



## Polychromatism in the thornback ray, *Raja clavata* (Chondrichthyes: Rajidae) off northern Tunisian coast (central Mediterranean)

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**Abstract.** Colour pattern changes in dorsal surface of thornback ray *Raja clavata* Linnaeus 1758 allowed to record seven different types among specimens caught off northern coast of Tunisia which are presented in this paper.

**Keywords:** Morphomeric measurements, meristic counts, Aloncle's line, nictitating lamellae, taxonomy.

**Resumen.** Policromatismo en la raya de clavos *Raja clavata* (Chondrichthyes: Rajidae) aguas fuera de la costa norte de Túnez (Mediterráneo Central). Cambios en el patrón de coloración de la superficie dorsal de la raya de clavos *Raja clavata* Linnaeus 1758 permitió registrar siete tipos diferentes entre especímenes capturados aguas fuera de la costa de Túnez, los cuales son presentados en este trabajo.

**Palabras-Clave:** Mediciones morfométricas, conteo merístico, línea de Aloncle, lamellae nictitante, taxonomía.

Diversity of coloration patterns or polychromatism was previously reported in batoid species such as torpedinids (Cadenat *et al.* 1978, Capapé & Desoutter 1980, 1981, Fechhelm & McEachran 1984, Capapé *et al.* 2006), rajids (Aloncle 1966, Capapé *et al.* 1980, McEachran and Matheson, 1985), dasyatids (Capapé & Desoutter 1990) and potamotrygonids (Almeida *et al.* 2002, 2003). For instance, polychromatism in the thornback ray *Raja clavata* Linnaeus 1758 caused misidentifications with the close relative species *R. maderensis* Lowe 1887 according to Lozano Rey (1928) and Aloncle (1966).

The latter noted that a thornback ray captured in southern Moroccan waters and deposited in the Ichthyological Collection of the Institut Scientifique Chérifien of Rabat (Morocco) was wrongly identified as *R. maderensis*. Consequently, Aloncle (1966) described four types of colour

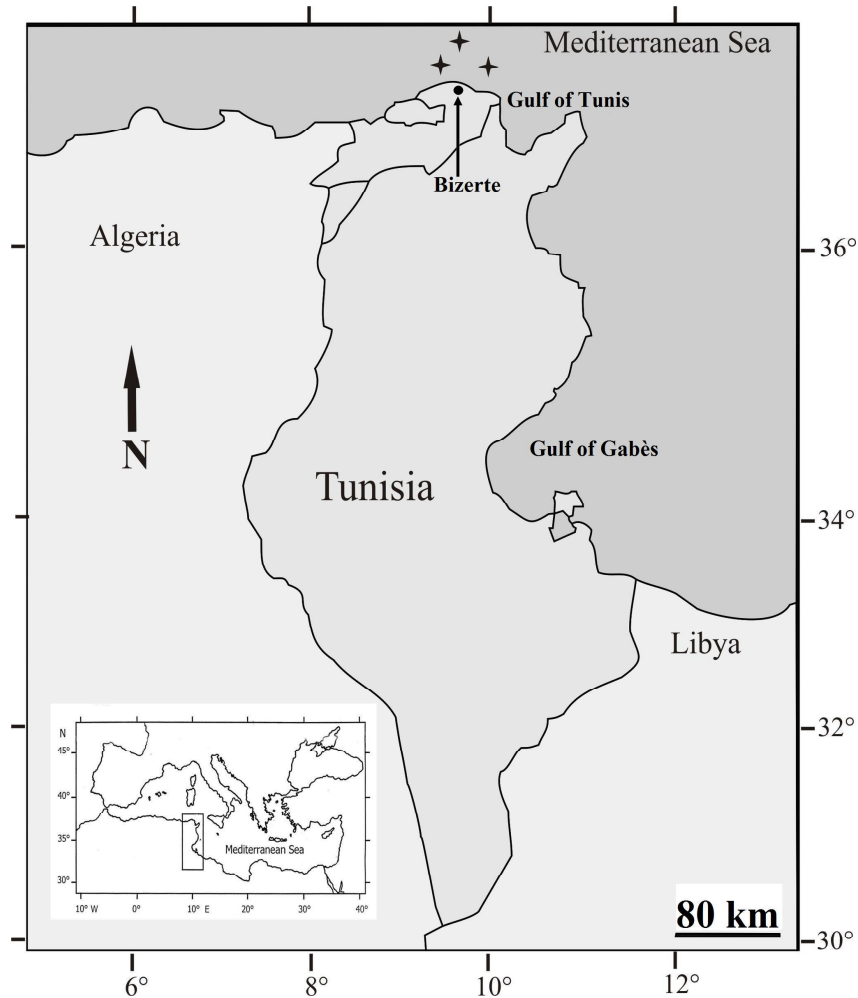
patterns in *R. clavata* from Moroccan waters.

