

Reproductive biology of European hake *Merlucciusmerluccius* (Linnaeus, 1758) in the Egyptian Mediterranean waters

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ABSTRACT

The reproductive biology of the European hake (*Merlucciusmerluccius*, Linnaeus, 1758) was studied in the Egyptian Mediterranean waters from December 2009 to November 2011. The sex ratio revealed that males dominated the catch in groups from 13.0 to 32.0 cm, while females dominated for larger groups (33.0- 47.0 cm). Generally, males dominated the catch in all seasons. Length at first sexual maturity was found to be 21.8 cm and 24.0 cm for males and females respectively. For both sexes gonadosomatic index reached maximum values during February and March, and the spawning season extended from April to June. Hepatosomatic index showed higher values during April and May. Ova diameter ranged from 0.28 mm to 0.84 mm. The average fecundity ranged from 40706 to 420950 eggs for the size range 25.0-53.0 cm. Absolute fecundity increased proportionally with fish length and weight.

Keywords: *Merlucciusmerluccius*, Reproductive biology, Mediterranean waters.

INTRODUCTION

European hake *Merlucciusmerluccius* is ademersal and bathypelagic species. It is found between 27° W and 40° E of longitude and between 16° N and 70° N of latitude, in temperate areas of the Eastern Atlantic i.e., from the coast of Norway and Iceland to Mauritanian waters (Lloris and Matallanas, 2003). In the Mediterranean Sea, the highest concentrations of individuals are found at depths from 100m to 200m and increasing in abundance from west to east (Oliver, 1991; Orsi-Reliniet *al.*, 2002; Maynouet *al.*, 2003). In the north western Mediterranean, on the Catalanian coast, Olivaret *al.* (2003) recorded that eggs and larvae of this species are concentrated over the continental shelf.

Merlucciusmerluccius is considered as a common and commercially important gadidae fish in Mediterranean Sea (Al-Absaway, 2010). Reproductive biology and histological structure of *Merlucciusmerluccius* in the Bay of Biscay was studied by Murua and Motos (2004). In Egyptian Mediterranean waters, Abd El Aziz (1976) studied the reproductive biology of this species in Alexandria.

The present study was carried to investigate different reproductive aspects such as sex ratio, maturation, length at first maturity, spawning season, egg diameter and fecundity of this species in Egyptian Mediterranean waters, which could be essential for the management and development for such valuable fish.

MATERIAL AND METHODS

A total of 524 fish of European hake *Merlucciusmerluccius* were randomly collected from the trawlers operated in the Egyptian Mediterranean waters, during the period from December 2009 to November 2011. For every fish, total length and gutted weight were recorded to the nearest millimeter and gram respectively. Gonads

and liver were weighed at accuracy of 0.01gm. Sex and maturity stages were determined according to Nikolsky (1963) with some modifications into six maturity stages: immature (stage I), maturation (stage II), nearly ripe (stage III), ripe (stage IV), spawning (stage V) and spent (stage VI). Samples of gonads were preserved in 10% formalin for fecundity and ova diameter studies.

Gonadosomatic index was calculated by using the following formula:

$$G.S.I = \frac{\text{Gonad weight (gm)} \times 100}{\text{Gutted weight (gm)}}$$

and Hepatosomatic index:

$$H.S.I = \frac{\text{Liver weight (gm)} \times 100}{\text{Gutted weight (gm)}}$$

Absolute fecundity was estimated as the number of mature ova that are likely to be spawned using ripe ovaries of higher gonado-somatic index by the method of Batts (1972). Ova diameters were measured using an eye piece micrometer under binocular microscope. The relationship between absolute fecundity (F_a) and relative fecundity (F_r) with fish length (cm) are of type $F_a = aL^b$, where a and b constants. Statistical analyses were calculated to support this research.

RESULTS AND DISCUSSION

Sex ratio:

Variations of sex ratio with length:

Table (1) determined the percentage of males to females (M : F) for *Merlucciusmerluccius*, it was showed that males dominated the catch in groups from 13.0cm to 32.0cm, while females dominated the catch for larger groups from 33.0 to 47.0cm. Chi-square was computed according to Snedecor (1956) and Snedecor & Cochran (1982) showed that sex ratio was favor of males for whole catch (1: 0.596).

