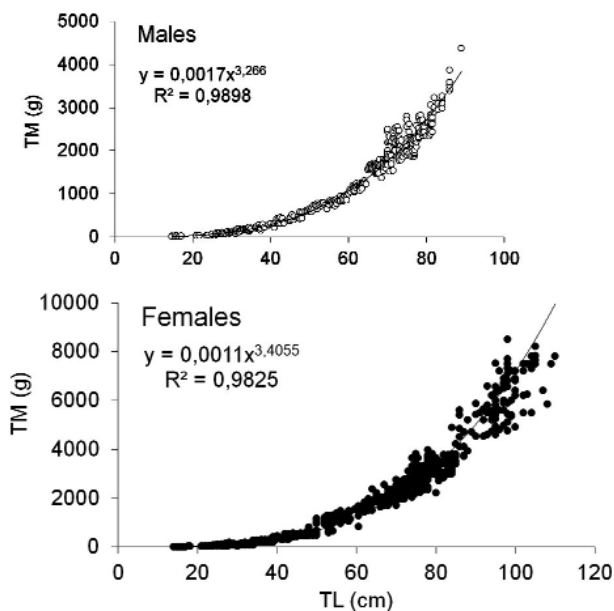
*Variation de la proportion de mâles et femelles de Raja clavata selon la saison, dans le golfe de Gabès (Tunisie), et la comparaison par un test de Student ( $p < 0,05$ ; valeurs en gras : statistiquement différent. NS : non significatif, SS : significatif).*

Parameters	NV	NL	NP	NPL	NT	
					upper jaw	lower jaw
Min	20	11	75	13	35	33
Max	35	15	86	15	45	48
Mean $\pm$ SE	28.66 $\pm$ 0.71	12.55 $\pm$ 0.15	78.76 $\pm$ 0.36	13.72 $\pm$ 0.09	39.77 $\pm$ 0.44	40.18 $\pm$ 0.96

**Tableau II**

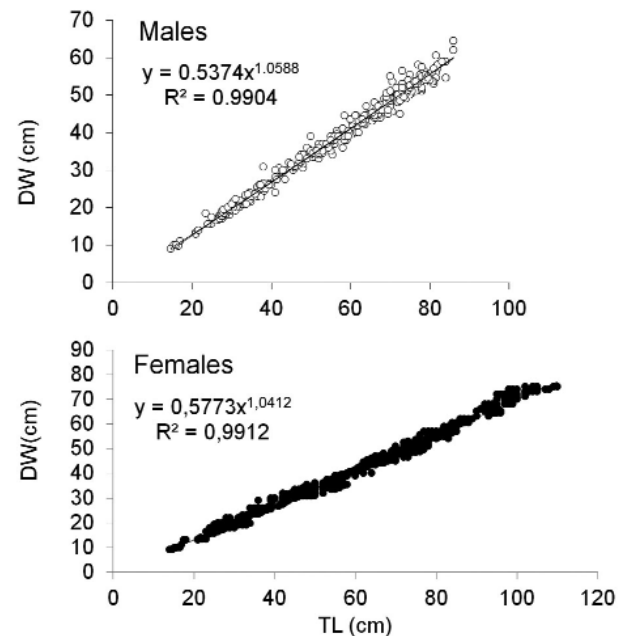
Morphometric characters of the Mediterranean Thornback ray (*Raja clavata*) in the Gulf of Gabès (Tunisia). Number of the truncal vertebrae (NV), number of nictitating lamellae (NL), number of pectoral fin rays (NP), number of pseudobranchial lamellae (NPL), number of the tooth rows (NT) (upper jaw, lower jaw), minimum (Min), maximum (Max) and average (Mean  $\pm$  SE).

*Caractères morphométriques de la raie bouclée de Méditerranée (Raja clavata) dans le golfe de Gabès (Tunisie). Nombre de vertèbres troncales (NV), nombre de lamelles nictitantes (NL), nombre de rayons pectoraux (NP), nombre de lamelles pseudobranchiales (NPL), nombre de rangées de dents (NT) (mâchoire supérieure, mâchoire inférieure), minimum (Min), maximum (Max) et moyenne (Mean  $\pm$  SE).*



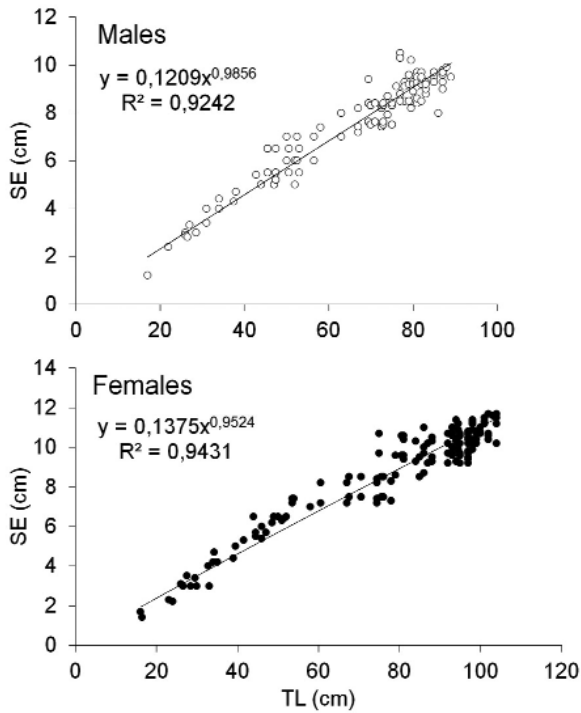
**Figure 4**  
Relationship between total length (TL) and total mass (TM) of *Raja clavata* in the Gulf of Gabès (Tunisia). R<sup>2</sup> = Coefficient of determination.

