ACTA ICHTHYOLOGICA ET PISCATORIA
Vol. XVI Fasc. 1 Szczecin 1986

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Fish systematics

MORPHOLOGY OF BLUE EYE SKATE, *RAJA OCELLIFERA* REGAN, 1906 (FAMILY: *RAJIDAE*) (FAM.: THE NAMIBIAN SHELF

MORFOLOGIA *RAJA OCELLIFERA* REGAN, 1906 (FAM.: *RAJIDAE*) Z SZELFU NAMIBII

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Metric characters and number of spines along the body axis were determined, using percentage indices, in a population of *Raja ocellifera* from the SW African fishing grounds. Sexual dimorphism in secondary sex attributes was found in the population.

INTRODUCTION

The objective of the present paper is to present metric characters of the blue eye skate, *Raja ocellifera,* and to detect differences between males and females.

There is virtually a lack of literature on morphology of the species, the few published papers concerning distribution (Hulley, 1969; Samuel, 1963; Wysokiński and Kolender, 1972) or giving a general description of the body and some data on meristic characters (Smith, 1965).

As shown by the literature, however, the species is closely related to *R. miraletus;* studies of the kind presented here may then contribute to elucidating the taxonomic position of the two species.

MATERIALS AND METHODS

Materials were collected during a cruise of MT "Kulbin" (owned by the Deep-Sea Fisheries Company "Gryf", Szczecin) to the Namibian shelf fishing grounds within 17 Dec. 1983 – 22 Feb. 1984. The 45 specimens of *R. ocellifera* were caught in the statistical subarea 1.3 (off the river Cunene mouth) belonging to the SE Atlantic area 47.

A total of 20 and 21 measurements were taken from every female and male caught, respectively. Spines along the body axis were counted as well. Fig. 1 presents diagrammatically the measurement design. All measurements were taken with a rule or callipers to 1 mm.

The results were treated statistically, the arithmetic mean ($\bar{x}$), standard deviation (S), and coefficient of variation (V) being calculated. Percentage ratios of the metric characters in question were related to body length.

Coefficient of variation (V) is of the greatest importance when evaluating metric characters. Its value and changes in various characters are an evidence of the importance of a given character and its variability. Ruszczyc (1981) considers significant the coefficients attaining 8–10%. Consequently, those characters showing coefficients of variation lower than 10% were considered poorly plastic.

When studying sex dimorphism, the degree of differentiation (d) was calculated as in the formula

$$d = \frac{M_1 - M_2}{\sqrt{m_1^2 + m_2^2}}$$

where M_1, M_2 = arithmetic means of the two sets compared
m_1, m_2 = corresponding standard errors.

RESULTS

1. Body shape and colour; distribution

The *R. ocellifera* body is dorsoventrally flattened, rhomboid in shape. The members of the species (Table 1) show a relatively very wide disc, its width (68.2–76.5% of the body length) exceeding its length 44.0–51.2% of the body length). The rostral cartilage is relatively small (7.8–13.8% of the body length). The disc length is sligthly smaller than the length of the tail. Spiracles behind the eyes are relatively large, their length reaching 2.3–4.1% of the body length. The sides of the body and the head are surrounded by very strongly developed pectoral fins. Two small dorsal fins are similar in shape and size and are placed far on the tail. The anal fin is lacking and the caudal fin is small.

