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Distribution and morphometric characters of the Mediterranean longnosed skate, *Dipturus oxyrinchus* (Chondrichthyans: Rajidae) in the Gulf of Gabes (Tunisia, Central Mediterranean)

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PEER REVIEW

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Comments

This manuscript is written well. Authors used some statistical tests. Results of this research will be effective for the conservation of this rare fish in the Gulf of Gabes and also form the basis for their inclusion in a regional security programme.
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ABSTRACT

Objective: To investigate biometrics of *Dipturus oxyrinchus* (*D. oxyrinchus*), including length-weight relationships, total length (TL), disc width (DW), distance measured of snout tip to eye, width of the mouth, distance from snout tip to first dorsal, and the numeric characters in the Gulf of Gabes.

Methods: Monthly sampling was conducted commercial bottom-trawl during December 2006 and January 2007, operating at a depth of 80-185 m. The TL, DW, distance of snout tip to eye, width of the mouth, distance from snout tip to first dorsal were measured to the nearest 0.1 cm and the weight was measured to the nearest 0.1 g. The parameters *a* and *b* were estimated by the least squares regression method.

Results: A total of 520 *D. oxyrinchus* was ranged from 16.5 to 105.0 cm in TL and 30-5 300 g in total mass were analyzed during this study. The overall sex ratio was significantly different from the expected value of 1:16 (df=1, χ^2=3.38, P<0.05), and there was significant difference in the TL (t-test=16.53, df=520, P<0.05). There was significant difference in the regression slopes between sexes for the TL and DW relationship (t-test=17.53, df=520, P<0.05). The b value for the TL/ weight relationship for males *D. oxyrinchus* sampled in this study (3.01) was lower than that for female (3.23). Morphometric characters were strongly positively correlated for TL.

Conclusions: This study reported the first description of biometric relationships for *D. oxyrinchus*, which would be useful for the sustainable conservation of this rear fishery in the Gulf of Gabes and also form the basis for their inclusion in a regional security programme.

KEYWORDS

Dipturus oxyrinchus, Morphometric and numeric characters, Gulf of Gabes, Mediterranean Sea

1. Introduction

Interest in skates is increasing because of their prevalence as by-catch in groundfish fisheries throughout the world[1]. The family Rajidae is considered to be one of the most vulnerable elasmobranch groups to overexploitation[2].

Off the Tunisian coasts, *Dipturus oxyrinchus* (*D. oxyrinchus*) is frequently captured as by-catch of demersal trawl throughout the year. In the Mediterranean Sea, no studies on distribution and morphometric characters of *D. oxyrinchus* were reported, but some information of

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its reproductive biology has been collected from some restricted areas[3,4].

In spite of the increasing fishing pressure, there is a paucity of information on longnosed skate life history resulting in an assessment of 'Near Threatened' on IUCN Red List assessments for Chondrichthyans in the Mediterranean Sea[5].

The purpose of the current study is to: (1) provide the distribution bathymetric of this species, (2) determine some morphometric characters for both sexes, (3) establish numeric characters for both sexes. This paper presents significant new information on the distribution, morphometric and numeric characters of the skate *D. oxyrinchus*.

2. Materials and methods

2.1. Study area

The Gabes region is located in Southern Tunisia and in Southern Mediterranean Sea. It extends along 750 km representing 58% of the Tunisian coast[6]. It extends from the city of Chebba (35.3°N) in the north of the region to the Island of Djerba (33.8°N) in the south, a distance of 200 km. In breadth, it extends from 10°E to just under 11.2°E.

The annual cycle of water temperature is very pronounced (13 °C to 29 °C) and resembles that of a lagoon. In summer, the particularly high temperatures and salinities (38‰ to 39‰) lead to the appearance of red algae. The second important feature of the Gulf of Gabes is the amplitude of the high tide which attains 1.8 m, the highest in the Mediterranean.

The salinity remains fairly stable throughout the year. It was recorded with high concentrations in summer (47‰-48‰) and often in winter (40‰-42‰).

The area is locally the most important fishing area and comprises most of the Tunisian fishing fleet. The gulf is a highly productive zone, one of the highest in the Eastern Mediterranean.

