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NEW BIOLOGICAL DATA ON THE EAGLE RAY, *MYLIOBATIS AQUILA* (CHONDRICHTHYES: MYLIOBATIDAE), OFF THE LANGUEDOCIAN COAST (SOUTHERN FRANCE, NORTHERN MEDITERRANEAN)

Christian CAPAPÉ, Yvan VERGNE & Jean-Pierre QUIGNARD

Laboratoire d'Ichtyologie, case 104, Université Montpellier II, Sciences et Techniques du Languedoc, 34095 Montpellier cedex 05, France
E-mail: capape@univ-montp2.fr

Christian REYNAUD

Laboratoire interdisciplinaire de Recherche sur la Didactique, l'Éducation et la Formation, E. A. 3749, case 77, Université Montpellier II,
Sciences et Techniques du Languedoc, 34095 Montpellier cedex 5, France

ABSTRACT

*Investigations conducted off the Languedocian coast allowed the authors of the paper to capture 73 specimens of the eagle ray *Myliobatis aquila* (Linnaeus, 1758) and to obtain information on hepatosomatic index (HSI) and gonosomatic index (GSI) in males and females. Relationships between disc width (DW) and HSI, and DW and GSI did not show significant differences between males and females. However, the highest value of HSI and GSI were recorded in both sub-adult and adult specimens, especially in adult females showing the role of the liver in the gonadal production as well as in buoyancy.*

Key words: Chondrichthyes, Myliobatidae, *Myliobatis aquila*, liver, gonads, Languedocian coast, Mediterranean

NUOVI DATI BIOLOGICI PER L'AQUILA DI MARE, *MYLIOBATIS AQUILA* (CHONDRICHTHYES: MYLIOBATIDAE), AL LARGO DELLA COSTA DI LANGUEDOC (FRANCIA MERIDIONALE, MEDITERRANEO SETTENTRIONALE)

SINTESI

*Gli autori riportano la cattura di 37 esemplari di Aquila di mare, *Myliobatis aquila* (Linnaeus, 1758), durante una ricerca al largo della costa di Languedoc. Sono state così ottenute informazioni sull'indice epatosomatico (HSI) e sull'indice gonosomatico (GSI) sia nei maschi che nelle femmine della specie. Le relazioni fra la larghezza del disco (DW) e l'HSI, e fra DW e GSI, non hanno evidenziato importanti differenze fra i sessi. I valori più elevati di HSI e GSI, comunque, sono stati registrati in individui quasi adulti ed adulti, principalmente femmine, il che evidenzia il ruolo del fegato nella produzione gonadica e sulla galleggiabilità.*

Parole chiave: Chondrichthyes, Myliobatidae, *Myliobatis aquila*, fegato, gonadi, Languedoc, Mediterraneo

INTRODUCTION

According to McEachran & Capapé (1984), the common eagle ray *Myliobatis aquila* (Linnaeus, 1758) is a typical Atlanto-Mediterranean species. It has been reported from off Scandinavia (Muus & Dahlstrøm, 1964-1966) and British Isles (Wheeler, 1969) to Portugal (Albuquerque, 1954-1956), south of the Strait of Gibraltar, from off Morocco (Collignon & Aloncle, 1972) and Mauritania (Maurin & Bonnet, 1970) to Senegal (Cadenat, 1951). It is known throughout the Mediterranean and has recently been reported from the eastern Levantine Basin by Golani (2005).

From off the Languedocian coast, *M. aquila* was formerly reported by various authors, from Doumet (1860) to Quignard *et al.* (1962). In this area, the species was not considered as abundantly landed; due to their low economical interest, eagle rays were generally discarded at sea by fishermen soon after capture. However, investigations carried out in the area allow Capapé *et al.* (2007) to collect several specimens and to present some traits of the reproductive biology of the species, such as size at sexual maturity, reproductive cycle and fecundity, which were compared with similar data recorded from specimens off the Tunisian coast (Capapé & Quignard, 1974).