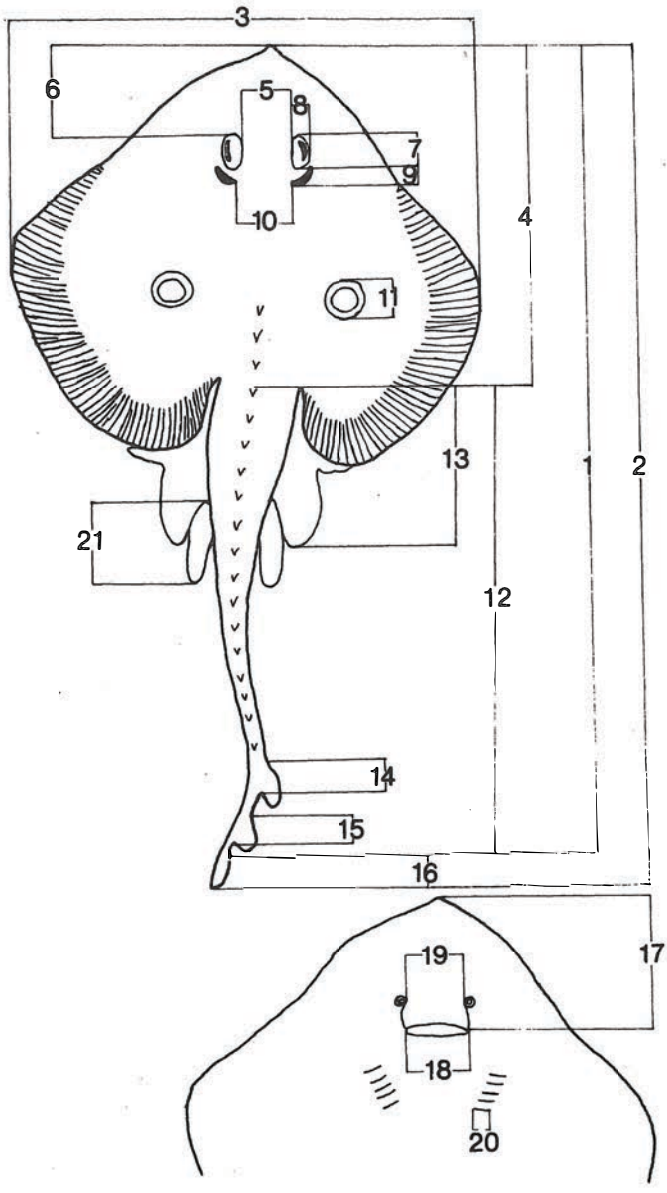

Fig. 1. Diagram of measurements of metric characters. 1 – body length (l.c.); 2 – total length (l.t.); 3 – disc width; 4 – disc length; 5 – inter-ocular distance; 6 – snout length; 7 – longitudinal eye diameter; 8 – transverse eye diameter; 9 – spiracle length; 10 – distance between spiracles; 11 – vertical spot diameter; 12 – tail length; 13 – ventral (V) fin length; 14 – anterior dorsal fin (D_1) base length; 15 – posterior dorsal fin (D_2) base length; 16 – caudal fin (C) length; 17 – rostrum length; 18 – mouth width; 19 – distance between nostrils; 20 – length of largest gill slit; 21 – clasper length

Table 1

Biometric characters of *Raja ocellifera;* absolute values and % body length

Charakter	Absolute value				% body length			
	Range	$\bar{x}$	S	V	Range	$\bar{x}$	S	V
Body length (l.c.)	32.0–58.5	49.46	5.86035	11.85				
Total length (l.t.)	33.7–61.9	52.30	6.12142	11.70	103.2–108.2	105.69	1.03559	0.98
Disc width	23.0–42.5	35.87	4.28005	11.93	68.2– 76.5	72.53	1.72453	2.38
Disc length	15.0–29.5	23.68	3.16782	13.38	44.0– 51.2	47.80	1.73984	3.64
Inter ocular distance	1.1– 2.6	2.17	0.34419	15.86	3.4– 5.4	4.38	0.40235	9.19