*Raja clavata* is rather commonly landed in Tunisian fishing sites, even if it is locally considered as by-catch species (Bradaï *et al.* 2004, Mnasri 2008). Observations made on specimens caught off Bizerte, city located in northern Tunisia showed changes in colour patterns of the dorsal surface. These specimens are described in the present paper and compared with those of Aloncle (1966), in order to improve the knowledge on both morphology and systematics of the species.

Thornback rays were collected during investigations conducted off Bizerte (northern Tunisia) from September 2006 to June 2009. They were identified as *Raja clavata* following Clark (1926), Tortonese (1956), Quignard (1965), Bini (1967), Quéro *et al.* (2003) and Hemida (2005). In all 64 specimens were caught by trawlers using demersal gill-nets at depths between 150 and 300 m,

on sandy-muddy or rocky bottoms. The disc width specimens were measured to the nearest mm following Clark (1926), Mejri *et al.* (2004) and Mnasri *et al.* (2009), clasper length following Collenot (1969), and weighed to the nearest gramme, while meristic counts were carried out following Quignard (1965), Capapé & Quignard (1981) and Mnasri *et al.* (2009). Morphometric measurements and meristic counts were carried out in 7 specimens (summarized in Table I)

showed different colour patterns and were arbitrary divided in 7 types, according to colour of dorsal surface and, especially, morphology and arrangement of ornamentation. For each type, we give the number of observed specimens (n). They were preserved in 5 % buffered formaline and deposited in the Ichthyological Collection of the Faculté des Sciences of Bizerte (Tunisia) under the catalogue numbers, FSB- Raj- clav 01 to FSB- Raj- clav 07.