*Relation entre la longueur totale (TL) et le poids total (TM) de Raja clavata dans le golfe de Gabès (Tunisie). R<sup>2</sup> = Coefficient de détermination.*



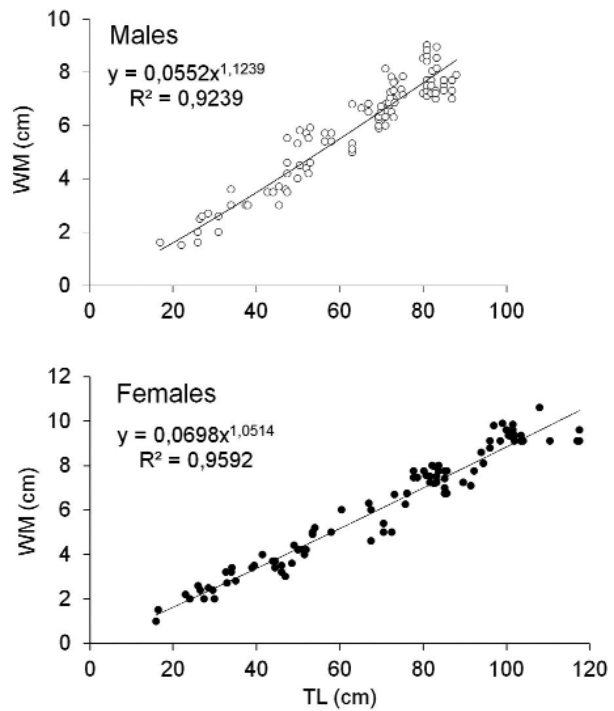
**Figure 5**  
Relationship between total length (TL) and disc width (DW) of *Raja clavata* in the Gulf of Gabès (Tunisia). R<sup>2</sup> = Coefficient of determination.

*Relation entre la longueur totale (TL) et la largeur du disque (DW) de Raja clavata dans le golfe de Gabès (Tunisie). R<sup>2</sup> = Coefficient de détermination.*



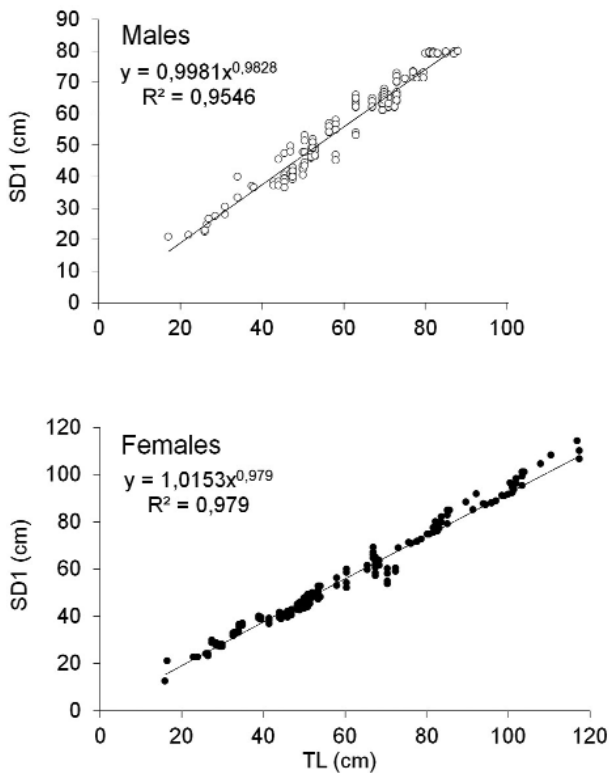
**Figure 6**  
 Relationship between total length (TL) and snout tip to eye (SE) of *Raja clavata* in the Gulf of Gabès (Tunisia).  $R^2$  = Coefficient of determination.

*Relation entre la longueur totale (TL) et la distance de la pointe du museau à l'œil (SE) de Raja clavata dans le golfe de Gabès (Tunisie).  $R^2$  = Coefficient de détermination.*



**Figure 7**  
 Relationship between total length (TL) and width of the mouth (WM) of *Raja clavata* in the Gulf of Gabès (Tunisia).  $R^2$  = Coefficient of determination.