Snout length	4.0– 7.7	5.91	0.73862	12.50	10.5– 14.1	11.98	0.87780	7.33
Longitudinal eye diameter	1.0– 2.6	1.81	0.32221	17.80	2.9– 4.8	3.64	0.41909	11.51
Transverse eye diameter	0.6– 1.6	1.25	0.22925	18.34	1.8– 3.1	2.52	0.32305	12.82
Spiracle length	0.8– 2.1	1.59	0.28859	18.15	2.3– 4.1	3.21	0.43662	13.60
Distance between spiracles	1.7– 3.8	3.00	0.43090	14.36	4.8– 6.7	6.04	0.36275	6.01
Vertical spot diameter	1.4– 3.6	2.56	0.43753	17.09	3.7– 6.5	5.18	0.59588	11.50
Tail length	17.0–30.0	25.79	2.92421	11.34	48.8– 56.0	52.20	1.73984	3.33
Ventral fin (V) length	5.0–12.0	8.92	1.38283	15.50	12.2– 22.6	18.05	1.96961	10.91
D_1 fin base length	1.4– 3.6	2.58	0.53596	20.77	2.9– 6.6	5.24	0.86291	16.47
D_2 fin base length	1.6– 3.5	2.66	0.48362	18.18	3.8– 6.8	5.36	0.69320	12.93
Caudal fin (C) length	1.7– 3.7	2.83	0.52829	18.67	3.2– 8.2	5.75	0.96803	16.84
Rostrum length	3.7– 6.7	5.34	0.76638	14.35	7.8– 13.8	10.84	1.31273	12.11
Mouth width	2.8– 5.4	4.54	0.58481	12.88	7.9– 10.2	9.18	0.50774	5.53
Distance between nostrils	2.6– 5.2	4.19	0.52031	12.42	7.6– 9.7	8.47	0.47176	5.57
Largest gill slit length	0.8– 2.0	1.40	0.22207	15.86	2.4– 4.0	2.84	0.29961	10.55
No. of spines along body axis	17–44	28.69	7.11855	24.81				

