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NEW BIOLOGICAL DATA ON THORNBACK RAY, *RAJA CLAVATA* (CHONDRICHTHYES: RAJIDAE), OFF THE LANGUEDOCIAN COAST (SOUTHERN FRANCE, NORTHERN MEDITERRANEAN)

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ABSTRACT

Investigations conducted off the Languedocian coast (southern France, the northern Mediterranean) allowed the authors of this paper to capture 252 specimens of the thornback ray Raja clavata *(Linnaeus, 1758) and to present information on hepatosomatic index (HSI) and gonadosomatic index in both males and females which significantly increased with the size of specimens. A positive relation was observed between the mass of oviducal glands and size (as disc width). Oviducosomatic index (OSI), was only calculated in females. HSI, GSI and OSI reached the maximum values in adult specimens. These indexes did not show significant changes throughout the year, suggesting that reproductive activity of* R. clavata *occurred permanently.*

Key words: Chondrichthyes, *Raja clavata*, liver, gonads, oviducal glands, Languedocian coast, Mediterranean

NUOVI DATI BIOLOGICI SU RAZZA CHIODATA, *RAJA CLAVATA* (CHONDRICHTHYES: RAJIDAE), AL LARGO DELLA COSTA DI LANGUEDOC (FRANCIA MERIDIONALE, MEDITERRANEO SETTENTRIONALE)

SINTESI

Ricerche condotte al largo della costa di Languedoc (Francia meridionale, Mediterraneo settentrionale) hanno permesso agli autori di catturare 252 individui di razza chiodata Raja clavata *(Linnaeus, 1758) e di presentare informazioni inerenti l'indice epatosomatico (HSI) e l'indice gonadosomatico in maschi e femmine. I valori degli indici aumentavano significativamente con l'aumentare della grandezza degli individui. Gli autori hanno osservato una correlazione positiva fra la massa delle ghiandole dell'ovidotto e la grandezza (ossia larghezza del disco corporeo). L'indice oviducosomatico (OSI) è stato calcolato solo per le femmine. Gli indici HSI, GSI e OSI hanno raggiunto i valori massimi negli individui adulti. Tali indici non hanno evidenziato differenze significative nell'arco dell'anno, il che suggerisce che l'attività riproduttiva di* R. clavata *è permanente.*

Parole chiave: Chondrichthyes, *Raja clavata*, fegato, gonadi, ghiandole dell'ovidotto, costa di Languedoc, Mediterraneo

INTRODUCTION

According to Chavelot *et al.* (2006), prior to the 1950s, the thornback ray *Raja clavata* Linnaeus, 1758 was common and widely distributed in the seas of northwest Europe. Since then, it has decreased in abundance and geographic range due to over-fishing and its *K*-selected biological characteristics (*sensu* McAuley *et al.,* 2007), such as in other elasmobranch species, for instance growth rate, late maturity and low fecundity, that make *R. clavata* susceptible to exploitation as victims of by-catch in northern European marine regions (Hunter *et al.*, 2005; Whittamore & McCarthy, 2005). Similar patterns were observed in specimens from other Mediterranean areas such as the coast of Languedoc (Capapé *et al.*, 2006, 2007); the rare landings of specimens collected in the area in a 16-year period showed a decline of captures. However, Garofalo *et al.* (2003) noted an increasing abundance trend of *Raja clavata* on the southwest side of the Sicilian shelf, due to the fact that fishing pressure in the area considerably decreased in the last ten years.

Additionally, the thornback ray is not abundant off the Mediterranean coast of Turkey (H. Kabasakal, *pers. comm.*), however, the species is abundant and targeted by the fishermen deploying bottom fishing gear off the Black Coast of Turkey (mainly along the western shoreline), as well as in the Sea of Marmara (H. Kabasakal, *pers. comm.*; Torku Koç *et al.*, 2004, Saglam & Bascinar, 2008). The thornback ray *R. clavata* was formerly known as relatively abundant throughout the Tunisian coast, (Capapé, 1976). At present, this skate is rather commonly landed even if it is locally considered as a by-catch species (Mnasri, 2008).

The reproductive biology of *R. clavata* was previously studied from specimens caught off the British coasts (Steven, 1936; Chevolot *et al.*, 2007), the Atlantic coast (Du Buit, 1968) and the Mediterranean coast of France (Capapé *et al.*, 2007), the Adriatic Sea (Zupanovic, 1961; Jardas, 1973) and the Tunisian coast (Capapé, 1976, 1979). Investigations conducted during a 16-year period off the coast of Languedoc (Mediterranean shore of France) allowed us to collect specimens of *R. clavata* and data on some traits of its reproductive biology, such as size at sexual maturity, reproductive cycle and fecundity (Capapé *et al.*, 2007). Therefore, in this paper, we provide additional observations on thornback rays by analyzing variations of gonadosomatic and hepatosomatic indexes in both sexes, and oviducosomatic index only in females, in order to try to detect seasonal variations in the gonadal production. Our results are compared and contrasted with those carried out in thornback rays from other regions, such as off the Tunisian coast (Capapé, 1979).