Table 1: Sex ratio variation with fish size groups for *Merlucciusmerluccius* in Egyptian Mediterranean waters (2009 – 2011).

Total length groups (cm)	Males		Females		Sex ratio M : F	Chi-square Value
	No	%	No	%		
13 - 17	13	100.00	-	-	-	-
18 - 22	48	75.00	16	25.00	1 : 0.333	16
23 - 27	163	69.96	70	30.04	1 : 0.429	27.12
28 - 32	98	61.25	62	38.75	1 : 0.633	8.10
33 - 37	10	22.22	35	77.78	1 : 3.500	13.89
38 - 42	-	-	10	100.00	-	-
43 - 47	-	-	5	100.00	-	-
Total	332	62.17	198	37.83	1 : 0.596	33.88

Seasonal variation of sex ratio:

Seasonal variations of sex ratio for *Merlucciusmerluccius* (Table 2) showed that males dominated the catch in all seasons with higher ratio during spring (69.06%). Generally for the whole period of investigation, males accounted 62.64% of the total catch with sex ratio (1: 0.596). The chi-square value computed was 33.88 ($p > 0.05$), this values showed highly significant difference between both sexes.

Table 2: Seasonal variation in sex ratio for *Merlucciusmerluccius* in Egyptian Mediterranean waters (2009 – 2011).

Seasons	Males		Females		Sex ratio M : F	Chi-square Value
	No	%	No	%		
Spring	96	69.06	43	30.94	1 : 0.448	20.210
Summer	78	59.54	53	40.46	1 : 0.679	4.771
Autumn	67	58.26	48	41.74	1 : 0.716	3.139
Winter	91	62.76	54	37.24	1 : 0.593	9.441
Total	332	62.64	198	37.36	1 : 0.596	33.879

Length at first sexual maturity:

According to Pitt (1970) the length at which 50% of a fish population reaches maturity (L_{50}) is considered to be the length of the onset sexual maturity. Fig. (1) shows that, L_{50} for females and males of this species reach at a total length of 24.0cm and 21.8cm respectively.

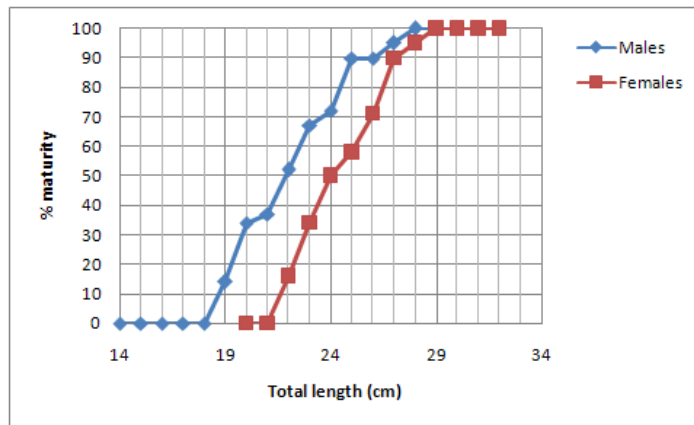


Fig. 1: Length at first sexual maturity for males and females *Merlucciusmerluccius* in Egyptian Mediterranean waters (2009 – 2011).

Monthly distribution of maturity stages:

The monthly percent frequency of maturity stages for males and females of *Merlucciusmerluccius* were given in Table (3). It is obvious that, individuals of maturing stage (stage II) for both males and females were recorded during the whole year reaching maximum percentages in both September and October (100%).

The nearly ripe (stage III) of males were observed through the period from November to February, while that of females were detected during the period from November to March with high percentages for both sexes in January.

Ripe stage (stage IV), for both males and females were represented through the period from January to April.

Spawning stage (stage V), for both sexes extended from April to June reaching maximum percentage during April for females and May for males (Table 3).

