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AGE AND GROWTH OF BARRACUDAS IN THE EGYPTIAN MEDITERRANEAN WATERS

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Key words: *Sphyraena, age and growth, length-weight relationship, coefficient of condition and growth performance.*

ABSTRACT

Age and growth of barracudas from the Egyptian Mediterranean waters were studied by otolith reading during the period from March 1998 to February 1999. Growth in length and weight between males and females showed insignificant difference among *Sphyraena* species. For combined sexes, the maximum length of *Sphyraena chrysotaenia* (24.91 cm) was attained at 5-years old whereas *S. flavicauda* reached 38.65cm at 6-years old. *S. sphyraena* and *S. viridensis* attained 41.17 and 54.46 cm respectively at 8-years old. The rate of growth was higher in the first year of life, showing a gradual decrease in growth as the fish got older. Length-weight relationships, coefficient of condition and von Bertalanfy growth models were calculated. The growth performance of *S. viridensis* (2.95) was the highest in comparison with the other *Sphyraena* species studied.

INTRODUCTION

The barracudas fish form a well-defined group, widely distributed in the tropical and temperate waters (Ben-Tuvia, 1986). They constituted about 2.6 % of the total landed catch from the Egyptian Mediterranean waters (GAFRD, 1991 – 2000). They are mainly caught by trawl nets, purse-seines, gill nets and trammel nets.

The barracudas of the Egyptian Mediterranean waters include four species: *Sphyraena chrysotaenia*, *S sphyraena*, *S. viridensis* and *S. flavicauda* (a new Red Sea immigrant). Age and growth of barracudas have been studied by Wadie *et al.* (1989) for *Sphyraena chrysotaenia* and *S. sphyraena* in the Egyptian Mediterranean waters, De Sylva (1963) for *S. barracuda* from Miami and Florida and Hart (1973) for *S. argentae* from California waters.

The present work aims to study age and growth of the barracudas. This may contribute in managing its fisheries in the Egyptian Mediterranean waters.

MATERIALS AND METHODS

Random samples of barracudas *(Sphyraena chrysotaenia*, *S. flavicauda*, *S. sphyraena* and *S.* viridensis) were weekly collected from the commercial catch landing at Alexandria fishing centers during the period from March 1998 to February 1999. For each individual, total length (L; cm), total weight (W; g), gutted weight (W_g; g) and sex were recorded. Otoliths (sagitta) were taken and kept for age determination. The whole otoliths were immersed in glycerol with a black background and examined under a binocular microscope with reflected light. Relationships between otolith radius (OR) and total length (L) were determined using least square regression analysis [L = a + b (OR)]. Comparison between sexes showed insignificant difference by analysis of

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covariance. The value of intercept (a) was used as a correction factor for back-calculated lengths at the end of each year of life using Lee's equation. The mean lengths at each age for males and females showed insignificant difference by analysis of variance.

The commonly used length-weight relationships ($W = a L^b$) were applied and covariance analysis showed insignificant differences between sexes. The total weights at different ages were calculated using length-weight relationship. The coefficient of condition (K) was calculated as $K = 100 W_g / L^3$. Theoretical growth equation was computed using the von Bertalanffy equation developed by Beverton & Holt (1957). Growth parameters ($L\infty$, K & t_o) were calculated by the method of Gulland (1965).Growth performance index ($\Phi = \text{Log } K + 2 \log L\infty$) was calculated according to Moreau *et al* (1986). Since, there was insignificant difference between males and females for all species studied, the sexes were pooled.

RESULTS

Otolith radius–total length relationship

Otolith radii were found to be directly proportional (Fig. 1) and highly correlated with total lengths for all *Sphyraena* species studied as follows:

For *S. chrysotaenia*: L = -2.17 + 4.75 OR (n = 1285, r = 0.999)

For *S. flavicauda*: L = -14.00 + 7.22 OR (n = 427, r = 0.993)

For *S. sphyraena*: L = -3.46 + 4.59 OR (n = 627, r = 0.997)

For *S. viridensis*: L = -9.57 + 10.05 OR (n= 71, r = 0.998)

Growth in length

Sphyraena chrysotaenia grew to approximately 16.5 cm in the first year reaching a maximum 24.9 cm in the 5–year–old fish and *S. flavicauda* reached about 18.7 cm in the first year reaching a maximum 38.7 cm in a 6–yr–old fish whereas *S. sphyraena* and *S. flavicauda* grew to approximately 21.7 and 14.7 cm in the first year reaching a maximum 41.2 and 54.5 cm respectively in a 8–yr–old fish (Table 1). Growth rate was rapid in the first year of life (59.82 % for *S. chrysotarnia*, 47.28 % for *S. flavicauda*, 52.50 % for *S. sphyraena* and 26.36 % for *S. viridensis*) showing a steady decrease in growth as the fish got older.