*Relation entre la longueur totale (TL) et la largeur de la bouche (WM) de Raja clavata dans le golfe de Gabès (Tunisie).  $R^2$  = Coefficient de détermination.*



**Figure 8**  
 Relationship between total length (TL) and snout tip to first dorsal (SD1) of *Raja clavata* in the Gulf of Gabès (Tunisia).  $R^2$  = Coefficient of determination.

*Relation entre la longueur totale (TL) et la distance de la pointe du museau à la première dorsale (SD1) de Raja clavata dans le golfe de Gabès (Tunisie).  $R^2$  = Coefficient de détermination.*

	Quignard, 1965 (Gulf of Lion)	Mnasri, 2008 (Gulf of Tunis)	Present study (Gulf of Gabès)
Number of trunchal vertebrae	23-25	23-28	20-35
Number of nictitating lamellae		11-14	11-15
Number of pectoral fin rays	77-81	74-81	75-86
Number of pseudobranchial lamellae	13-16	13-15	13-15
Number of tooth rows on the upper jaw	36-51	36-46	33-45
Number of tooth rows on the lower jaw	35-53	36-48	33-48

Tableau III

Comparison of numerical counts with various other studies in the Mediterranean.  
*Comparaison des valeurs numériques avec différentes études en Méditerranée.*

## Discussion and conclusion

The overall sex ratio was close to 1: 1.42, in favor of females in this study, females dominated catches, despite the overall sex ratio around 0.5 in results previously reported from other areas in the Mediterranean and Atlantic waters (Krstulovic-Sifner *et al.*, 2009; Serra-Pereira *et al.*, 2012), the similar proportions of males and females on the coast of Languedoc in each category of specimens and the relatively high proportion of both adult males and females (Capapé *et al.*, 2007). It is difficult to determine whether the differences observed are biological or methodological. The probable reasons for the dissimilarity between different localities may be related to the use of different sampling gear (beach seine, gillnet, longline etc.), samples collected from different areas and depths and the selectivity of sampling gears (Kadri *et al.*, 2014).

The population structure of *R. clavata* from the Bay of Douarnenez showed a certain imbalance in the sex ratio, favouring males among the adults and females among the juveniles, attributed to different migration patterns of males and females (Rousset, 1990). As our study covered a much wider area, these differences in the overall sex ratio were not observed.

The differences in skate sex ratios may be a consequence of behavior, because many species segregate by sex, size, and maturity (Fitz, Daiber, 1963; Richards *et al.*, 1963; Holden, 1975; Braccini, Chiaramonte, 2002). The length–frequency distribution of *R. clavata* was dominated by juvenile specimens. The maximum size for males and females in this study (89 and 110 cm TL, respectively) is greater than the previously recorded maximum size in other studies (Capapé *et al.*, 2007; Serra-Pereira *et al.*, 2012; Bottari *et al.*, 2013). The reason for this difference may be the sample size, different habitat and reproduction season (Kadri *et al.*, 2014).

The length–weight relationships for males and females showed a positive allometry for this species, the coefficient *b* had a higher value for females than for males,

the *b* values vary according to species, sex, age, seasons and feeding. In addition, changes in physiological conditions, different amounts of available food, life span or growth rate can all affect the *b* growth exponent (Le Cren, 1951; Ricker, 1975). The difference between sexes was statistically significant (Kadri *et al.*, 2014), indicating faster weight increase in females in relation to length in accordance with results of previous studies (Borges *et al.*, 2003; Mendes *et al.*, 2004; Demirhan *et al.*, 2005; Krstulovic-Sifner *et al.*, 2009; Bottari *et al.*, 2013).

Differences in growth rates between sexes are a common feature in *Raja* species. Females typically attain larger size than males, but they grow more slowly (Kadri *et al.*, 2012, 2013, 2014).

Weight-size relationships can provide useful information regarding the increase in weight of a population and this parameter could also be important for comparative studies between populations (Mori *et al.*, 1990). The relationship between TL and DW for males and females was linear and not significantly different as reported previously by another study by our team (Kadri *et al.*, 2014). In contrast to these findings, a significant difference in the same relationship between sexes was reported for *R. clavata* (Nottage, Perkins, 1983).

Moreover, we have shown that the number of numerical characters recorded for *R. clavata* (Table III) was in accordance with a study done in the Gulf of Lion (Quignard, 1965) and in the Gulf of Tunis (Mnasri, 2008). Various factors may be responsible for the similar or different biological parameters, such as temperature, salinity, food (quantity and quality), sex and maturity stage (Kadri *et al.*, 2014).

In conclusion, this study shows a close relationship between the total length, disc width (DW), distance measured from snout tip to eye (SE), width of the mouth (WM) and distance from snout tip to first dorsal (SD1) of *R. clavata* in the Gulf of Gabès.

Results from this research will provide a starting point for the development of a management plan for the thornback ray in the Gulf of Gabès. Further investigations

are necessary to quantify the impact of the existing regulations on the population dynamics and recruitment patterns of this species in the region. The data from this study can be used for stock assessment investigations in future. In addition, the results of this study provide invaluable information for the online FishBase database, as well as an important baseline for further studies.

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