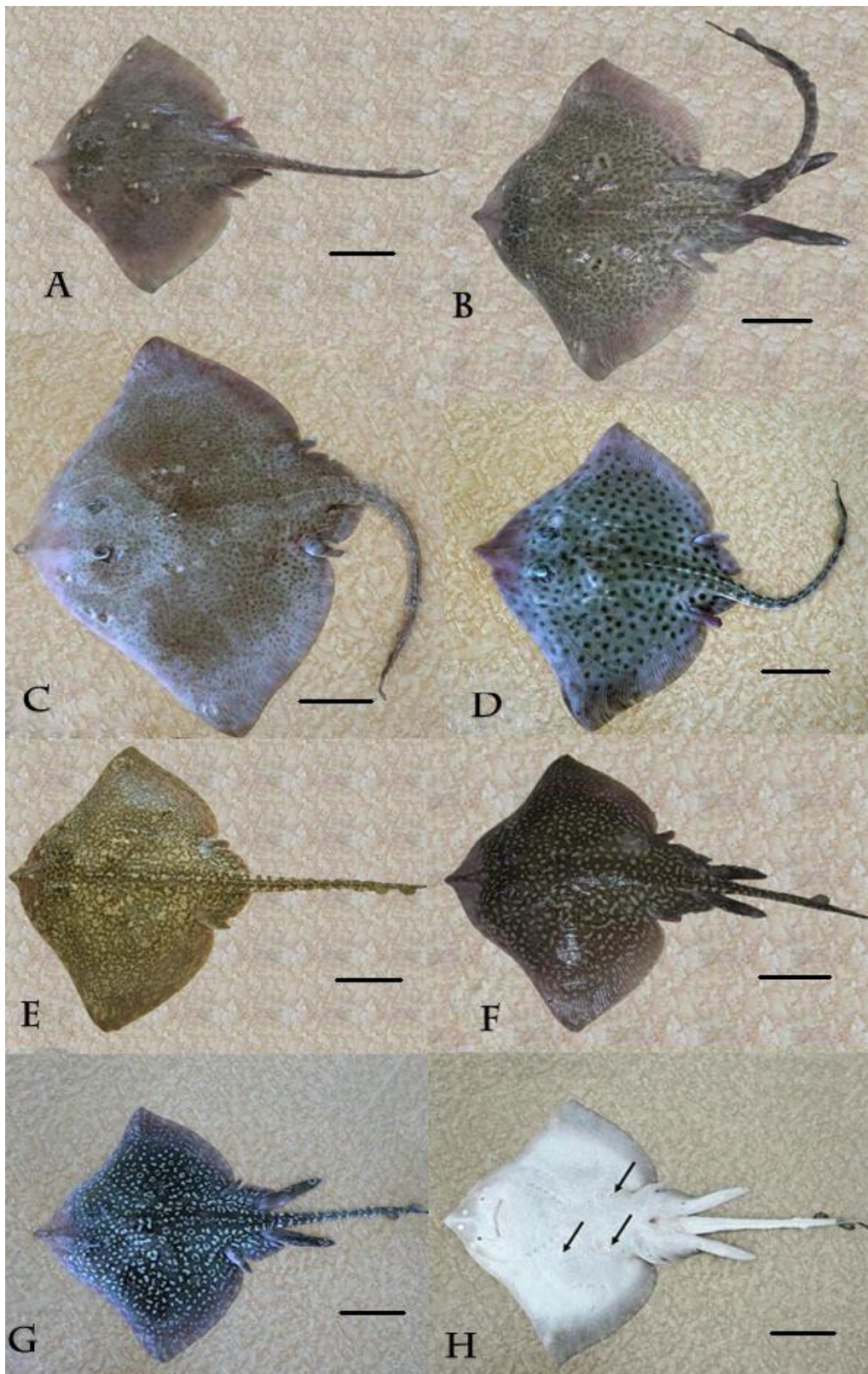
**Figure1.** Map of Tunisia showing the capture sites (black stars) of *Raja clavata* off Bizerte (northern Tunisia),

**Table I.** Morphometric measurements and meristic counts carried out in seven types of polychromatism in *Raja clavata* from the northern Tunisian coast.