Length-weight relationship

For each species studied, the equations representing the length-weight relationship were highly correlated as follows:

For *S. chrysotaenia*: $W = 0.0027 L^{3.33}$ (n = 1285, r = 0.999)

For *S. flavicauda:* $W = 0.0018 L^{3.27}$ (n = 427, r = 0.999)

For *S. sphyraena*: $W = 0.0050 L^{2.92}$ (n = 627, r = 0.999)

For *S. viridensis*: $W = 0.0045 L^{2.93}$ (n = 71, r = 0.999)

Graphical representations of length-weight relationships show a satisfactory agreement between calculated and empirical weights for all *Sphyraena* species (Fig. 2).

Coefficient of condition

The variations in the value of coefficient of condition (K) with fish length for combined sexes of different species of *Sphyraena* are represented in Table 2. The value of "K" were increased gradually reaching its peak at 21 and 26 cm TL (K = 0.512 & 0.422) for *S. chrysotaenia* and *S. flavicauda* respectively, then after it showed various fluctuations. For *S sphyraena*, the K value increased with increasing length reaching a maximum value at lengths of 28 & 29 cm TL (K = 0.379 & 0.371), after which it decreased reaching a minimum value at 35 cm TL (K = 0.331). For *S. viridensis* the K value was generally decreased with various fluctuations by increasing fish length. The mean value of K was high for *S. chrysotaenia* (K = 0.496) and low for *S. viridensis* (K = 0.332; Table 2).

Table (1): Back calculated lengths (cm) and weights (g) at different years and those predicted from von Bertalanffy equation for *Sphyraena* species.

Age	1	2	3	4	5	6	7	8
S. chrysotaenia								
Number of fish	508	360	92	42	7			
Average length at capture	19.50	22.19	24.38	25.15	26.24			
Back-calculated lengths	16.54	19.94	22.33	23.84	24.91			
Increment of length	16.54	3.94	2.96	2.33	1.88			
Percent increament	59.82	14.25	10.70	8.43	6.80			
Predicted lengths	16.57	19.99	22.30	23.86	24.92			
Calculated weight	22.65	42.05	61.38	76.15	88.00			
Predicted weight	22.73	42.37	60.93	76.30	88.11			
S. flavicauda								
Number of fish	189	160	27	27	15	3		
Average length at capture	22.41	27.97	32.07	35.58	37.89	40.53		
Back-calculated lengths	18.68	25.33	30.14	33.89	36.80	38.65		
Increment of length	18.68	7.22	5.02	3.64	2.99	1.96		
Percent increment	47.28	18.27	12.71	9.21	7.57	4.96		
Predicted lengths	18.57	25.23	30.18	33.68	36.60	38.65		
Calculated weight	25.85	69.62	123.00	180.50	236.20	277.28		
Predicted weight	25.37	68.76	123.41	179.84	232.04	277.19		
S. Sphyraena								
Number of fish	105	109	235	85	26	11	10	5
Average length at capture	23.29	28.63	31.40	33.42	35.32	38.08	39.03	42.32
Back-calculated lengths	21.66	26.01	29.39	31.81	34.26	36.67	38.57	41.17
Increment of length	21.66	4.27	3.52	2.89	2.74	2.40	2.09	1.69
Percent increment	52.50	10.35	8.53	7.00	6.64	5.82	5.06	4.10
Predicted lengths	22.50	26.29	29.65	32.61	35.24	37.56	39.61	41.42
Calculated weight	39.47	67.30	96.07	120.97	150.17	183.17	212.33	256.55
Predicted weight	44.03	69.37	98.47	130.04	162.94	196.21	229.10	161.03
S. viridensis								
Number of fish	6	20	5	5	14	8	4	3
Average length at capture	20.12	27.94	34.86	39.34	43.03	46.93	52.23	56.50
Back-calculated lengths	14.69	22.42	28.38	34.88	40.54	44.97	49.67	54.46
Increment of length	14.69	8.13	7.01	6.99	5.98	4.49	4.48	3.96
Percent increment	26.36	14.59	12.58	12.54	10.73	8.05	8.04	7.11
Predicted lengths	15.03	22.29	28.93	35.01	40.58	45.67	50.33	54.60
Calculated weight	12.40	42.24	83.15	151.07	234.38	317.90	425.40	557.12
Predicted weight	13.28	41.33	88.05	153.36	235.77	333.02	442.52	561.58

The seasonal variation in K value for combined sexes of different *Sphyraena* species are represented in Table 3. The K value was higher in autumn and lower in spring & summer for all *Sphyraena* species.