Table 2

Biometric characters of *R. ocellifera* females (n = 32) and males (n = 13); absolute values and + body length

	Females								Males							
	Absolute value				% body length				Absolute value				% body length			
	Range	$\bar{x}$	S	V	Range	$\bar{x}$	S	V	Range	$\bar{x}$	S	V	Range	$\bar{x}$	S	V
Body length (l.c.)	32.0–58.5	48.76	6.69563	13.73					48.0–56.0	51.19	2.35884	4.61				
Total length (l.t.)	33.7–61.9	51.60	6.99186	13.55	103.2–108.2	105.77	1.03001	0.97	50.5–59.1	54.02	2.56932	4.76	103.4–106.9	105.51	1.06729	1.01
Disc width	23.0–42.5	35.51	4.97914	14.02	68.2– 76.5	72.80	1.81339	2.49	35.0–39.5	36.85	1.50533	4.09	69.6– 74.0	71.87	1.31997	1.84
Disc length	15.0–29.5	23.59	3.66618	15.54	44.9– 51.2	48.27	1.68148	3.48	22.0–26.5	23.88	1.41648	5.93	44.0– 48.6	46.64	1.32195	2.83
Interocular distance	1.1– 2.6	2.13	0.39318	18.46	3.4– 5.4	4.36	0.45710	10.48	2.0– 2.5	2.26	0.15021	6.65	4.0– 4.8	4.42	0.22674	5.13
Snout length	4.0– 7.7	6.01	0.84041	13.98	10.9– 14.1	12.35	0.73878	5.98	5.3– 6.2	5.66	0.28442	5.03	10.5– 11.6	11.06	0.37758	3.41
Longitudinal eye diameter	1.0– 2.6	1.77	0.34848	19.69	2.9– 4.8	3.62	0.45133	12.47	1.6– 2.4	1.89	0.23616	12.50	3.3– 4.5	3.68	0.33874	9.20
Transverse eye diameter	0.6– 1.6	1.24	0.24211	19.53	1.9– 3.1	2.54	0.30874	12.16	0.9– 1.6	1.27	0.20160	15.76	1.8– 3.0	2.48	0.36550	14.74
Spiracle length	0.8– 2.1	1.61	0.31102	19.32	2.3– 4.1	3.29	0.42681	12.97	1.2– 1.9	1.55	0.23317	15.04	2.4– 3.8	3.00	0.40415	13.47
Distance between spiracles	1.7– 3.8	2.94	0.49046	16.68	4.8– 6.6	6.00	0.38729	6.45	2.8– 3.4	3.14	0.17097	5.44	5.6– 6.7	6.14	0.28442	4.63
Vertical spot diameter	1.4– 3.6	2.44	0.45148	18.50	3.7– 6.2	5.00	0.56767	11.35	2.5– 3.3	2.86	0.20223	7.07	5.0– 6.5	5.60	0.44159	7.89
Tail length	17.0–30.0	25,17	3.18416	12.65	48.8– 55.1	51.73	1.68148	3.25	25.0–30.0	27.31	1.28352	4.70	51.4– 56.0	53.36	1,32195	2.48
Ventral fin (V) length	5.0–11.2	8.70	1.28100	14.72	15.0– 21.5	17.90	1.67890	9.38	6.0–12.0	9.46	1.52618	16.13	12.2– 22.6	18.43	2.59338	14.07
D_1 fin base length	1.4– 3.6	2.50	0.56283	22.51	2.9– 6.4	5.11	0.83695	16.38	1.7– 3.3	2.79	0.41122	14.74	3.5– 6.6	5.46	0.81500	14.93
D_2 fin base length	1.6– 3.4	2.56	0.50157	19.59	3.8– 6.8	5.23	0.66305	12.68	2.2– 3.5	2.91	0.34025	11.69	4.0– 6.5	5.69	0.68003	11.95
Caudal fin (C) length	1.7– 3.7	2.84	0.52410	18.45	3.2– 8.2	5.84	0.92490	15.84	1.7– 3.6	2.82	0.55999	19.86	3.4– 6.9	5.51	1.06729	19.37
Rostrum length	3.7– 6.7	5.59	0.72350	12.94	10.3– 13.8	11.51	0.81713	7.10	3.8– 5.5	4.71	0.44807	9.51	7.8– 10.1	9.18	0.66439	7.24
Mouth width	2.8– 5.4	4.43	0.64269	14.51	7.9– 10.2	9.08	0.50401	5.55	4.6– 5.4	4.82	0.26723	5.54	8.6– 10.0	9.42	0.44879	4.76
Distance between nostrils	2.6– 5.2	4.20	0.60294	14.36	7.6– 9.7	8.62	0.43975	5.10	3.8– 4.6	4.15	0.22589	5.44	7.6– 8.6	8.10	0,32660	4.03
Largest gill slit length	0.8– 2.0	1.39	0.25241	18.16	2.4– 4.0	2.86	0.32818	11.47	1.2– 1.6	1.44	0.11929	8.28	2.4– 3.1	2.81	0.22159	7.89
Clasper length									7.2–13.3	11.17	2.19104	19.62	14.7– 26.0	21.76	3.97503	18.27
No. of spines along body axis	17–44	30.69	7.19066	23.43					17–30	23.77	3.91905	16.49				