MATERIAL AND METHODS

A total of 252 specimens were studied, 114 males and 138 females. Samples of *Raja clavata* were collected by gill-netters and trawlers at depths up to 80 m, on sandy and muddy bottoms between November 1988 and December 2008, between 43° and 43°30′ N, and between 3°40′ and 4°15′ E. They were generally landed at the harbours of Palavas-Les-Flots and Sète. Moreover, research surveys were conducted in the same areas on board of the oceanographic trawler 'Georges Petit', in November 1988 and 1990 and May 1992 and 1993 (see Capapé *et al.*, 2007).

Disc width (DW) of the specimens was measured to the nearest millimetre following Clark (1926) and mass (TM) was measured to the nearest gram, liver, gonads and oviducal glands masses to the nearest decigram. Clasper length was measured from the forward rim of the pelvic girdle to the tip of the clasper following Collenot (1969). Three stages of male maturity were considered relative to the degree of calcification of claspers and the morphology of the genital duct, following Capapé *et al.* (2007). They were juvenile, sub-adult and adult. Similar stages were also considered in females from the condition of ovaries, the morphology of the reproductive tract and the mass of oviducal glands following Callard *et al.* (2005) and Capapé *et al.* (2007). Hepatomosatic index (HSI), gonadosomatic index (GSI) were calculated in both males and females, as

HSI = (LM/TM) x 100; LM = liver mass

GSI = (GM/TM) x 100; GM = gonad mass

while the oviducosomatic index (OSI) was calculated only in females, as

OSI = (OM/TM) x 100; OM = oviducal glands mass

Variations in GSI, HSI and OSI related to size were considered in all categories of specimens in both sexes, while monthly variations were only considered in adult males and females.

Tests for significance ($p < 0.05$) were performed by using ANOVA, with special regard to variations in HSI, GSI and OSI related to size, while monthly comparisons were performed using non-parametric H-test of Kruskal-Wallis. The linear regression was expressed in decimal logarithmic coordinates. Correlations were assessed by least-squares regression.

RESULTS

Juvenile males ranged in size between 110 and 370 mm DW and weighed between 31 and 985 g; they were mostly caught in March and between May and August. Juvenile females ranged between 110 and 440 mm DW and weighed between 440 and 1645 g; captures mainly occurred in November (Tab. 1).

Sub-adult males were between 350 and 440 mm DW and weighed between 840 and 2598 g. The specimens were caught throughout the year. Sub-adult females were 410 and 540 mm DW and weighed between 3300 and 4950 g; they were captured in May, April, August and December.

The smallest adult male was 420 mm DW and weighed 2130 g, while the largest specimen was 510 mm DW and weighed 4500 g; some specimens were collected every month. The smallest adult female was 540 mm DW and weighed 4950 g; the largest was 690 mm DW and weighed 5980 g; captures occurred throughout the year. The mass of both oviducal glands (OG Mass) was weighed in the three categories of females. The relationship between DW and OG Mass was: log OG Mass = 4.678 log DW -11.513; r = 0.884 (Fig. 1).

Values of HSI recorded in male *Raja clavata* ranged between 1.74 and 6.76 (mean = 4.22±1.16), while in females they ranged between 1.44 and 6.90 (mean = 3.51±0.79). Considering the whole sample (see Fig. 2A) these values were significantly higher in males than in females (F = 82.13, df = 1, p <0.001). Values of male HSI showed significant changes according to stages *i.e.*, juvenile, sub-adult and adult (Fig. 2B). HSI values in juvenile males ranged between 1.74 and 6.42 (mean = 3.56±1.04), they ranged between 2.20 and 6.42 (mean = 4.47±1.02) in sub-adults and between 2.69 and 6.76 (mean = 5.05±0.83) in adults. As in males, values of female HSI showed significant changes according to age stages (Fig. 2C). HSI values in juvenile females ranged between 1.76 and 4.10 (mean = 3.16±0.59), they ranged between 2.29 and 6.02 (mean = 3.88±1.2) in sub-adults and between 2.29 and 6.90 (mean = 3.69±0.43) in adults. Values of female HSI, (Fig. 6) showed significant changes between juveniles and sub-adults (df = 2, p<0.001), by contrast these changes were not significant between sub-adults and adults (df = 2, p = 0.69).

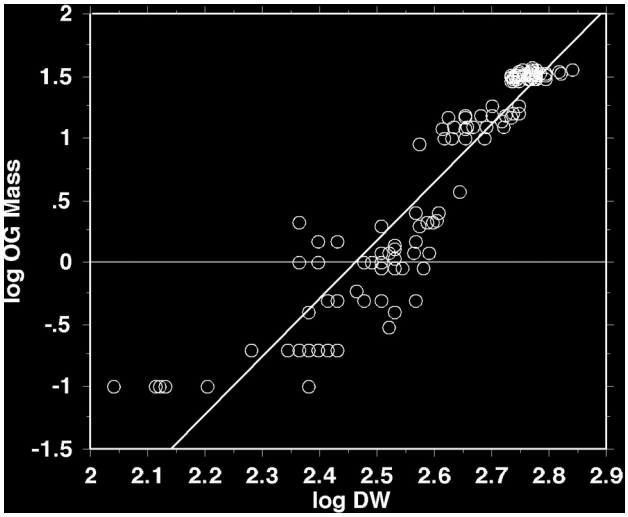

Fig. 1: Relationship between Oviducal Gland Mass (OG Mass) and Disc Width (DW) expressed in logarithmic co-ordinates for female *Raja clavata*.
Sl. 1: Razmerje med maso jajcevodnih žlez (OG) in širino telesne plošče (DW) pri samici vrste *Raja clavata*, ***izraženo v logaritmičnih koordinatah.***