Spent stage (stage VI), was observed from May to August with maximum in July for both sexes.

Table 3: Monthly distribution of maturity stages for males and females *Merlucciusmerluccius* in Egyptian Mediterranean waters (2009 – 2011).

Month	Males					Females				
	mature II	nearly ripe III	ripe IV	spawning V	spent VI	mature II	nearly ripe III	ripe IV	Spawning V	Spent VI
December	61.4	38.6	-	-	-	56.0	44.0	-	-	-
January	26.8	58.2	15.0	-	-	27.5	50.0	22.5	-	-
February	23.0	17.0	60.0	-	-	26.8	12.2	61.0	-	-
March	23.5	-	76.5	-	-	26.2	14.3	59.5	-	-
April	21.6	-	21.6	56.8	-	13.2	-	20.1	66.7	-
May	20.7	-	-	64.6	14.6	22.5	-	-	55.0	22.5
June	29.4	-	-	18.8	51.8	29.3	-	-	24.4	46.3
July	23.6	-	-	-	76.4	34.3	-	-	-	65.7
August	73.3	-	-	-	26.7	76.2	-	-	-	23.8
September	100.0	-	-	-	-	100.0	-	-	-	-
October	100.0	-	-	-	-	100.0	-	-	-	-
November	84.8	15.2	-	-	-	72.0	28.0	-	-	-

Gonado-somatic index (G.S.I):

It is clear in Fig. (2) that females acquired higher G.S.I than males in all months. In both sexes, G.S.I begin to increase from December and January, coincide the beginning of the breeding season. These G.S.I values were increased progressively to reach maximum value in March in both sexes which represent the optimum time of spawning.

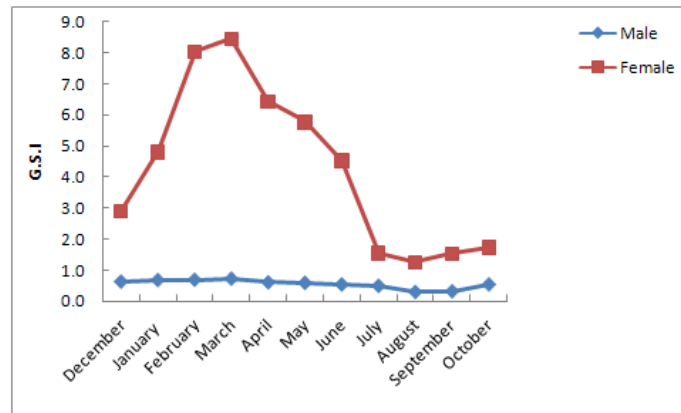


Fig. 2: Monthly variation in gonado-somatic index of males and females *Merlucciusmerluccius* in Egyptian Mediterranean waters (2009 – 2011).

Hepato-somatic index (H.S.I):

From Fig. (3), the hepato-somatic index showed higher values for males and females during April 3.863 & 6.782 respectively) and May (3.999 & 8.889 respectively).

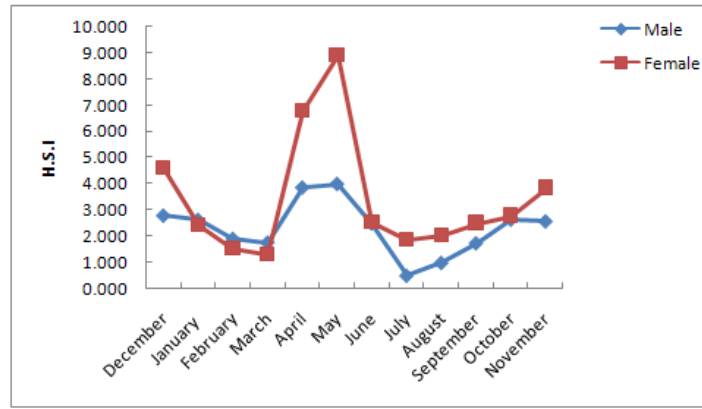


Fig. 3: Monthly variation in hepato-somatic index of males and females *Merlucciusmerluccius* in Egyptian Mediterranean waters (2009 – 2011).