In the present paper, we provide additional observations on *M. aquila* by analyzing variations of gonadosomatic and hepatosomatic indexes in both sexes, in order to detect seasonal variations in the gonadal production. Our results are compared and contrasted with those carried out in the viviparous angular rough shark *Oxynotus centrina* (Linnaeus, 1758) and the oviparous smallspotted catshark *Scyliorhinus canicula* (Linnaeus, 1758) from the same area (Capapé *et al.*, 1999, 2008).

MATERIAL AND METHODS

Between 1990 and 2004, specimens were captured by demersal gill-nets at depths from 30 to 40 m, between Sète and Le Grau-du-Roi (Fig. 1). Disc width (DW) of the specimens was measured to the nearest millimetre following Clark (1926) and mass (TM) to the nearest gram, liver, gonads and the masses of oviducal glands to the nearest decigram.

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 following Callard *et al.* (2005), Henderson *et al.* (2006) and Capapé *et al.* (2007). Hepatosomatic index (HSI) and gonadosomatic index (GSI) were calculated in both males and females as $HSI = (LM/TM) * 100$, $GSI = (GM/TM) * 100$. Variations in GSI and HSI were consid-

ered in all categories of specimens in both sexes. Tests for significance ($p < 0.05$) were performed by using ANOVA, with special regard to variations in HSI and GSI and related to size.

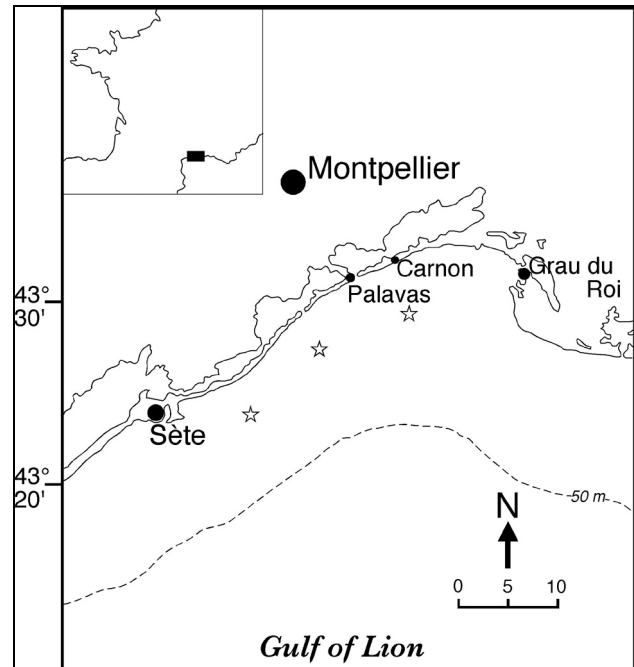


Fig. 1: Map of France pointing with the coast of Languedoc and captures sites (stars) of the eagle ray *Myliobatis aquila* in the area (redrawn from Capapé *et al.*, 2000).

Sl. 1: Zemljevid Francije z obrežnimi vodami pokrajine Languedoc in lokalitetami (zvezdice), kjer so bili ujeti navadni morski golobi *Myliobatis aquila* (narisano po Capapé *et al.*, 2000).

RESULTS

In all, 73 common eagle rays were observed, 41 were males and 32 females. The monthly collection of the observed specimens is summarized in Table 1. Juvenile males comprised 16 specimens, with their disc width ranging between 210 and 490 mm and weight between 166 and 1495 g. Juveniles were generally caught between August and October, one specimen was caught in March, one in May. Eight sub-adults were collected, seven between August and October and a single specimen in May. The smallest sub-adult observed was 460 mm DW and weighing 1600 g, the largest 520 mm DW and weighing 1780 g. The smallest adult male was 500 mm DW and weighing 2,000 g, the largest was 720 mm DW and weighing 5,250 g, while the heaviest specimen weighed 5,460 g and was 710 mm DW. All males above 540 mm DW were adult.

Tab. 1: Monthly collection of the observed *M. aquila* captured off the coast of Languedoc.

Tab. 1: Mesečna zbirka navadnih morskih golobov *M. aquila*, ujetih v obrežnih vodah pokrajine Languedoc.