Concomitantly, values of male GSI ranged between 0.15 and 0.93 (mean = 0.48±0.15), while in females they ranged between 0.1 and 6.00 (mean = 1.55±0.46). However, in the whole sample (see Fig. 3A) these values were significantly higher in females than in males (F = 80.29, df = 1, p <0.001). GSI both regularly and significantly increased between juveniles and sub-adults (df = 2, p <0.001), and between sub-adults and adults (df = 2, p = 0.024). Similarly, values of male GSI showed significant changes according to the three stages *i.e.*, juvenile, sub-adult and adult (Fig. 3B). GSI values in juveniles ranged between 0.15 and 0.74 (mean = 0.38±0.12), they ranged between 0.32 and 0.86 (mean = 0.51±0.12)

Tab. 1: Monthly collection of the observed *Raja clavata* ***captured off the coast of Languedoc.***
Tab. 1: Mesečna zbirka opazovanih raž trnjevk *Raja clavata*, ***ujetih v obalnih vodah Languedoca.***

Sex	Category	Months												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Males	Juveniles	-	4	8	–	10	12	9	8	4	–	–	2	57
	Sub–adults	3	3	2	3	3	3	3	1	2	1	1	–	25
	Adults	2	1	2	4	3	2	2	2	3	3	2	6	32
	Total	5	8	12	7	16	17	14	11	9	4	3	8	114
Females	Juveniles	4	7	3	3	3	3	2	8	3	4	13	4	57
	Sub–adults	4	2	2	1	8	2	2	–	2	1	1	1	26
	Adults	2	4	3	1	5	6	5	2	7	4	10	6	55
	Total	10	13	8	5	16	11	9	10	12	9	24	11	138
Grand total		**15**	**21**	**20**	**12**	**32**	**28**	**23**	**21**	**21**	**13**	**27**	**19**	**252**