Ova diameter:

The percent frequency of ova diameter of ripe selected fishes during December, February and May is graphically represented in Fig. (4). The results indicate that, the maximum ova diameter (0.84 mm) was observed in February for fish of T.L 43.0 cm with higher G.S.I (8.047). This reveals that, *Merlucciusmerluccius* have a short spawning period.

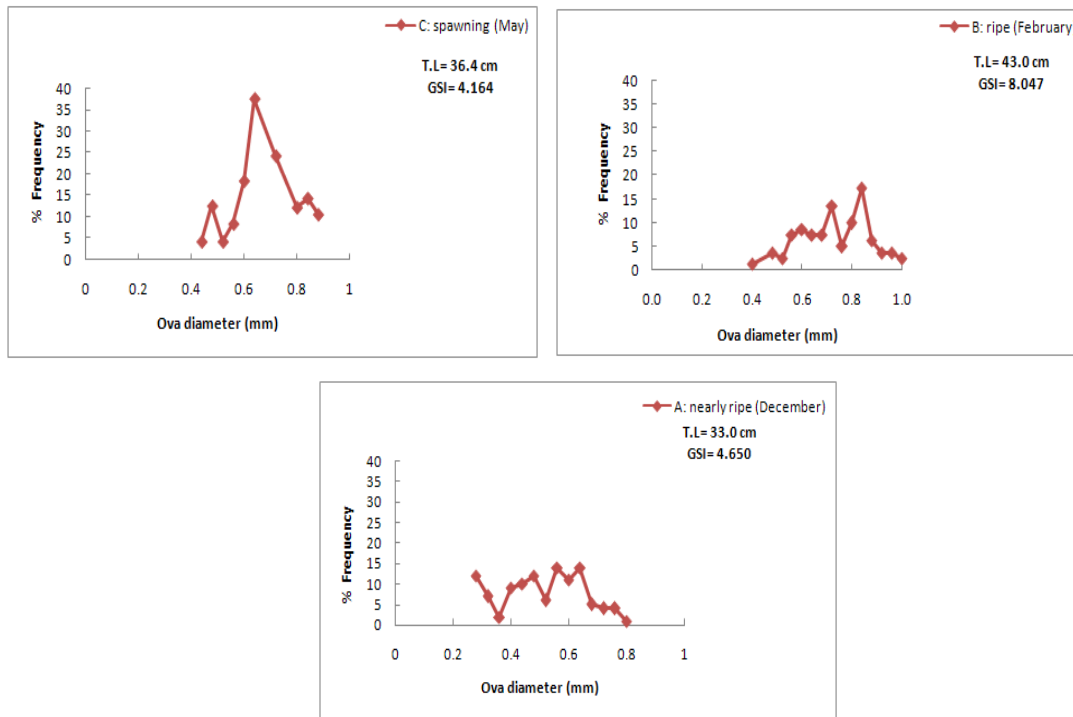


Fig. 4: Frequency distribution of ova diameter in A: nearly ripe, B: ripe and C: spawning of *Merlucciusmerluccius* in Egyptian Mediterranean waters (2009 – 2011).

Fecundity:

The relation between fecundity and total length:

This relation takes curvilinear and expressed by the following equations:

$$\text{Log } F_a = 0.18712 + 3.15446 \log L (r = 0.99935) \text{ and}$$

$$\text{Log } F_r = 0.19719 + 2.14794 \log L (r = 0.99827).$$

From Table (4), the absolute fecundity ranged from 40706 to 420950 eggs, and relative fecundity ranged from 1628 to 7942 eggs for length range (25.0cm to 53.0cm). The high correlation coefficients (r) in these two equations indicate a high degree of significance and predictability between fecundity and length.

Table 4: Relationship between absolute and relative fecundity with total length (cm) for *Merlucciusmerluccius* in Egyptian Mediterranean waters (2009 – 2011).