Two characteristic dark-blue spots lie on the dorsal side of the disc, symmetrically arranged. The right spot vertical diameter (Fig. 1) is 3.7–6.5% of the body length. The spots contrast strongly with the grey-brown coloration of the dorsal surface. The ventral side of the disc is white. The dorsal surface of the trunk and tail is covered by numerous spines. On the tail, they are arranged – as a rule – in three rows; the middle one, running along the body axis, consists of 17 to 44 spines. Fine spines occur also on the disc margins.

The species shows a well defined sexual dimorphism, the claspers being its most distinct manifestation. Additionally, the dimorphism was evidenced by the following secondary sex attributes: the length of the snout, tail, and rostrum; the vertical diameter of the spots; the between-nostrils distance: and the number of spines along the body axis (Tables 2 and 3).

Fig. 2 presents (after Hulley, 1969) distribution of two *Raja* species, *R. ocellifera* and *R. miraletus*. The sampling site for this study is shown as well. According to the author mentioned, *R. ocellifera* is synonymous with *R. miraletus*, hence distribution of the two species on the map.

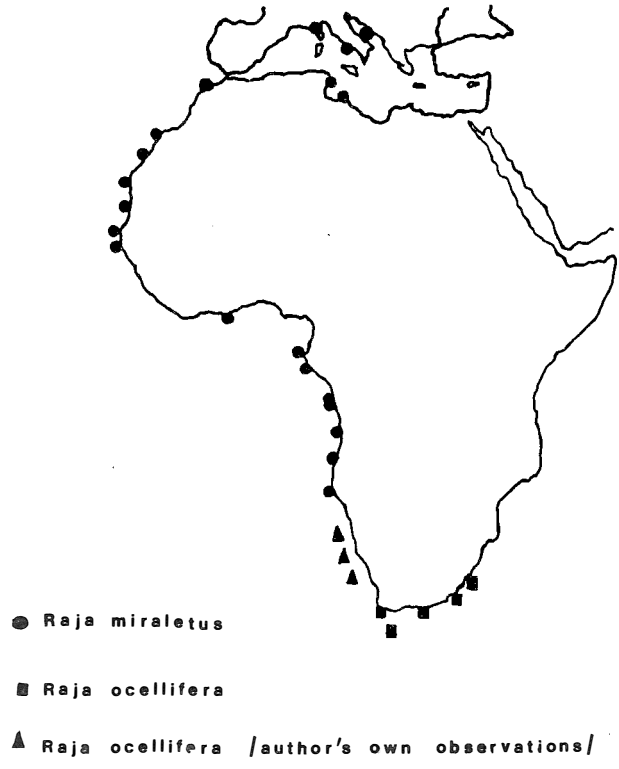

Fig. 2. Distribution of *Raja ocellifera* and *R. miraletus* (according to Hulley, 1969).

Accodring to Barnard and Smith (after Hulley, 1969), *R. ocellifera* is widely known from False Bay and Agulhas Bank, reaching north up to Natal. The species has not been recorded from off SW Africa.

According to Hulley (1969) who, as already mentioned, treats the two species as one, they occur along the whole western coast of Africa, from the Mediterranean Sea down to the southern border of Angola. They are, however, absent from Walvis Bay to Cape Point, to be found again along the eastern coast of Africa. The author referred to suggests that the cold Benguela Current may act as a thermal barrier to the fish in question. On the other hand, Wysokiński and Kolender (1972) found *R. ocellifera* just in that area. They caught a few individuals in the SW African fishing grounds within latitudes 25–30°S.

During the cruise discussed, *R. ocellifera* individuals were recorded in an area delimited by

17°31′ – 20°03′ S
11°26′ – 12°41′ E.

According to Samuel (after Hulley, 1969), *R. ocellifera* was recorded off the coast of Kerala (southern India).

2. Length distribution of *R. ocellifera* studied

Fig. 3 presents the length distribution among 1-cm classes for all the individuals measured and for males and females separately.

The most abundant length classes, 53.1–54.0; 52.1–53.0; and 57.1–58 cm consisting of 7, 5 and 5 individuals, respectively, contributed 15.6; 11.1; and 11.1% to the whole sample. The three classes together contributed 37.8% of the sample. The least abundant were the first seven classes (33.1–48.0 cm), the ninth one (49.1–50.0 cm), and the last three length classes (59.1–62.0 cm).

The whole sample consisting of 45 individuals contained 32 females and 13 males. The length distribution of females is basically similar to that of the whole sample, while it is different in males. They are not represented in the first nine classes and are most abundant in class 52.1–53.0 cm (30.7% of the total number of males).

The mean total length (l.t.) of males exceeded that of females by 2.42 cm; however, a low number of males should be borne in mind.

3. Analysis of metric characters

The data on metric characters for the whole sample are contained in Table 1. The table shows almost 50% of the characters evaluated should considered plastic (coefficient of variation higher than 10%). The highest plasticity is observed in the anterior dorsal fin base length (V = 16.47%).

Table 2 compares the metric characters of males and females from percentage indices.