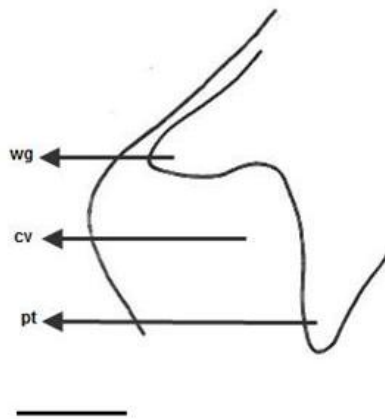
References	FSB- Raj-clav-01		FSB- Raj-clav-02		FSB- Raj-clav-03		FSB- Raj-clav-04		FSB- Raj-clav-05		FSB- Raj-clav-06		FSB- Raj-clav-07	
Total mass (g)	162		2028.4		2321.4		1395.6		310		1184.2		1263	
Measurements	mm	%DW	mm	%DW	mm	%DW	mm	%DW	mm	%DW	mm	%DW	mm	%DW
Total length	635	157.6	734	156.2	794	139.3	715	152.8	790	177.5	570	144.7	690	164.3
Disc-length	302	74.9	315	67	415	72.8	360	76.9	391	87.9	275	69.8	335	79.8
Disc-width (DW)	403	100	470	100	570	100	468	100	445	100	394	100	420	100
Disc-depth	32	7.9	28	6	48	8.4	29	6.2	35	7.9	28	7.1	27	6.4
Eyball length	18	4.5	23	4.9	23	4	23	4.9	23	5.2	19.5	4.9	20	4.8
Cornea	15	3.7	18	3.8	16	2.8	16	3.4	17	3.8	15	3.8	15	3.6
Pre-orbital length	75	18.6	83	17.7	96	16.8	97	20.7	95	21.3	72	18.3	83	19.8
Inter-orbital width	26	6.5	35	7.4	40	7	33	7.1	39	8.8	28	7.1	33	7.9
Spiracle length	17	4.2	22	4.7	27	4.7	21	4.5	23	5.2	17	4.3	23	5.5
Spiracle width	13	3.2	13	2.8	17	3.0	10	2.1	18	4	11	2.8	12	2.9
Inter-nasal width	51	12.7	52	11.1	65	11.4	59	12.6	65	14.6	43	10.9	50	11.9
Nasal curtain	54	13.4	65	13.8	68	11.9	65	13.9	72	16.2	51	12.9	55	13.1
Interspiracular width	38	9.4	45	9.6	54	9.5	45	9.6	52	11.7	39	9.9	42	10
Pre-oral length	75	18.6	73	15.5	86	15.1	83	17.7	88	19.8	59	15	70	16.7
Mouth width	46	11.4	58	12.3	63	11.1	53	11.3	60	13.5	47	11.9	53	12.6
First gill slit	12	3	18	3.8	21	3.7	17	3.6	19	4.3	13	3.3	17	4
Second gill slit	12	3	17	3.6	22	3.9	16	3.4	21	4.7	14	3.6	17	4
Third gill slit	14	3.5	18	3.8	21	3.7	16	3.4	20	4.5	13	3.3	17	4
Forth gill slit	14	3.5	18	3.8	20	3.5	15	3.2	18	4	13	3.3	15	3.6
Fifth gill slit	12	3	16	3.4	15	2.6	14	3	14	3.1	11	2.8	10	2.4
Width between first gill slit	89	22.1	98	20.9	125	21.9	110	23.5	121	27.2	79	20.1	93	22.1
Width between fifth gill slit	45	11.2	44	9.4	63	11.1	55	11.8	66	14.8	39	9.9	44	10.5
Snout tip to eye	89	22.1	96	20.4	110	19.3	107	22.9	105	23.6	80	20.3	93	22.1
Snout tip to mouth	85	21.1	85	18.1	101	17.7	100	21.4	100	22.5	70	17.8	85	20.2
Snout tip to first gill slit	126	31.3	140	29.8	150	26.3	147	31.4	167	37.5	110	27.9	136	32.4
Snout tip to fifth gill slit	171	42.4	190	40.4	215	37.7	198	42.3	200	44.9	155	39.3	176	41.9
Snout tip to pelvic fin	260	64.5	300	63.8	345	60.5	288	61.5	330	74.2	245	62.2	270	64.3
Snout tip to vent	280	69.5	325	69.1	367	64.4	315	67.3	360	80.9	270	68.5	310	73.8
Pectoral fin anterior margin	263	65.3	305	64.9	360	63.2	315	67.3	343	77.1	252	64	288	68.6
Pectoral fin posterior margin	194	48.1	215	45.7	270	47.4	225	48.1	255	57.3	182	46.2	196	46.7
Pectoral fin inner margin	36	8.9	23	4.9	35	6.1	33	7.1	37	8.3	29	7.4	35	8.3
Pelvic fin anterior margin	55	13.6	66	14	66	11.6	58	12.4	55	12.4	55	14	58	13.8

**Table I.** Morphometric measurements and meristic counts carried out in seven types of polychromatism in *Raja clavata* from the northern Tunisian coast (cont.).