2.2. Sex ratio and population structure

The sex ratio according to fish size provides a useful tool to examine the biological characteristics of the fish species, such as sexual inversion, longevity in relation to sex, vulnerability to fishing gear and the spatial, seasonal and even daily distribution of species.

Samples of *D. oxyrinchus* (240 females and 280 males) were landed monthly by the commercial fleets in the Gulf of Gabes (Figure 1). All specimens were sexed and sized. The sex ratio was analyzed by using a *Chi*-square test.

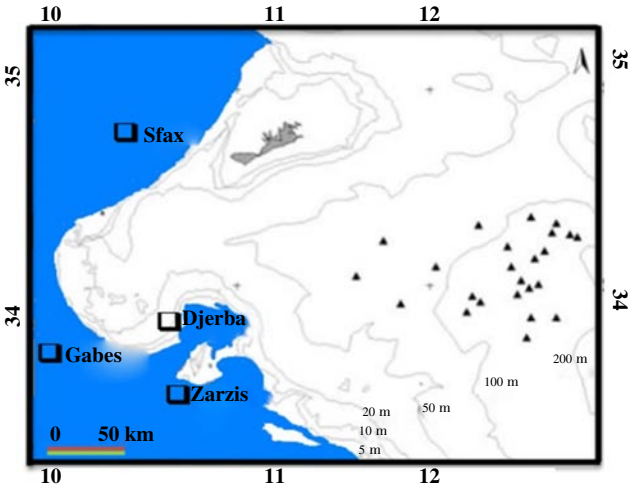

Figure 1. Map of the study area, indicating the sampling location (Gulf of Gabes, Southern Tunisia, Central Mediterranean).

The size frequency was analyzed at a 5 cm interval standard length class using a histogram to determine the type of distribution, which characterizes the fish population.

The Kolmogorov-Smirnov test[7] was applied to evaluate differences in the population size distributions between sexes.

2.3. Sampling and general biological measurements

A total of 520 *D. oxyrinchus* specimens were collected monthly in the Gulf of Gabes between December 2006 and January 2007 from commercial bottom-trawl landings in the Gulf of Gabes and using a beam trawl lasted for 2 h, during both day and night. Specimens were captured use a 22-mm stretched-mesh size cod-end, operating at a depth of 80-185 m (Figure 1).

Length-frequency distributions of females and males were compared using the Kolmogorov-Smirnov two-sample test (Figure 2).

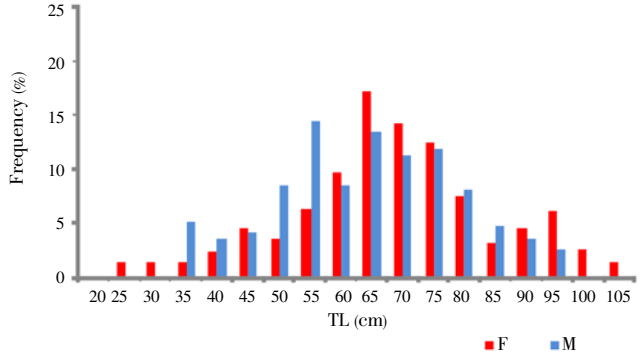

Figure 2. Length-frequency distributions (5 cm length classes) of female and male *D. oxyrinchus* sampled in Gulf of Gabes (Tunisia).

All specimens were sexed and sized including total length (TL, cm), disc width (DW, cm), distance measured of 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 (χ^2).

The TL was measured to the nearest 0.1 cm, weight was measured to the nearest 0.1 g and the sex was determined by macroscopic observation of the gonads.

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 TL (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 slopes of the logarithmic relationships TL-TM and TL-DW were compared between the sexes with student's *t*-tests[8].

The mathematical function suggested by Zar[9] was used in estimating:

$W=aL^b$

Where W is the total body weight (g), L the TL (cm), a and b are the coefficients of the functional regression between W and L. An allometric coefficient b value larger or smaller than 3.0 shows an allometric growth, or isometric growth when it is equal to 3.0[4]. In order to confirm whether the b values obtained in the linear regressions were significantly different from the isometric value (b=3), *t*-test for independent samples were used.

The allometric equation $Y=aX^b$ was used to define the relationship between the TL (cm), DW (cm), SE cm), WM (cm), SD1 (cm) where Y is the various dimensions (TM, DW, SE, WM, SD1 (cm) respectively, and X is the TL (cm).