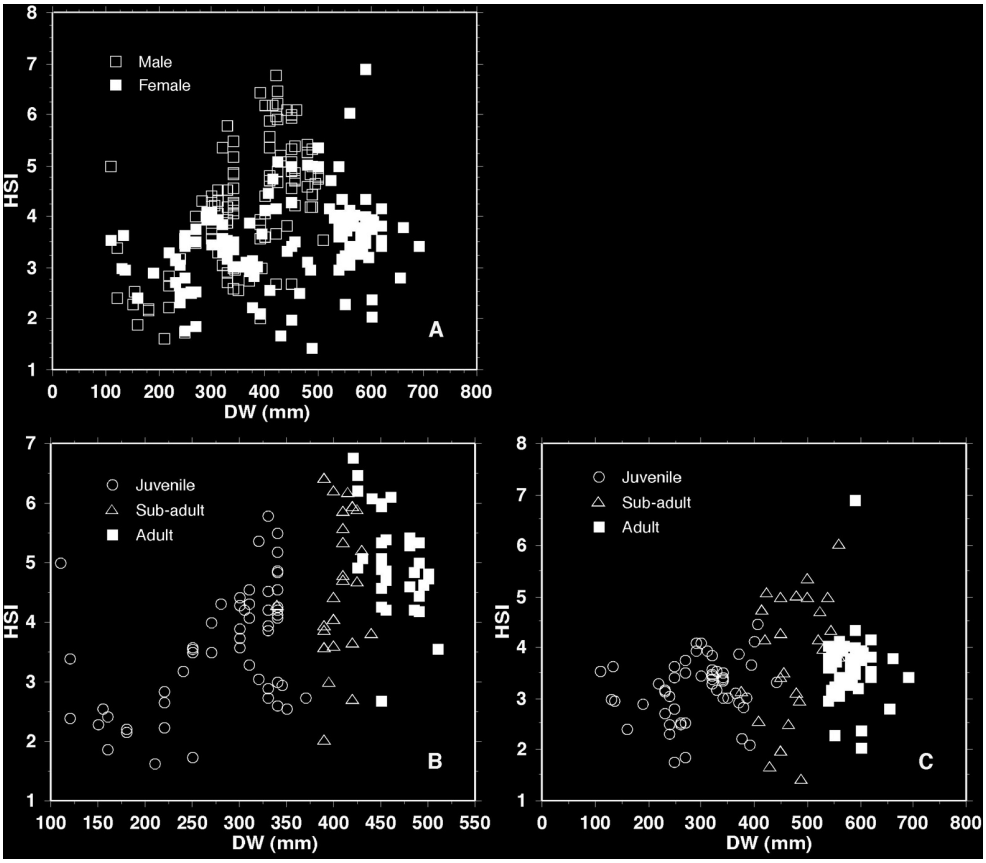

Fig. 2: (A) Variations in hepatosomatic index (HSI) *vs.* ***Disc Width (DW) in male and female*** *R. clavata.* ***(B) Variations in hepatosomatic index (HSI)*** *vs.* ***Disc Width (DW) in juvenile, sub-adult and adult male*** *R. clavata.* ***(C) Variations in hepatosomatic index (HSI)*** *vs.* ***Disc Width (DW) in juvenile, sub-adult and adult female*** *R. clavata.*
Sl. 2: (A) Variacije hepatosomatskega indeksa (HSI) *vs.* ***širina telesne plošče (DW) pri samcih in samicah vrste*** *R. clavata.* ***(B) Variacije hepatosomatskega indeksa (HSI)*** *vs.* ***širina telesne plošče pri mladostnih, subadultnih in odraslih samcih vrste*** *R. clavata.* ***(C) Variacije hepatosomatskega indeksa (HSI)*** *vs.* ***širina telesne plošče pri mladostnih, subadultnih in odraslih samicah vrste*** *R. clavata.*

in sub-adults and between 0.40 and 0.93 (mean =0.56±0.13) in adults. GSI both regularly and significantly increased between juveniles and sub-adults (df = 2, p <0.001), and between sub-adults and adults (df = 2, p = 0.024). Values of female GSI ranged between 0.10 and 1.50 (mean = 0.45±0.42) in juveniles, they ranged between 0.30 and 1.97 (mean = 0.60±0.25) in sub-adults and between 1.14 and 5.35 (mean = 2.09±1.50) in adults (Fig 3C). GSI both regularly and significantly increased between juveniles and sub-adults (df = 2, p <0.001), and between sub-adults and adults (df = 2, p = 0.024). Values of OSI, only recorded in females, (Fig. 4), showed significant changes between juveniles and sub-adults and between sub-adults and adults (df = 1, p <0.001). These values ranged between 0.10 and 0.40 (mean = 0.20±0.05), between 0.30 and 0.40 (mean = 0.38±0.08) and between 0.50 and 0.99 (mean = 0.64±0.07), in juveniles, sub-adults and adults, respectively.

The monthly mean values of adult male HSI plotted in Figure 5A did not show significant variations throughout the year (H = 7.12, df = 11, p = 0.78). As in males, the monthly mean values of adult female HSI plotted in Figure 5B did not show significant variations throughout the year, (H = 11.24, df = 11, p = 0.42). Similar patterns were observed in monthly mean values of adult male GSI (Fig. 6A), although it exhibited low values in April and December (H = 11.4, df = 11, p = 0.41), while monthly mean values of adult female GSI (Fig. 6B) exhibited low values in March and October, and a high value in December. However, these monthly differences were not significant (H = 17.03, df = 11, p = 0.23). Additionally, monthly mean values of OSI in adult females (Fig. 7) did not show significant changes (H = 14.28, df = 11, p = 0.19).