References	FSB- Raj-clav-01		FSB- Raj-clav-02		FSB- Raj-clav-03		FSB- Raj-clav-04		FSB- Raj-clav-05		FSB- Raj-clav-06		FSB- Raj-clav-07	
Pelvic fin posterior margin	75	18.6	99	21.1	90	15.8	67	14.3	70	15.7	69	17.5	75	17.9
Pelvic fin inner margin	28	6.9	20	4.3	31	5.4	29	6.2	34	7.6	14	3.6	13	3.1
Span of pelvic fin	142	35.2	171	36.4	180	31.6	150	32.1	180	40.4	130	33	158	37.6
Tail base width	33	8.2	32	6.8	37	6.5	32	6.8	45	10.1	32	8.1	33	7.9
Tail base depth	21	5.2	20	4.3	26	4.6	21	4.5	32	7.2	17	4.3	22	5.2
Tail length	350	86.8	370	78.7	375	65.8	362	77.4	410	92.1	290	73.6	340	81
Snout tip to first dorsal	517	128.3	603	128.3	660	115.8	588	125.6	645	144.9	490	124.4	570	135.7
Snout tip to second dorsal	560	139.0	652	138.7	712	124.9	640	136.8	702	157.8	526	133.5	620	147.6
Superior caudal edge	33	8.2	31	6.6	26	4.6	41	8.8	36	8.1	26	6.6	27	6.4
Inferior caudal edge	4	1	4	0.9	6	1.1	2	0.4	5	1.1	3	0.8	5	1.2
First dorsal anterior edge	35	8.7	41	8.7	42	7.4	38	8.1	40	9	27	6.9	32	7.6
First dorsal posterior edge	15	3.7	22	4.7	19	3.3	21	4.5	22	4.9	19	4.8	23	5.5
First dorsal base	37	9.2	38	8.1	44	7.7	38	8.1	41	9.2	32	8.1	35	8.3
Second dorsal anterior edge	34	8.4	37	7.9	41	7.2	37	7.9	36	8.1	32	8.1	38	9
Second dorsal posterior edge	17	4.2	23	4.9	18	3.2	23	4.9	24	5.4	16	4.1	20	4.8
Second dorsal base	37	9.2	43	9.1	48	8.4	39	8.3	55	12.4	36	9.1	39	9.3
Inter-dorsal distance	10	2.5	12	2.6	16	2.8	12	2.6	13	2.9	8	2	12	2.9
Clasper length	93	23.1	205	43.6							185	47	202	48.1
<b>Counts</b>														
Tooth rows upper jaw	38		41		38		42		37		39		-	
Tooth rows lower jaw	45		44		42		40		40		43		-	
Trunchal vertebrae	-		26		-		-		-		-		-	
Pectoral fin rays	93		91		-		-		-		-		-	
Pseudobranchial lamellae	13		14		14		13		14		14		-	
Nictitating lamellae	13		11		12		-		12		11		-	



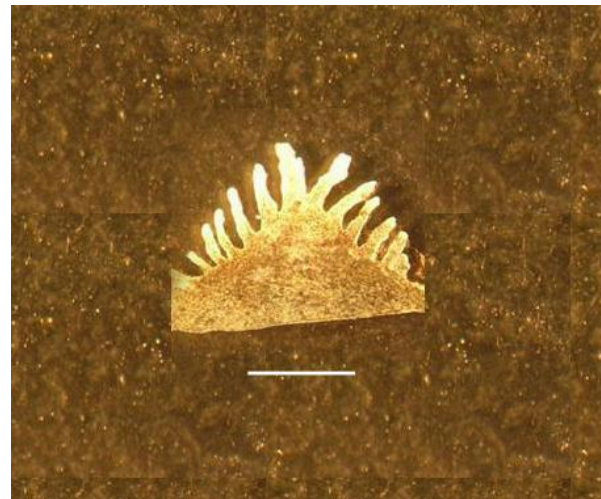
**Figure 2.** Colour patten changes observed in specimens of *Raja clavata* caught off Bizerte, scale bar = 100 mm (photos N. Mnasri). **A:** Type 1, uniform, FSB- Raj- clav 01. **B:** Type 2, ocellated, FSB- Raj- clav 02. **C:** *Raja clavata*. Type 3, speckled, FSB- Raj- clav 03. **D:** Type 4, spotted, FSB- Raj- clav 04. **E:** Type 5, reticulated, FSB- Raj-clav 05. **F:** Type 6, marbled, FSB- Raj-clav 06. **G:** Type 7, vermiculated, FSB- Raj-clav 07, dorsal surface. **H:** Type 7, ventral surface showing thorns (black arrows).