Sex	Category	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Males	Juveniles	-	-	1	-	-	-	-	5	6	4	-	-	16
	Sub-adults	-	-	-	-	1	-	-	2	4	1	-	-	8
	Adults	-	-	2	-	4	-	-	3	2	6	-	-	17
	Total	-	-	3	-	5	-	-	10	12	11	-	-	41
Females	Juveniles	-	-	1	-	-	-	-	2	11	2	-	-	16
	Sub-adults	-	-	2	-	-	-	-	2	1	3	-	-	8
	Adults	1	-	1	-	-	-	-	2	3	1	-	-	8
	Total	1	-	4	-	-	-	-	6	15	6	-	-	32
Grand total		1	-	7	-	5	-	-	16	27	17	-	-	73

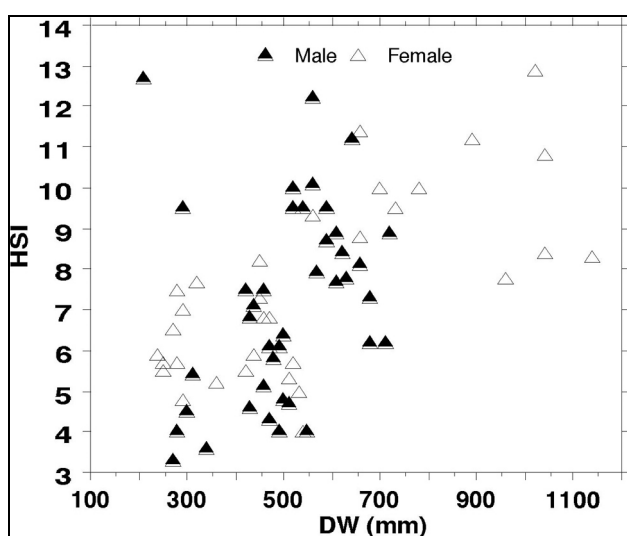


Fig. 2: Relationship between hepatosomatic index (HSI) and disc width (DW) for both male and female *M. aquila* from the Languedocian coast.

Sl. 2: Razmerja med hepatosomatskim indeksom (HSI) in širino diska (DW) pri samcih in samicah vrste *M. aquila*, ujetih v obrežnih vodah pokrajine Languedoc.

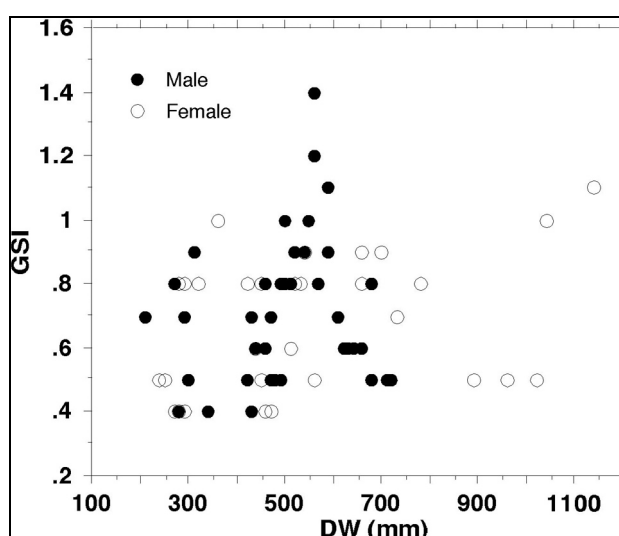


Fig. 3: Relationship between gonosomatic index (GSI) and disc width (DW) for both male and female *M. aquila* from the Languedocian coast.

Sl. 3: Razmerja med gonosomatskim indeksom (GSI) in širino diska (DW) pri samcih in samicah vrste *M. aquila*, ujetih v obrežnih vodah pokrajine Languedoc.

Seventeen adult males were collected, 2 in March, 4 in May and 11 between August and October (Tab. 1).

Juvenile females ranged between 240 and 470 mm DW and weighing between 190 and 1,405 g. Sixteen juveniles were collected, fourteen from August to October, one in March and one in May (Tab. 1). Eight sub-adults were captured, 2 specimens in May and 6 between August and October. The smallest sub-adult was 360 mm DW and weighed 862 g; the largest specimen was 700 mm DW and weighed 4,850 g. Eight adults were collected, a single specimen in May and seven between August and October (Tab. 1). The smallest adult was 730 mm DW and weighed 6,100 g; the largest was 1,140 mm and weighed 29,400 g.