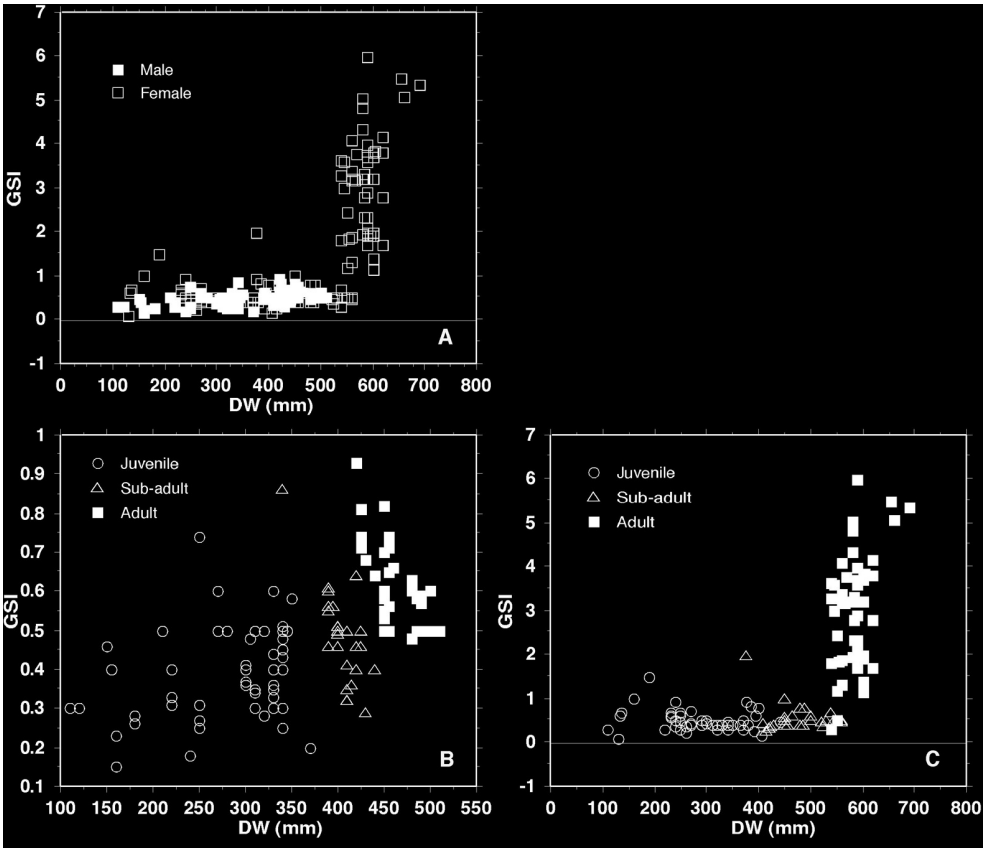

Fig. 3: (A) Variations in gonosomatic index (GSI) *vs.* ***Disc Width (DW) in male and female*** *R. clavata.* ***(B) Variations in gonosomatic index (GSI)*** *vs.* ***Disc Width (DW) in juvenile, sub-adult and adult female*** *R. clavata.* ***(C) Variations in gonosomatic index (GSI)*** *vs.* ***Disc Width (DW) in juvenile, sub-adult and adult female*** *R. clavata.*
Sl. 3: (A) Variacije gonosomatskega indeksa (GSI) *vs.* ***širina telesne plošče (DW) pri samcih in samicah vrste*** *R. clavata.* ***(B) Variacije gonosomatskega indeksa (GSI)*** *vs.* ***širina telesne plošče pri mladostnih, subadultnih in odraslih samcih vrste*** *R. clavata.* ***(C) Variacije gonosomatskega indeksa (GSI)*** *vs.* ***širina telesne plošče pri mladostnih, subadultnih in odraslih samicah vrste*** *R. clavata.*

DISCUSSION

Previous observations carried out on thornback rays from the Languedocian coast showed positive relationships between disc width and liver mass in both males and females (Capapé *et al.*, 2007). These observations were corroborated by regular increasing of HSI values in three categories of specimens, juveniles, sub-adults and adults, even if in females significant differences in HSI values between sub-adults and adults did not appear. All these observations confirm the liver role in buoyancy in agreement with previous reports (Bones & Roberts, 1969; Baldridge Jr., 1970, 1972; Capapé *et al.*, 2008a, b), but also its role in reproduction. A large liver plays an important role in gonadal products, especially in females, such as the production of yolk in both viviparous and oviparous species (García-Garrido *et al.*, 1990; Magrabaña *et al.*, 2002; Capapé *et al.*, 2008a). Liver stores nutriments which are transferred and used for fabrication of gonadal products. This phenomenon is more important in females than in males, due to the fact that vitellogenesis occurs throughout the year. It could explain why HSI was significantly higher in males than in females, especially in adults. HSI values varied between 3.5 and 6.0 in female *R. clavata* from both the Languedocian and Tunisian coast (Capapé, 1979). Close HSI values between 1.55 and 6.30 were reported by Oddone *et al.* (2008) for female of the eye-spot skate *Atlantoraja cyclophora* (Regan, 1903) from off southeastern Brazil. Higher values, 6.5 and 10, were reported in the oviparous smallspotted catshark *Scyliorhinus canicula* (Linnaeus, 1758) from the coast of Languedoc (Capapé *et al.*, 2008a) and the Tunisian coast (Capapé, 1978). However, they are lower than those reported in viviparous species from the Languedocian coast, such as a HSI value of 14 calculated in the eagle ray *Myliobatis aquila* (Linnaeus, 1758) according to Capapé *et al.* (2008b), and especially in the angular rough shark *Oxynotus centrina* (Linnaeus, 1758), where

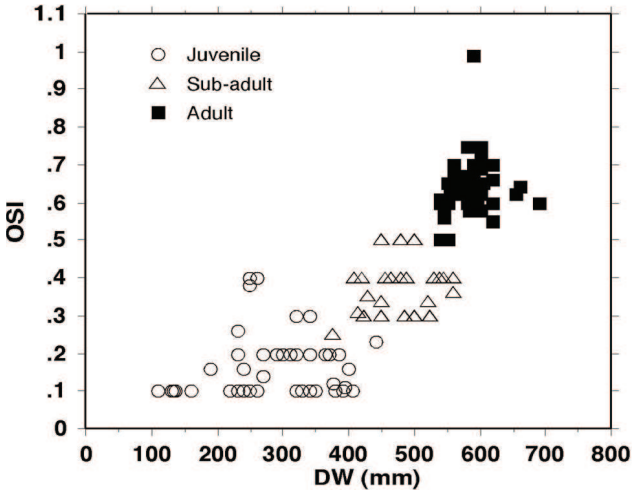

Fig. 4: Variations in oviducosomatic index (OSI) *vs.* ***Disc Width (DW) in juvenile, sub-adult and adult female*** *R. clavata.*
Sl. 4: Variacije ovidukosomatskega indeksa (OSI) *vs.* ***širina telesne plošče (DW) pri mladostnih, subadultnih in odraslih samicah vrste*** *R. clavata.*

Capapé *et al.* (1999) noted that they varied between 23.0 and 42.2, and Dragicevic *et al.* (2009) reported a HSI of 35.5 in a female caught in the eastern Adriatic Sea.