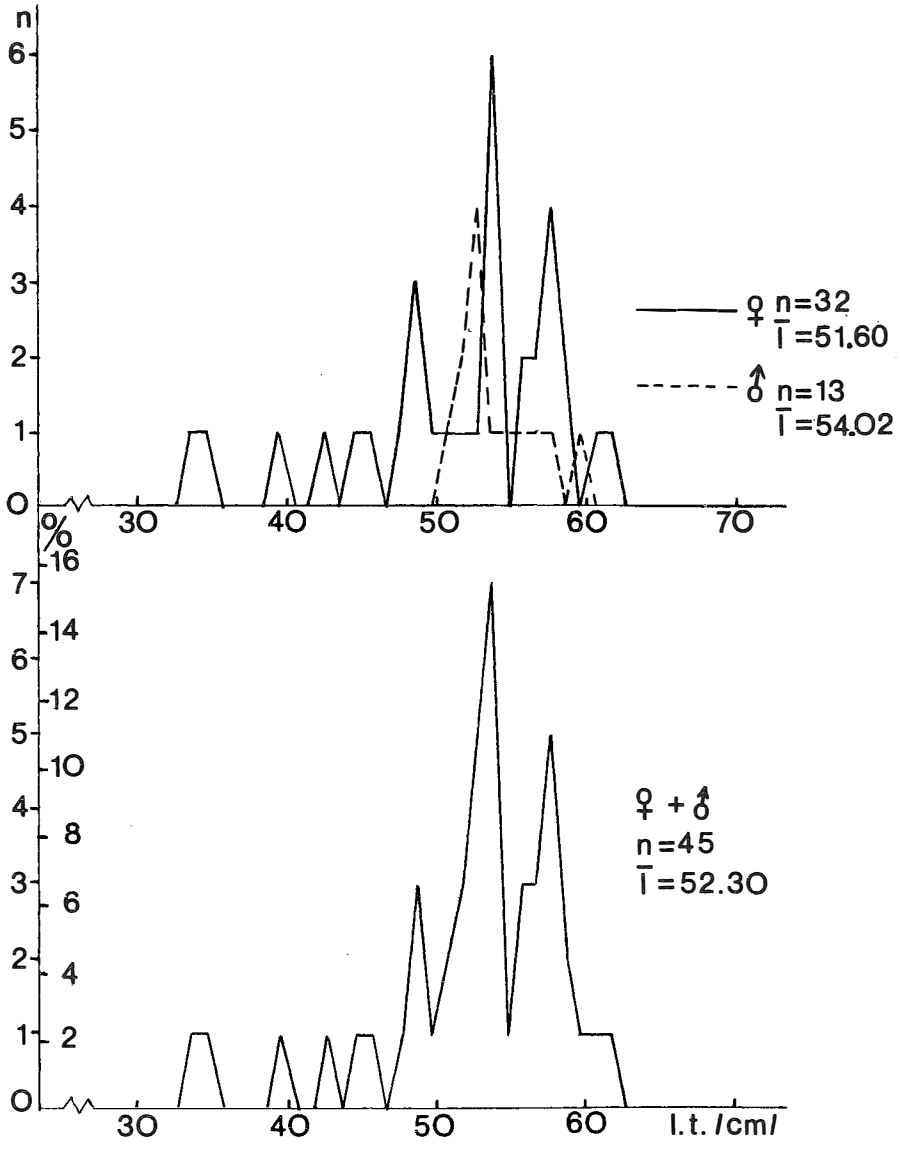

Fig. 3. Length distribution of the individuals studied

Between-sexes differences in proportions of the body were observed. Females had a wider and longer disc as well as a longer snout and rostrum. Those differences amount to about 1–2%. On the other hand, males show clearly a longer (by 1.63%) tail. Moreover, noteworthy is a difference between vertical diameters of dorsal spots, the diameter being longer in males.

The only meristic character studied in the present work, namely the number of spines along the body axis, was much higher in females (about 31 on the average as opposed to about 24 in males).

In order to demonstrate a possibility of sexual dimorphism in secondary sex attributes, Table 3 shows the degree of differentiation (d) between mean values of the characters studied in both sexes. As seen from the table, values of „d" exceeded 3 in some characters (snout length, vertical diameter of the dorsal spot, tail length, rostrum length, and number of spines along the body axis).