Considering the whole sample, values of male HSI (Fig. 2), did not significantly differ from those of female HSI ($F = 0.06$, $df = 1$, $p = 0.94$). Similar patterns were recorded in GSI values (Fig. 3) between males and females ($F = 3.53$, $df = 1$, $p = 0.75$). The highest value of HSI in males was recorded in the smallest free-swimming specimen having 210 mm DW, and decreased from DW of about 250 DW onward (Fig. 4). HSI then globally increased; when males entered maturation stage and became sub-adults, HSI reached the highest values in adult specimens. Among males, however, no significant differences were detected in HSI values between juveniles and sub-adults ($df = 2$, $p = 0.423$) and between sub-adults and adults ($df = 2$, $p = 0.178$). By contrast, HSI

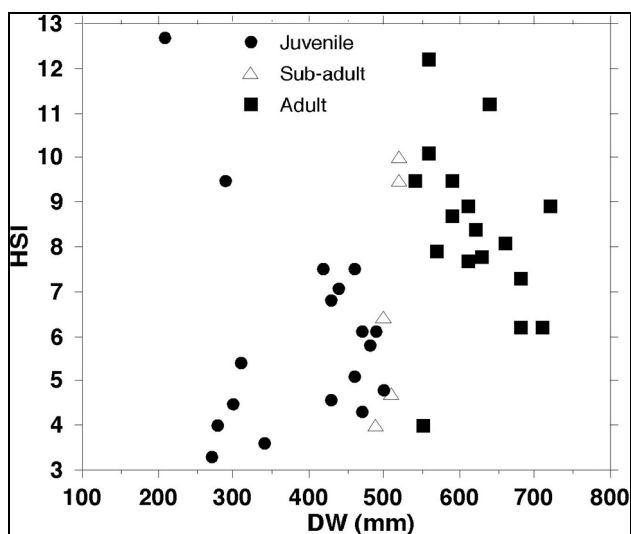


Fig. 4: Variations in hepatosomatic index (HSI) vs disc width (DW) in juvenile, sub-adult and adult males of *M. aquila* from the Languedocian coast.

Sl. 4: Razlike med hepatosomatskim indeksom (HSI) in širino diska (DW) pri mladostnih, skoraj odraslih in odraslih samcih vrste *M. aquila*, ujetih v obrežnih vodah pokrajine Languedoc.

showed significant differences in females (Fig. 5), between juveniles and sub-adults ($df = 2$, $p = 0.043$) and between sub-adults and adults ($df = 2$, $p = 0.030$).

The male GSI values significantly increased with TL of specimens (Fig. 6); additionally, they showed significant differences between juveniles and sub-adults ($df = 2$, $p = 0.010$), and between sub-adults and adults ($df = 2$, $p = 0.040$). Similar patterns were observed in female GSI values (Fig. 7); however, significant differences in GSI values were recorded between juvenile and sub-adult specimens ($df = 2$, $p = 0.025$), and between sub-adults and adults ($df = 2$, $p = 0.047$).

DISCUSSION

Previously, Capapé *et al.* (2007) showed that both male and female eagle rays from the Languedocian coast demonstrated a positive relationship between disc width (DW) and total mass (TM), and disc width (DW) and liver mass (LM). This relationship, however, significantly differed between males and females, for it was significantly higher in the former than in the latter. The high HSI values observed in both males and females could be explained by the role of liver in buoyancy in agreement with previous reports (Bones & Robert, 1969; Baldrige Jr., 1970, 1972; Rossouw, 1987). Additionally, these significant differences between males and females (Capapé *et al.*, 2008), suggested that liver plays an important role in the life cycle of the latter (Oddone & Velasco, 2006). Liver size is sexually dimorphic in both