**Figure 3.** Line of Aloncle drawn from external distribution of mucous pores (ampullae of Lorenzini) on ventral surface of *Raja clavata* showing wing (wg), curve (cv) and point (pt), scale bar = 100 mm.

All the described types concerned juveniles and adults of both sexes. Morphology morphometric measurement, meristic counts are in agreement with Clark (1926), Tortonese (1956), Quignard (1965), Aloncle (1966), Bini (1967), Quéro *et al.* (2003) and Hemida (2005). However, specimens of Type 6, marbled, did not clearly show alternance of light and dark crossbars, characteristic pattern in *R. clavata* (see Fig. 2F), but in contrast exhibited conspicuous thorns on the ventral surface. Additionally, specimens of Type 4, spotted, were juveniles and did not present characteristic thorns, but an alternance of light and dark crossbars, even if these latter were not complete at the end of the tail (see Fig. 2D), pattern we have often observed in other thornback rays.

Type 1, uniform, was the most frequently observed, 39 specimens, then type 3 speckled, 10 specimens, representing 60.93% and 15.62% of total sample, respectively. A chi-square test showed that these differences in numbers in the seven types were significant ( $df = 6$ ;  $p < 0.001$ ). Aloncle (1966) considered four types, 2, 3, 4 and 6. We think that the three other types, 1, 5 and 7 deserved to be distinguished and added in our description. Type 1 could be confused with specimens of the speckled ray, *R. polystigma* Regan 1923 even if the dorsal surface of this skate is entirely smooth (Capapé *et al.* 1980), while type 5 with the rough ray *R. radula* Delaroche 1809. Type 7 was very close to the Madeira ray *Raja maderensis* Lowe 1839, but presence of large thorns on both dorsal and ventral surfaces and alternance of light and dark crossbars on tail (see Fig. 2 H) allow to identify it as *R. clavata*. Additionally, Table 1 shows that it does



**Figure 4.** Nictitating lamellae removed from eye of *Raja clavata*, scale bar = 3 mm (photo N. Mnasri).

not exist both morphological and meristic differences between the 7 types.

Aloncle (1966) suggested the use of the external distribution of the mucous pores (ampullae of Lorenzini) in ventral surface, for taxonomy of rajid species. Similar pattern was also used by Bini (1967) and Gomes & Parago (2005) for distinguish some skate species from off Italian Seas and Brazil, respectively. Aloncle (1966) drew a line subdivided in three different regions (see Fig. 6): wing, curve and point, presenting interspecific variations in skate species from off the Moroccan coast. Aloncle's line is presented in Fig. 3; it and shows a wing slightly rounded in its distal end, the curve is rather concave while the point is elongated, all patterns in agreement with Aloncle (1966). Capapé & Quignard (1981) noted the role of shape and number of nictitating lamellae in taxonomy of rajids, so in Fig. 4 is presented a photograph of these features similar to those drawn by Capapé & Quignard (1981).

This paper completes and enlarges the works of Aloncle (1966) and Hemida (2005) on polychromatism in *Raja clavata*, and try to avoid possible misidentifications with close relative rajids especially from the eastern Mediterranean and the neighbouring eastern Atlantic (Hemida *et al.* 2007). Moreover, it confirms the diversity of colour patterns already shown by Capapé *et al.* (1980) and Hemida (2005) in other skate species such as *R. polystigma* and *R. montagui*.

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