GSI was significantly higher in female *R. clavata* than in the male ones, due to the fact that female adults produce large, heavy and numerous yolky oocytes and vitellogenesis. Consequently, the reproductive activity occurs throughout the year (Capapé *et al.*, 2007), in agreement with the regular and significant increasing of GSI during the different stages of maturation in specimens of both sexes. Additionally, monthly changes of GSI were not significant in either males or females, corroborating the permanence of reproductive activity in all adult specimens throughout the year (see Capapé *et al.*, 2007). Similar patterns were reported for *R. clavata* from the Tunisian coast (Capapé, 1976, 1979), and other oviparous species such as skates (Oddone & Velasco, 2006; Oddone *et al.*, 2007, 2008) or sharks (Capapé, 1977, 1978; Capapé *et al.*, 2008a).

The positive relationship between disc width and mass of oviducal glands (see Fig. 1) showed that the development of oviducal glands considerably and signifi-

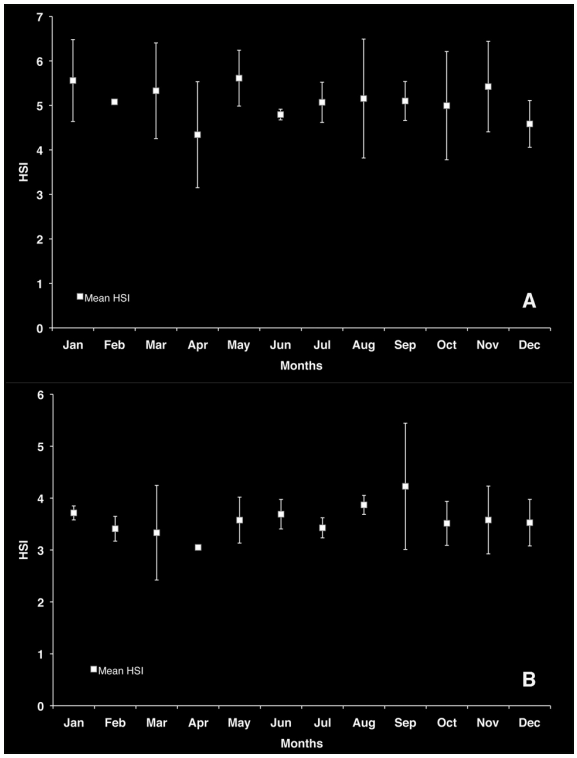

Fig. 5: (A) Monthly variations in hepatosomatic index (HSI) in male *R. clavata.* ***(B) Monthly variations in hepatosomatic index (HSI) in female*** *R. clavata.*
Sl. 5: (A) Mesečne variacije hepatosomatskega indeksa (HSI) pri samcih vrste *R. clavata****. (B) Mesečne variacije hepatosomatskega indeksa (HSI) pri samicah vrste*** *R. clavata.*

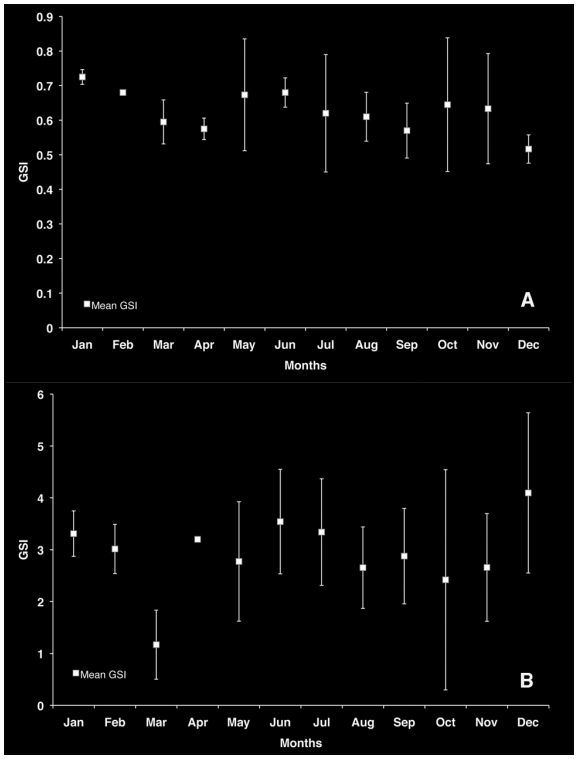

Fig. 6: (A) Monthly variations in gonosomatic index (GSI) in male *R. clavata.* ***(B) Monthly variations in gonosomatic index (GSI) in female*** *R. clavata.*
Sl. 6: (A) Mesečne variacije gonomatskega indeksa (GSI) pri samcih vrste *R. clavata.* ***(B) Mesečne variacije gonosomatskega indeksa (GSI) pri samicah vrste*** *R. clavata.*

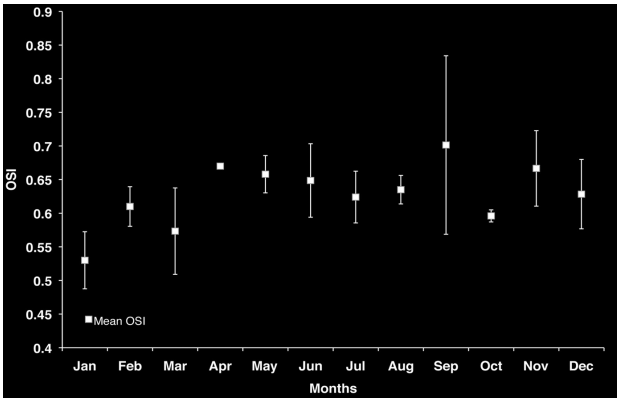

***Fig. 7: Monthly variations in oviducosomatic index (OSI) in female** R. clavata.*
***Sl. 7: Mesečne variacije ovidukosomatskega indeksa (OSI) pri samicah vrste** R. clavata.*

cantly increased in juveniles, sub-adults and adults. Capapé *et al.* (2007) reported that this development could be used as a good parameter to assess size at sexual maturity in oviparous species. The oviducal glands are well developed in adult oviparous species. Additionally, no significant changes throughout the year suggest that the reproductive activity is permanent, activity of oviducal glands and vitellogenesis being linked in all oviparous elasmobranch species.