It should, however, be stressed that, while the number of females examined can be regarded as representative, the number of males (although the species is usually not

Table 3

Sex-dependent degree of differentiation (d) in biometric characters

Character	Females (n = 32)	Males (n = 13)	d
	M±m		
	% body length		
Total length	105.77±0.18208	105.51±0.29601	0.75
Disc width	72.80±0.32057	71.87±0.36609	1.91
Disc length	48.27±0.29725	46.64±0.36664	1.98
Interocular distance	4.36±0.08080	4.42±0.06289	−0.59
Snouth length	12.35±0.13060	11.06±0.10472	7.71
Longitudinal eye diameter	3.62±0.07978	3.68±0.09395	−0.49
Transverse eye diameter	2.54±0.05458	2.48±0.10137	0.52
Spiracle length	3.29±0.07545	3.00±0.11209	2.15
Distance between spiracles	6.00±0.06846	6.14±0.07888	−1.34
Vertical spot diameter	5.00±0.10035	5.60±0.12248	−3.79
Tail length	51.73±0.29725	53.36±0.36664	−3.45
Ventral fin (V) length	17.90±0.29679	18.43±0.71927	−0.68
D_1 fin base length	5.11±0.14795	5.46±0.22604	−1.30
D_2 fin base length	5.23±0.11721	5.69±0.18861	−2.07
Caudal fin (C) length	5.84±0.16350	5.51±0.29601	0.98
Rostrum length	11.51±0.14445	9.18±0.18427	9.95
Mouth width	9.08±0.08910	9.42±0.12447	−2.22
Distance between nostrils	8.62±0.07774	8.10±0.09058	4.36
Largest gill slit length	2.86±0.05801	2.81±0.06146	0.59
No. of spines along body axis	30.69±1.27114	23.77±1.08695	4.14

numerous in the fishing grounds) may raise reservations. Therefore the analysis of males should be repeated on a higher number of fish.

DISCUSSION

R. ocellifera is a species which is relatively poorly known. There is basically a lack of literature on morphological description of *R. ocellifera.* The few published papers deal only with the taxonomic position of two very similar species, *R. ocellifera* and *R. miraletus.*

According to Norman (1935), *R. ocellifera* from off southern Africa is closely related to *R. miraletus* occurring in the Mediterranean Sea. The similarity between the two species is so great that specimens caught near Mossel Bay were identified as *R. miraletus* by Boulenger (von Bonde and Swart, 1923) and as *R. ocellifera* by Norman (op. cit.).

Hulley (1969) states that morphological characters and the construction of claspers are almost identical in the two species. There are, however, certain differences between the species in tail length, the tail being slightly shorter in *R. ocellifera.* Ishiyama (1952) is of the opinion that counting chordal vertebrae in the tail is the best way to compare tail lengths. *R. ocellifera* has 49–53 chordal vertebrae, while *R. miraletus* has 49–54 vertebrae. It seems, however, that the difference is not significant and does not allow to identify a species. Other characters of taxonomic importance, mentioned by Ishiyama (op. cit.) include snout length, distance between the eyes, and the size of upper jaw teeth. According to the author reffered to, *R. miraletus* has a somewhat longer snout, a slightly shorter interocular distance, and smaller teeth in the upper jaw than *R. ocellifera.*

On the other hand, Hulley (1969) states that the principal difference between the two species is in the shape of dorsal spots. *R. miraletus* has round spots, while the spots in *R. ocellifera* are oval. That author, however, does not think that it is enough to separate the two species. He maintains that those external and sex-related differences are presumably of a secondary importance in taxonomy; as the claspers are similar in structure and the numbers of chordal pre-caudal vertebrae are almost identical, *R. ocellifera* and *R. miraletus* should be considered extremes within one variable species.

To render the results presented in the present paper applicable to the discussion outlined above, it seems very purposeful to carry out a similar study on metric characters of *R. miraletus.*

CONCLUSIONS

1. The materials analysed comprised individuals of total length (l.t.) ranging within 33.7–61.9 cm; the dominant size range was 53.1–58.0 cm. Mean total length in the whole sample was 52.3 cm, males being larger than females.

2. Sexual dimorphism was seen in proportions of the body. Female snout and rostrum were longer and the distance between them significantly larger than in males. On the other hand, males showed a significantly longer tail and larger vertical diameter of dorsal spots.
3. Females and males differed significantly numbers of spines along the body axis, mean numbers for females and males being 31 and 24, respectively.
4. It seems purposeful to carry out a similar study on metric characters in *R. miraletus* in order to compare the results with data presented here on *R. ocellifera* and to find out if there are significant differences between the two closely related species with respect to the characters evaluated.