The parameters a and b were estimated by linear regression analysis (least-squares method) of log-transformed data, and 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 (the number of the tooth rows lower, the number of the tooth rows upper jaw, number of pectoral fin rays, number of nictitating lamellae, number of pseudobranchial lamellae, the number of the Trunchal vertebrae.

The parameters of distribution (average) and parameters of dispersion (minimum, maximum, ecartype, interval of confidence) of this morphometric characters were calculated.

3. Results

This study provides morphometric information for the Mediterranean skate *D. oxyrinchus* in Southern Tunisian waters (Gulf of Gabes).

A total of 520 *D. oxyrinchus* (240 females and 280 males) was sampled with an overall female: male (F:M) sex ratio of 1:1.16 that significantly different from the expected 1:1 ratio ($P>0.05$). The sex-ratio is in favor of males (Table 1).

Table 1
Variation in the proportion of male and female *D. oxyrinchus* according to season in the Gulf of Gabes (Tunisia), and comparison through student's *t*-test.

	Male	Female	Total	Male%	Female%	χ^2	*P*	Significance
Summer	28	108	136	27.25	72.75	47.06	0	NS
Autumn	56	39	95	35.35	64.65	3.04	0.0811307	SS
Winter	82	58	140	48.72	51.28	4.11	0.0425225	SS
Spring	74	75	149	46.08	53.92	0.01	0.93	NS
Annual	240	280	520	37.02	62.97	3.08	0.0794106	SS

$P<0.05$; bold values: statistically different; NS: not significant; SS: significant.

The distribution of specimens according to sexes and sampling dates is presented in Figure 2.

The number of males sampled in this study of specimens (35<TL <60 cm) was higher than that of females.

Length-frequency distribution of *D. oxyrinchus* was dominated by specimens ranged of TL between 50 and 80 cm, the distribution of length within these ranges was not significantly different (Kolmogorov-Smirnov test, D=0.287, $n=520$, $P=0.21$) (Figure 2).

In total, 520 *D. oxyrinchus* were measured in this study. Females ($n=240$) ranged from 16.5 to 105.0 cm LT and 30-5 300 g MT, whereas males ($n=280$) ranged from 15.5 to 95.0 cm LT and 30-3 650 g MT (Figure 3).

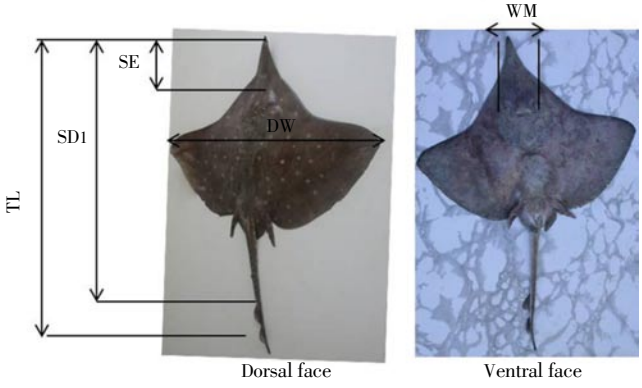

Figure 3. Measurements made on *D. oxyrinchus*.

Linear regression of LT on WD resulted in the following equation for both sexes (Figure 4).