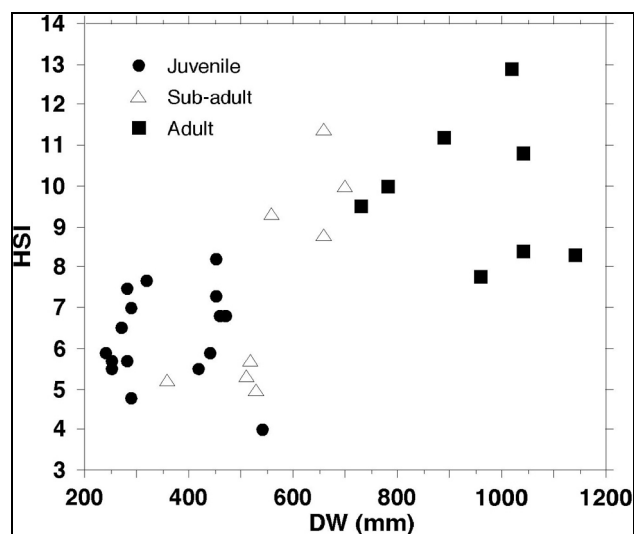


Fig. 5: Variations in hepatosomatic index (HSI) vs disc width (DW) in juvenile, sub-adult and adult females of *M. aquila* from the Languedocian coast.

Sl. 5: Razlike med hepatosomatskim indeksom (HSI) in širino diska (DW) pri mladostnih, skoraj odraslih in odraslih samcih vrste *M. aquila*, ujetih v obrežnih vodah pokrajine Languedoc.

oviparous and viviparous chondrichthyan species. A larger liver may allow females to maximize the production of yolk, such as in the viviparous lesser guitarfish *Rhinobatos annulatus* Müller & Henle, 1841 (Rossouw, 1987), as well as in the small spotted catshark (García-Garrido *et al.*, 1990; Capapé *et al.*, 2008) and the small-nose fanskate *Sympterygia bonapartii* (Magrabaña *et al.*, 2002). Moreover, cartilaginous fish store energy as lipids in the liver (Craik, 1978). In viviparous females, larger liver observed may be related to the increased energy expenditure during vitellogenesis, oocyte maturation and gestation. Furthermore, females store large quantities of lipids in the liver during the reproductive cycle (Lucifora *et al.*, 2005). The highest HSI value was recorded in a neonate male and suggested that liver constituted a reserve of nutrients for free-swimming specimens soon after parturition. This hypothesis was corroborated by decreasing HSI values in larger juveniles.

Both HSI and GSI values are lower in *M. aquila* than in other aplacental viviparous species, such as the angular rough shark *Oxynotus centrina* (Linnaeus, 1758), especially in females. The former is a matrotrophic species (*sensu* Hamlett *et al.*, 2005), in which the mother supplements yolk from other sources such as uterine secretions; the phenomenon was called histotrophy by Hamlett *et al.* (2005). The latter is a pure lecithotrophic species (*sensu* Hamlett *et al.*, 2005), the female produces larger and heavier eggs; the mother only protects the embryonic development and supplies inorganic nu-

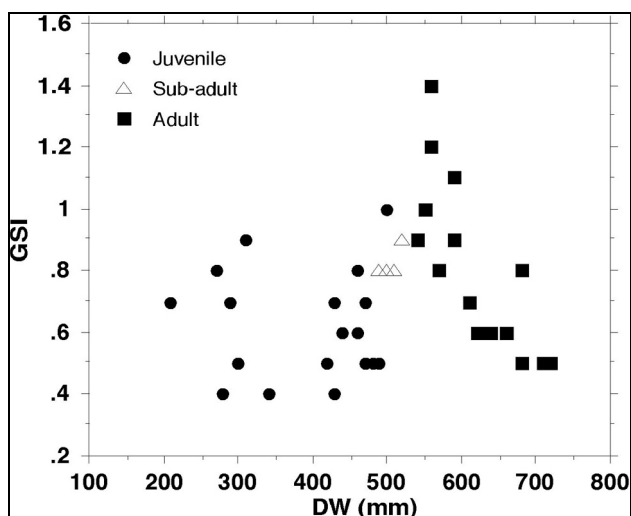


Fig. 6: Variations in gonosomatic index (GSI) vs disc width (DW) in juvenile, sub-adult and adult males of *M. aquila* from the Languedocian coast.