Total length (cm)	No.	Absolute fecundity		Relative fecundity	
		Obs.	Cal.	Obs.	Cal.
25	10	40706	39524	1628	1584
26	10	42625	44730	1639	1724
27	10	52650	50385	1950	1869
28	10	56917	56510	2033	2021
29	10	59159	63124	2040	2179
30	8	75330	70249	2511	2344
31	5	78021	77904	2517	2515
32	6	83236	86110	2601	2693
33	6	98010	94888	2970	2877
34	3	103879	104258	3055	3067
35	3	111979	114241	3199	3264
36	4	128466	124857	3569	3468
37	3	136406	136129	3687	3678
38	4	145829	148076	3838	3895
39	3	154229	160720	3955	4118
40	2	174340	174082	4359	4348
41	2	194275	188184	4738	4585
42	1	207385	203046	4938	4829
43	1	214650	218691	4992	5079
47	1	284928	289525	6062	6148
53	1	420950	422940	7942	7958

The relation between fecundity and gutted weight:

The relation between absolute fecundity F_a and gutted weight (gm) expressed by the following equation:

$$\text{Log } F_a = 2.51137 + 1.016176 \text{ Log } W (r = 0.99773).$$

This equation shows a high correlation coefficient ($r = 0.99773$), this means a satisfactory agreement between range of gutted weight from 109 to 1166 gm (Table 5).

Table 5: Relationship between absolute and relative fecundity with Guttred weight (gm) for *Merlucciusmerluccius* in Egyptian Mediterraneanwaters (2009 – 2011).

Guttred weight (gm)	No.	Absolute fecundity		Relative fecundity	
		Obs.	Cal.	Obs.	Cal.
109	10	40706	38173	373	122
127	10	42625	44587	336	142
137	10	52650	48156	384	153
158	10	56917	55666	360	177
184	10	59159	64987	322	206
210	8	75330	74328	359	236
246	5	78021	87293	317	277
268	6	83236	95232	311	302
280	6	98010	99567	350	315
296	3	103879	105351	351	333
312	3	111979	111140	359	352
353	4	128466	125996	364	398
365	3	136406	130350	374	412
381	4	145829	136158	383	430
402	3	154229	143788	384	454
472	2	174340	169264	369	534
514	2	194275	184580	378	582
577	1	207385	207592	359	654
614	1	214650	221126	350	696
809	1	284928	292656	352	920
1166	1	420950	424302	361	1331

The relation between relative fecundity and gutted weight given by the following equation: $\text{Log } F_r = 0.027224 + 1.009867 \text{ Log } W (r = 0.40925)$ shows a weak relationship between relative fecundity and gutted weight.

DISCUSSION

The reproductive strength of any fish species is controlled by several factors, such as length of spawning period, number of females and the length and age composition of females in the catch (Al-Absawey, 1997).

In the present study of *Merlucciusmerluccius* in the Egyptian Mediterranean waters, sex ratio was 1:0.596 in favor of males while that ratio for this species on the eastern central Atlantic Moroccan coast was close to 1:1 (El- Habouz *et al.*, 2011), also, in the present investigation, males predominated the smaller populations since fishes $\leq 17.0\text{cm}$ T.L were all males, while fishes $\geq 38.0\text{cm}$ T.L were all females. These differences may be attributed to various aspects such as temperature influences on sex determination (Conver & Kynard, 1981), selective mortality by sex through differential predation and differential sexual behavior or growth rate (Schultz, 1996). The disappearance of males from the population at an earlier time than females could be explained by differential mortality rates in sex (Solomon *et al.*, 1984) and

(Abdallah & Faltas, 1998). The shorter life span of males may be associated with their earlier attainment of sexual maturity (Hashem, 1981).

The length at first sexual maturity is a very important parameter in fisheries research to assess the optimum length of first capture of this species and to determine the minimum legal size that needed to maintain the suitable spawning stock to ensure at least one spawning for the mature individuals (Farrag, 2008).