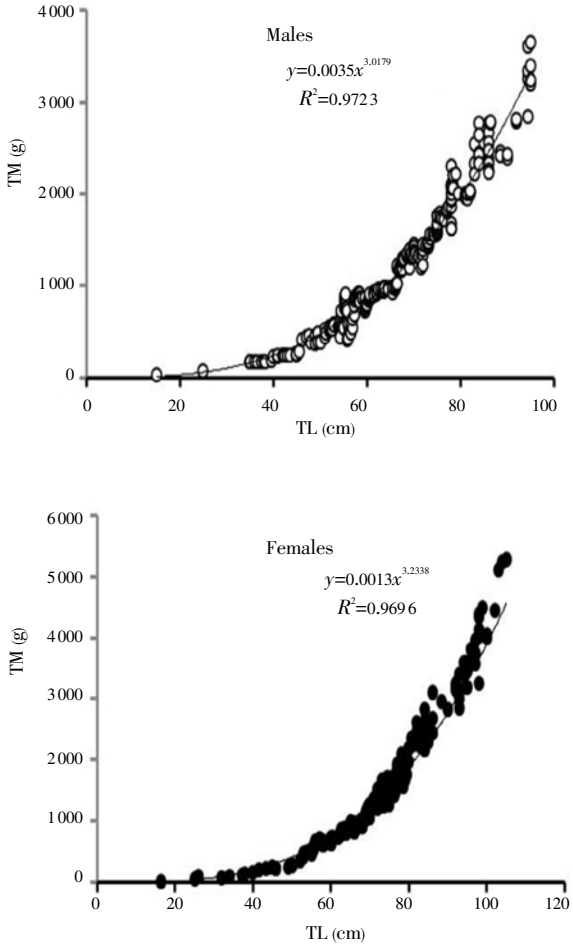

Figure 4. Relationship between TL and total mass (TM) of *D. oxyrinchus* in the Gulf of Gabes (Tunisia). R^2=Coefficient of determination.

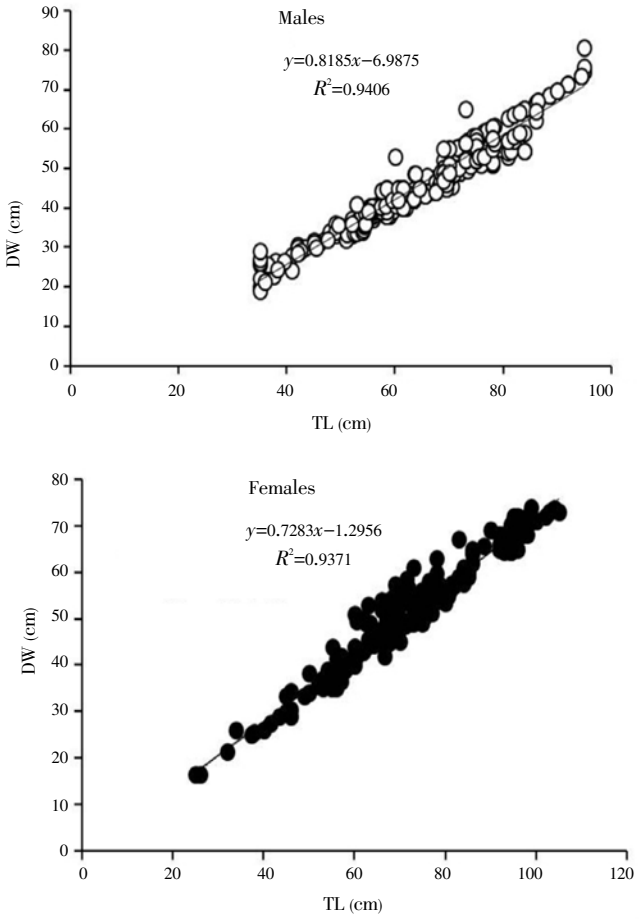

Figure 5. Relationship between TL and DW of *D. oxyrinchus* in the Gulf of Gabes (Tunisia). R^2=Coefficient of determination.

There was significant difference in the regression slopes between sexes for the TL and DW relationship (t-test=17.53; df=520; P<0.05).

In the present study, the TL and DW of females ranged from 37.3 to 105 cm and from 16.5 to 73 cm and the TL and DW of males from 35 to 95 cm and 25.7 to 80.7 cm, respectively.

Therefore, the relationship of TL-TM is presented separately for each sex (Figure 2). The TL-TM relationship differed significantly between the sexes (student's t-test: t=1.87, df=520, P<0.05), Females and males had similar length-mass relationships, but females reached almost twice the mass of males.

The b value for the TL/ weight relationship for males *D. oxyrinchus* sampled in this study (3.01) was lower than that for female (3.23).

Morphometric characters were strongly positively correlated for TL and are presented in Figures 4-8, and other numeric counts characters are presented (Tables 2 and 3).