Sl. 6: Razlike med gonosomatskim indeksom (GSI) in širino diska (DW) pri mladostnih, skoraj odraslih in odraslih samcih vrste *M. aquila*, ujetih v obrežnih vodah pokrajine Languedoc.

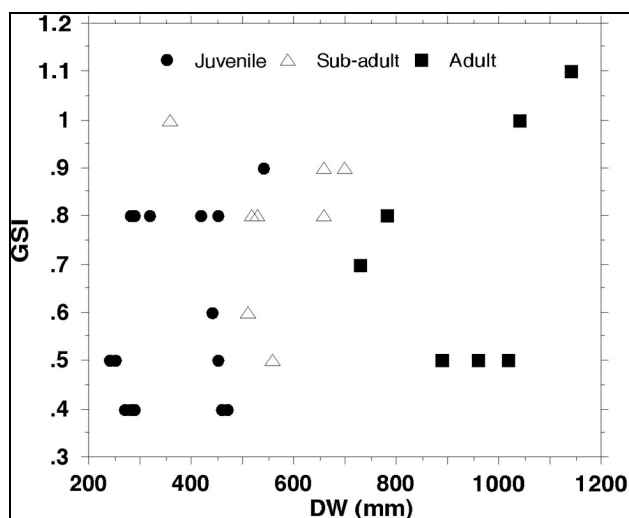


Fig. 7: Variations in gonosomatic index (GSI) vs disc width (DW) in juvenile, sub-adult and adult females of *M. aquila* from the Languedocian coast.

Sl. 7: Razlike med gonosomatskim indeksom (GSI) in širino diska (DW) pri mladostnih, skoraj odraslih in odraslih samicah vrste *M. aquila*, ujetih v obrežnih vodah pokrajine Languedoc.

triments especially in squatinids, displaying an utero-clocal gestation (Capapé *et al.*, 2005). Additionally, transfers of nutriments are less evident in *M. aquila* than in *O. centrina*, and similar patterns were observed in an

oviparous species, the smallspotted catshark *Scyliorhinus canicula* (Linnaeus, 1758) from off the Languedocian coast (Capapé *et al.*, 2008).

NOVI BIOLOŠKI PODATKI O NAVADNEM MORSKEM GOLOBU *MYLIOBATIS AQUILA* (CHONDRICHTHYES: MYLIOBATIDAE) V VODAH POKRAJINE LANGUEDOC (JUŽNA FRANCIJA, SEVERNO SREDOZEMLJE)

Christian CAPAPÉ, Yvan VERGNE & Jean-Pierre QUIGNARD

Laboratoire d'Ichtyologie, case 104, Université Montpellier II, Sciences et Techniques du Languedoc, 34095 Montpellier cedex 05, France
E-mail: capape@univ-montp2.fr

Christian REYNAUD

Laboratoire interdisciplinaire de Recherche sur la Didactique, l'Éducation et la Formation, E. A. 3749, case 77, Université Montpellier II, Sciences et Techniques du Languedoc, 34095 Montpellier cedex 5, France

POVZETEK

Avtorji članka so med raziskavami, ki so jih opravili v vodah južnofrancoske pokrajine Languedoc, ujeli 37 osebkov navadnega morskega goloba *Myliobatis aquila* (Linnaeus, 1758) in zbrali podatke o hepatosomatskem (HIS) in gonosomatskem indeksu (GSI) tako pri samcih kot samicah te vrste. Razmerja med širino diska (DW) in HIS ter med DW in GSI niso pokazala kakšnih pomembnejših razlik med spoloma. Pa vendar so bile najvišje vrednosti HIS in GSI zabeležene tako pri skoraj odraslih kot odraslih osebkih, še posebno pri odraslih samicah, kar kaže na vlogo jeter pri razvoju spolnih žlez in tudi plavnosti.

Ključne besede: Chondrichthyes, Myliobatidae, *Myliobatis aquila*, jetra, spolne žleze, Languedoc, Sredozemlje

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