NOVI BIOLOŠKI PODATKI O RAŽI TRNJEVKI, *RAJA CLAVATA* (CHONDRICHTHYES: RAJIDAE), IZ OBALNIH VOD LANGUEDOCA (JUŽNA FRANCIJA, SEVERNO SREDOZEMLJE)

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POVZETEK

V okviru raziskave, izvedene ob languedoški obali (južna Francija, severno Sredozemlje), so avtorji pričujočega članka proučili 252 primerkov raže trnjevke Raja clavata *(Linnaeus, 1758) in sedaj predstavljajo podatke o hepatosomatskem indeksu (HSI) in gonadosomatskem indeksu pri samcih in samicah. Ta sta z velikostjo primerkov znatno porasla. Ugotovljena je bila tudi pozitivna korelacija med maso jajcevodnih žlez in velikostjo (oz. širino telesne plošče). Ovidukosomatski indeks (OSI) je bil merjen samo za samice. HSI, GSI in OSI so dosegli najvišje vrednosti pri odraslih primerkih. Indeksi se med letom niso spreminjali, kar kaže na stalno razmnoževalno aktivnost vrste* R. clavata.

Ključne besede: Chondrichthyes, *Raja clavata,* jetra, spolne žleze, jajcevodne žleze, languedoška obala, Sredozemlje

REFERENCES

Baldridge, H. D. Jr. (1970): Sinking factors and average densities of Florida sharks as function of liver buoyancy. Copeia, 4, 744–754.
Baldridge, H. D. Jr. (1972): Accumulation and function of liver oil in Florida sharks. Copeia, 2, 306–325.
Bone, Q. & B. L. Roberts (1969): The density of elasmobranchs. J. Mar. Biol. Assoc. UK, 49, 913–917.
Callard, I. P., J. S. George & T. J. Koob (2005): Endocrine control of the female reproductive tract. In: Hamlett, W. C. (ed.): Reproductive biology and philogeny of Chondrichthyes. Sharks, Batoids and Chimaeras. Sciences Publishers Inc., Enfield (NH, USA), Plymouth (UK), pp. 283–300.
Capapé, C. (1976): Contribution à la biologie des Rajidae des côtes tunisiennes. III. *Raja clavata* Linné 1758. Répartition géographique et bathymétrique, sexualité, reproduction et fécondité. Bull. Mus. Natl. Hist. Nat. 3, 275, 907–922.
Capapé, C. (1977): Contribution à la biologie des Scyliorhinidae des côtes tunisiennes. I. *Scyliorhinus canicula* (Linné, 1758): répartition géographique et bathymétrique, sexualité, reproduction, fécondité. Bull. Off. Natn Pêch. Tunisie, 1(1), 83–101.
Capapé, C. (1978): Contribution à la biologie des Scyliorhinidae des côtes tunisiennes. VI. *Scyliorhinus canicula* (Linné, 1758): Étude complémentaire de la fécondité. Relations taille-poids du corps, taille-poids des gonades, poids du corps-poids du foie, poids du corps-poids des gonades, poids du foie-poids des gonades. Coefficients de condition. Rapports hépato et gonosomatique. Bull. Off. Natn Pêch. Tunisie, 2(1–2), 109–140.

Capapé, C. (1979): Contribution à la biologie des Rajidae des côtes tunisiennes. XX. *Raja clavata* Linné, 1758. Relations taille-poids du corps, taille-poids des gonades. Rapports hépato et gonosomatique. Coefficients de condition. Arch. Inst. Pasteur Tunis, 56(4), 425–469.

Capapé, C., A. A. Seck & J.-P. Quignard (1999): Observations on the reproductive biology of the angular rough shark, *Oxynotus centrina* (Oxynotidae). Cybium, 23(3), 259–271.

Capapé, C., O. Guélorget, Y. Vergne, A. Marquès & J.-P. Quignard (2006): Skates and rays (Chondrichthyes) from waters off the Languedocian coast (southern France, northern Mediterranean). Annales, Ser. Hist. Nat., 16(2), 166–178.

Capapé, C., O. Guélorget, Y. Siau, Y. Vergne & J.-P. Quignard (2007): Reproductive biology of the thornback ray *Raja clavata* L., 1758, (Chondrichthyes: Rajidae) from the coast of Languedoc (Southern France, Northern Mediterranean). Vie Milieu, 57(1–2), 83–90.

Capapé, C., C. Reynaud, Y. Vergne & J.-P. Quignard (2008a): Biological observations on the smallspotted catshark *Scyliorhinus canicula* (Chondrichthyes: Scyliorhinidae) off the Languedocian coast (southern France, northern Mediterranean). PanamJAS, 3(3), 282–289.