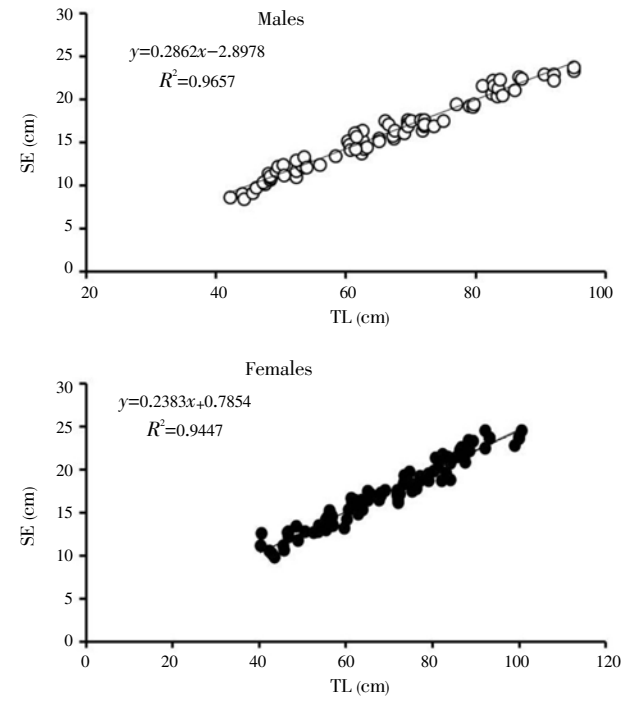

Figure 6. Relationship between TL and SE of *D. oxyrinchus* in the Gulf of Gabes (Tunisia). R^2=Coefficient of determination.

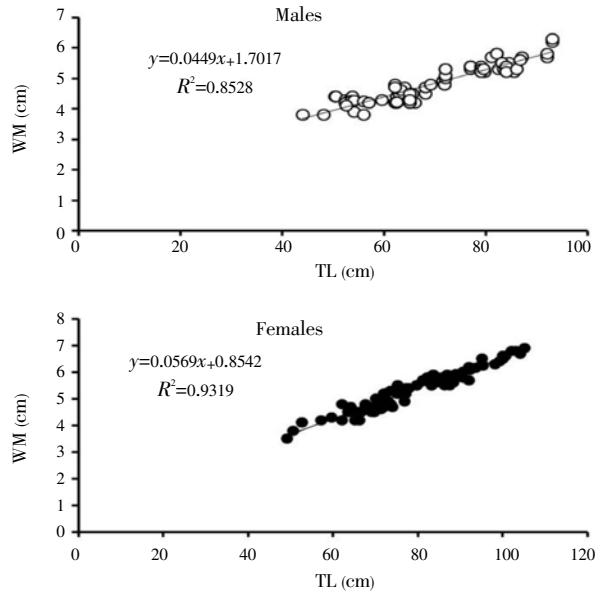

Figure 7. Relationship between TL and WM of *D. oxyrinchus* in the Gulf of Gabes (Tunisia). R^2=Coefficient of determination.

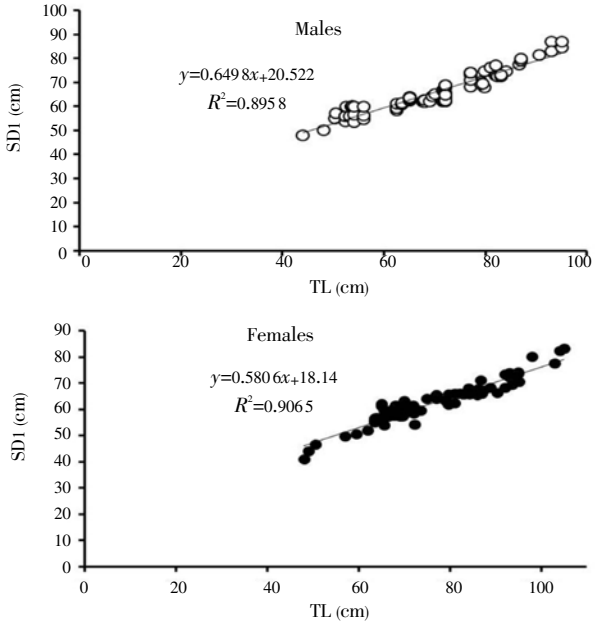

Figure 8. Relationship between TL and snout tip to first dorsal (SD1) of *D. oxyrinchus* in the Gulf of Gabes (Tunisia). R^2=Coefficient of determination.

Table 2

Morphometric characters of the Mediterranean longnosed skate (*D. oxyrinchus*) in the Gulf of Gabes.