Length at first sexual maturity of *Merlucciusmerluccius* was estimated for different areas by various authors. It was found that, males attain their first sexual maturity at smaller sizes than females. In Egyptian Mediterranean waters, Abd El-Aziz (1976) recorded L_{50} for males at 17.0cm and females L_{50} at 23.0cm; Al-Absawey (2008) L_{50} for males at 31.0 cm and Al-Absawey (2010) L_{50} for females 32.5cm. El Habouzet *al.* (2011) recorded L_{50} for males 28.6cm and females L_{50} 33.8cm for this species in Eastern central Atlantic Moroccan coast. Piñeiro and Sainza (2003) recorded L_{50} for males and females 32.8 and 45.4cm respectively in Iberian peninsula.

The present study revealed L_{50} for males and females at 21.8 and 24.0cm respectively, although differences in length of maturity for the same species in different regions depend partly on genetic factors, it is strongly influenced by environment, such as hydrographical conditions (i.e. water temperature) and biotic factors, such as food supply (Helser & Almeida, 1997, Helser & Brodziak, 1998 and Engelhard & Heino, 2006).

In the present study, the gonadosomatic index values of *Merlucciusmerluccius*, revealed that the spawning season of this species is short and only a single group of egg matures and such result agrees with that given by Abd El Aziz (1976), O'Brien (1986), Horstman (1988) and Leonart (2001) for Egyptian Mediterranean, western Irish Coast, Celtic sea and Mediterranean sea respectively. Other areas show long spawning periods such as in Tyrrhenian Sea (Biagiet *al.*, 1995), Bay of Biscay (Lucioet *al.*, 1998) and (Álvarezet *al.*, 2001), Adriatic Sea (Ungaroet *al.*, 2001), Tunisian shelf (Orsi-Reliniet *al.*, 2002) and Iberian waters (Piñeiro and Sainza, 2003).

From the present study of hepatosomatic index it is obvious that this index decreased as gonad weight increased due to the increase of reproductive activity during breeding season (January to March) as a result of consumption of lipid stored in the liver.

In the present study, the absolute fecundity for *Merlucciusmerluccius* increased with increasing of length and weight. These results agree with those of Abd El Aziz (1976) in Egyptian Mediterranean waters. Analysis of covariance for regression of absolute fecundity with respect to length for the present study and that of Abd El Aziz (1976) for the same length range (25.0 - 43.0cm) showed no significant difference (comparison of slopes $F= 0.47217$ & $df 1,34$).

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ARABIC SUMMARY

بيولوجيا تكاثر أسماك النازلى ميرلوشيصميرلوشيص (لينيبص، ١٧٥٨) فى مياه البحر المتوسط المصرية

آمال إسكندر فيلبس ، ايفيلين راغب

المعهد القومى لعلوم البحار و المصايد بالاسكندرية ، مصر

تم دراسة بيولوجيا تكاثر أسماك النازلى (ميرلوشيصميرلوشيص) فى مياه البحر المتوسط المصرية خلال الفترة من ديسمبر ٢٠٠٩م حتى نوفمبر ٢٠١١م. من دراسة نسبة الذكور والإناث تبين أن الذكور تسود المصيد فى الأطوال من ١٣سم إلى ٣٢سم بينما تزيد نسبة الإناث عن الذكور للأطوال من ٣٣سم إلى ٤٧سم . وبصفة عامة تزيد الذكور فى كل فصول السنة. تبلغ السمكة أول نضج جنسى عند طول ٢١,٨سم ، ٢٤سم تقريبا فى الذكور و الإناث على التوالى. كما وصل مؤشر حالة المناسل GSI أقصى قيمة خلال فبراير و مارس للجنسين وأن موسم التكاثر يمتد من إبريل إلى يونيه كما وصل مؤشر حالة الكبد HSI أقصى قيمة خلال إبريل ومايو. وتراوح قطر بيض هذه الأسماك من ٢,٨. مم إلى ٨,٤. مم. وبدراسة الخصوبة وجد أن الخصوبة المطلقة لهذه الأسماك تتراوح من ٤٠٧٠٦ بيضة إلى ٤٢٠٩٥٠ بيضة للأطوال من ٢٥ إلى ٥٣سم وتزداد الخصوبة المطلقة بزيادة الطول والوزن لهذا النوع من الأسماك.