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Translated: Dr. Teresa Radziejewska

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MORFOLOGIA *RAJA OCELLIFERA* REGAN, 1906 (FAM.: *RAJIDAE*) Z SZELFU NAMIBII

STRESZCZENIE

Celem pracy było określenie zróżnicowania cech wymierzalnych oraz liczby kolców wzdłuż osi ciała badanej populacji *Raja ocellifera* pochodzącej z łowisk południowo-zachodniej Afryki pomiędzy 17° – 20°S. Łącznie zbadano 45 ryb, które stanowiły przyłów w powłokach włokowych prowa-

dzonych przez statek m/t „Kulbin", należący do PPDiUR „Gryf" w Szczecinie, w okresie od 17 grudnia 1983 r. do 22 lutego 1984 roku. Charakterystykę tych cech zarówno dla całej próby jak również oddzielnie dla samic i samców przedstawiono przy zastosowaniu wskaźników procentowych. Otrzymane wyniki można ująć w następujące wnioski:

1. W analizowanym materiale znalazły się ryby o długości całkowitej (l.t.) 33,7–61,9 cm z dominacją osobników o długości 53.1–58.0 cm. Średnia długość całkowita dla całej próby wyniosła 52,3 cm, przy czym samce były większe od samic.
2. W proporcjach ciała zaznaczył się dymorfizm płciowy. Samice miały dłuższy pysk i rostrum jak również odległość między nozdrzami była u nich istotnie większa. Samce natomiast miały istotnie dłuższy ogon oraz średnicę pionową plamek znajdujących się na stronie grzbietowej.
3. Również istotna różnica zaznaczyła się w liczbie kolców wzdłuż osi ciała. Średnia wartość dla samic wyniosła 31 sztuk, zaś dla samców tylko 24 sztuki.
4. Wydaje się celowe określenie podobnej charakterystyki cech wymierzalnych dla gatunku *Raja miraletus* w celu porównania otrzymanych wyników z danymi zawartymi w niniejszej pracy a dotyczącymi *R. ocellifera* i stwierdzeniu czy w zakresie analizowanych cech występują istotne różnice między tymi bardzo zbliżonymi gatunkami.

Станислав Кшикавский, Адам Дубас

МОРФОЛОГИЯ RAJA OCELLIFERA REGAN, 1906 (FAM.: RAJIDAE) ШЕЛЬФА НАМИБИИ

Р е з ю м е

Целью работы было определение дифференцирования измеряемых признаков, а также числа шипов вдоль оси тела исследуемой популяции Raja ocellifera происходящей из промысловых районов юго-западной Африки, между 17 и 20° S. Всего исследовано 45 особей, которые являлись приловом в траловых уловах, проводимых МТ „Кулбин". принадлежащему рыболовецкому предприятию „Гриф" в Щецине, в период с 17 декабря 1983 по 24 февраля 1984 г. Характеристика признаков, принадлежащих всей пробе, а также отдельно мужскими и женским особям, пред-

ставлена с помощью процентных показателей. Полученные результаты можно объединить в следующие выводы:

1. В анализируемом материале находились особи с общей длиной (l.t.) 33,7-61,9 см, с преобладанием особей длиной 53,1-58,0 см. Средняя Общая длина для всей пробы - 52,3 см, причём самцы были больше, чем самки.

2. В пропорциях тела наблюдался половой диморфизм. У самок наблюдались более длинное рыло и рострум, а также значительно большее расстояние между ноздрями. А самцы имели значительно более длинной хвост, а также больший вертикальный диаметр пятен на спине.

3. Также наблюдалась существенная разница в количестве шипов, расположенных вдоль оси тела. Средняя величина для самок составляла 31ш. А для самцов - 24 ш.

4. Является целесообразным определение внвлогичных измеряемых признаков вида Raja miraletus с целью сравнения полученных результатов с данными, находящимися в настоящей работе и касающихся Raja ocellifera и установление, выступают ли существенные различия между этими близкими между собой видами, в анализируемых объёмах признаков.

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