Parameters	NV	NL	NP	NPL	Number of tooth rows	
					upper jaw	lower jaw
Minimum	25	12	90	10	38	41
Maximum	37	15	96	16	47	48
Mean±SE	32.28±0.91	13.68±0.21	92.61±0.38	14.06±0.47	42.79±0.76	44.42±0.46

NV: Number of the trunchal vertebrae; NL: number of nictitating lamellae; NP: number of pectoral fin; NPL: number of pseudobranchial lamellae.

Table 3

Comparison of numeric counts various of other studies in the Mediterranean.

	Gulf of Gabes[3]	Present study (Gulf of Gabes)
Number of the trunchal vertebrae	36-41	25-37
Number of the nictitating lamellae	11-12	12-15
Number of the pectoral fin	98-106	90-96
Number of pseudobranchial lamellae	14-16	10-16
Number of the upper jaw	38-44	38-47
Number of the lower jaw	40-48	41-48

4. Discussion

In this study males dominated catches, whereas the overall sex ratio around 0.5 with results previously reported from other areas in the Aegean Sea[4]. The sex-ratio is in favor of males, the differences in skate sex ratios may be a consequence of behaviour, because many species are segregated by sex, size, and maturity[10-13].

The maximum size for males and females in this work (95 and 105 cm TL, respectively) is greater than the previously recorded maximum size in other studies[4] but lower in the results recorded in the Italian seas[14] and in the North-eastern Atlantic and Mediterranean[15]. The TL was recorded in the Italian seas, with 112-115 cm TL, and a DW of 74-76 cm[14]. Ungaro *et al.*[15] recorded *D. oxyrinchus* achieving 150 cm TL. Yigin and Ismen recorded TL and DW of females ranged from 14.9 to 100 cm and from 9.8 to 65 cm and the TL and DW of males from 15.2 to 86.5 cm and 10 to 57.5 cm.

Weight-size relationships can provide useful information about the increase in weight of a population and this parameter could also be important for comparative studies between populations[16-18]. Similar results were observed in the North Aegean Sea (b at 3.26 and 3.31 for males and females respectively)[4]. Mori *et al.*[19] (b=3.40) and Kadri *et al.*[20] (b=3.53) reported a positive allometric growth pattern both in sex combined of *D. oxyrinchus* collected from Algarve (Southern Portugal) and in the North Aegean Sea. 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 increment can affect the b growth exponent[20,21]. The occurrence of sexual differences in growth is well documented in elasmobranchs, with females usually growing longer[22-25].

In this study, the counts of numeric caracters for *D. oxyrinchus* was similar of results observed in the Gulf of Tunis[3]. In conclusion, this study showed that there was a strong relationship between DW, SE, WM, SD1, H and TL for the *D. oxyrinchus* population in the Gulf of Gabes in Southern Tunisia.

Conflict of interest statement

We declare that we have no conflict of interest.

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We are grateful to all fishermen from the Gulf of Gabes who kindly allowed us to sample their catches. We thank the staff of the INSTM (Institut National des Sciences et Technolohgies de la Mer, Sfax). We also wish to extend our thanks to the anonymous reviewers for comments that greatly improved the submitted manuscript.

Comments

Background

D. oxyrinchus is frequently captured as by-catch of demersal trawl throughout the year. In the Mediterranean Sea, no studies

on distribution and morphometric characters of *D. oxyrinchus* were reported, but some information of its reproductive biology has been collected from some restricted areas.

Research frontiers

This study reported the first description of biometric relationships for *R. miraletus*, which would be useful for the sustainable conservation of this rear fishery in the Gulf of Gabes and also form the basis for their inclusion in a regional security programme. Indeed, it's very important for its wild stock assessment using such biometrics.

Related reports

To the best of the knowledge, this is the first report on this issue of the species, then there is nothing for comparison or stated here.

Innovations and breakthroughs

This paper presents significant new information on the distribution, morphometric and numeric characters of the skate *D. oxyrinchus*.

Applications

This study would be useful for the sustainable conservation of this rear fishery in the Gulf of Gabes and also form the basis for their inclusion in a regional security programme. Indeed, it's very important for its wild stock assessment using such biometrics.

Peer review

This manuscript is written well. Authors used some statistical tests. Results of this research will be effective for the conservation of this rare fish in the Gulf of Gabes and also form the basis for their inclusion in a regional security programme.

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