Capapé, C., Y. Vergne, J.-P. Quignard & C. Reynaud (2008b): Biological observations on the eagle ray *Myliobatis aquila* (Chondrichthyes:Myliobatidae) off the Languedocian coast (southern France, northern Mediterranean). Annales, Ser. Hist. Nat., 18(2), 167–172.

Chevolot, M., J. R. Ellis, G. Hoarau, A. D. Rijnsdorp, W. T. Stam & J. L. Olsen (2006): Population structure of the thornback ray *(Raja clavata* L.) in British waters. J. Sea Res., 56(4), 305–316.

Chevolot, M., J. R. Ellis, G. Hoarau, A. D. Rijnsdorp, W. T. Stam & J. L. Olsen (2007): Multiple paternity analysis in the thornback ray *Raja clavata* L. J. Hered., 98, 712–715.

Clark, R. S. (1926): Rays and skates, a revision of the European species. Scotland, Fish. Bd., Sci. Invest., no. 1, 66 p.

Collenot, G. (1969): Etude biométrique de la croissance relative des ptérygopodes chez la roussette *Scyliorhinus canicula* L. Cah. Biol. Mar., 10, 309–29.

Dragicevic, B., J. Dulcic & C. Capapé (2009): Capture of a rare shark, Oxynotus centrina (Oxynotidae), in the eastern Adriatic Sea. J. Appl. Ichthyol., 25 (Suppl. 1), 56–59.

Du Buit, M. H. (1968): Les raies (genre *Raja)* de la pêche française: écologie et morphométrie des principales espèces atlantiques. Trav. Fac. Sci. Rennes. Océanog. Biol., 1, 19–113.

García-Garrido, L., R. Muñoz-Chapuli & A. V. De Andres (1990): Serum cholesterol and triglyceride levels in *Scyliorhinus canicula* (L.) during sexual maturation. J. Fish Biol., 36, 499–509.

Garofalo, G., M. Gristina, F. Fiorentino, F. Cigala Fulgosi, G. Norrito & G. Sinacori (2003): Distributional pattern of rays (Pisces, Rajidae) in the Strait of Sicily in relation to fishing pressure. Hydrobiologia, 503, 245–250.

Hunter, E., A. A. Buckley, C. Stewart & J. D. Metcalfe (2005): Migratory behaviour of the thornback ray, *Raja clavata*, in the southern North Sea. J. Mar. Biol. Assoc. UK, 85, 1095–1105.

Jardas, I. (1973): A contribution to our knowledge of thornback ray (*Raja clavata* L.) and brown ray (*Raja miraletus* L.) in the Adriatic. Acta Adriat., 5(3), 1–42.

Magrabaña, E., L. O. Lucifora & A. M. Massa (2002: The reproductive ecology and abundance of *Sympterygia bonapartii* endemic to the south-west Atlantic. J. Fish Biol., 60, 951–967.

McAuley, R. B., C. A. Simpfendorfer, G. A. Hyndes & R. C. J. Lenanton (2007): Distribution and reproductive biology of the sandbar shark, *Carcharhinus plumbeus* (Nardo), in Western Australian waters. Mar. Freshw. Res., 58, 116–126.

Mnasri, N. (2008): Les élasmobranches de la Tunisie septentrionale: biodiversité et méthode d'approche de la production débarquée. Ph.D. Dissertation. Université du 7 novembre à Carthage, Faculté des Sciences de Bizerte (Tunisia), 125 p.

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

Oddone, M. C., A. F. Amorim, P. L. Mancini, W. Norbis & G. Velazco (2007): The reproductive biology and the cycle of *Rioraja agassizi* (Müller and Henle, 1841) (Chondrichthyes: Rajidae) in southeastern Brazil, SW Atlantic Ocean. Sci. Mar., 71(3), 593–604.

Oddone, M. C., W. Norbis, P. L. Mancini & A. F. Amorim (2008): Sexual development and reproductive cycle of *Atlantoraja cyclophora* (Regan 1903) (Chondrichthyes: Rajidae: Arhynchobatidae) in southeastern Brazil. Acta Adriat., 49(1), 73–87.

Saglam, H. & N. S. Bascinar (2008): Feeding ecology of thornback ray *(Raja clavata* Linnaeus, 1758) on the Turkish coast of the south-eastern Black Sea. Mar. Biol. Res., 4(6), 451–457.

Steven, G. A. (1936): Migrations and growth of the thornback ray *(Raia clavata).* J. Mar. Biol Assoc. UK, 20(3), 605–614.

Torku Koç, H., Z. Aka Erdogan & J. Dulcic (2004): Length-weight relationships on fishes from Turkish seas: a review. Annales, Ser. Hist. Nat., 14(2), 197–218.

Whittamore, J. M. & I. D. McCarthy (2005): The population biology of the thornback ray, *Raja clavata* in Caernarfon Bay, north Wales. J. Mar. Biol. Assoc. UK, 85, 1089–1094.

Zupanovic, S. (1961): Contribution à la connaissance des poissons de l'Adriatique. Acta Adriat., 9(4), 1–84.