Growth in weight

The annual weight ranged from 22.65 to 88.0 g at 1 to 5-years for *S. chrysotaenia*, 25.37 to 277.19 g at 1 to 6-years for *S. flavicauda* while at 1 to 8-years, it ranged from 39.47 to 256.55 and from 15.03 to 54.6 g for *S sphyraena* and *S. viridensis* respectively (Table 1). The annual weight increment was high in the third year for *S. chrysotaenia* (21.04 %), fifth year for *S. flavicauda* (20.1 %) and eighth year for *S. sphyraena* (20.10 %) and *S. viridensis* (20.19 %).

Theoretical growth

Von Bretalanfy growth equations for theoretical growth in length and weight for *Sphyraena* species were represented in Table 4. The von Bertalanfy growth models accurately estimated theoretical growth for all *Sphyraena* species. Back-calculated and predicted lengths-at-age agree closely (Table 1). *Sphyraena viridensis* has a higher asymptotic length (L_∞ = 100.64 cm) and weight (W_∞ = 3428.92 g) than other *Sphyraena* species.

Growth performance

It is found that the growth performance index (Φ) of *S. viridensis* (2.95) is higher than that recoded for *S. flavicauda* (2.77), *S. sphyraena* (2.58) and *S. chrysotarnia* (2.46).

DISCUSSION

Longevity of barracudas fish varies for the different species. The maximum recorded age of barracudas was 14 years for *S. barracuda* from Miami and Florida (De Sylva, 1963), 11 years for *S. argentae* from California waters (Hart, 1973), comparing to 8 years for both *S. sphyraena* and *S. viridensis*, 6 years for *S. flavicauda* and 5 years for *S. chrysotaenia* in the Egyptian Mediterranean coast (present study).

The mean length-at-age for all *Sphyraena* species in different regions indicated that growth rate was rapid during the first year of life and then decreased as the fish got older (Table 5; De Sylva, 1963; Sanders and Morgan, 1989; Wadie *et al.*, 1989). The growth rate of *S. chrysotaenia* is the least growth rate in comparison with other species of genus *Sphyraena* (Table 5). The lengths-at-age data in the present study point to a slower growth rate for *S. sphyraena* than those of the same species recorded by Wadie *et al*. (1989) in the same region (Table 5). This may be due to different food abundance or the difference in size composition of the stock (Naish *et al*., 1991). At 8-years old, *S. barracuda* from Miami and Florida would be about 95 cm (De Sylva 1963) and *S. jello* in Gulf of Aden reached 81.7 cm (Sanders and Morgan, 1989) while *S. sphyraena* and *S. viridensis* in present study recorded 41.2 and 54.5 cm respectively.

The values of length-weight constants (a & b) vary in different region as shown in Table 6. Back calculated weight-at-length indicated that fishes of *S. chrysotaenia* (*S. obtusata*) and *S. flavicauda* caught from the Egyptian Mediterranean waters (present work) were heavier than those having the same lengths from New Caledonia (Kulbicki *et al*., 1993) and Mediterranean coast of Turkey (Taskavak and Bilecenoglu, 2001). The variations of weights at different lengths among different regions are mainly attributed to water temperature (Alliot *et al.*, 1983) and food availability (Wassef and El-Emary, 1989). The present study showed a lower weight values for all lengths than those recorded before for *S. chrysotaenia* (Rizkalla, 1985). On the other hand, *S. sphyraena* with lengths less than 28 cm has low values of calculated weights but they are higher for larger fishes as comparing with Rizkalla (1985). Also, the weight-at-age showed a rapid growth rate for *S. chrysotaenia* and *S. sphyraena* studied by Wadie *et al*. (1989) than the same species in

Table 2. Variations of the coefficient of condition (K) with fish length of *Sphyraena* species.

Total length (cm)	*S. chrysotaenia*		*S. flavicuda*		*S. sphyraena*		*S. viridensis*	
	No.	**K**	**No.**	**K**	**No.**	**K**	**No.**	**K**
13								
14								
15								
16								
17			7					
18			1				3	0.3492
19			0				5	0.3394
20			1				3	0.3346
21			7				-	-
22			2				1	0.3192
23			0		1	0.3263	-	-
24			2		1	0.3380	1	0.3483
25			3		2	0.3226	3	0.3334
26			1	0.3814	10	0.3518	2	0.3318
27			7	0.3702	14	0.3609	2	0.3149
28			2	0.3764	16	0.3532	2	0.3211
29	12	0.4293	5	0.3687	11	0.3638	4	0.3265
30	21	0.4319	2	0.3817	17	0.3574	4	0.3184
31	49	0.4572	1	0.3864	27	0.3583	2	0.3128
32	81	0.4486	2	0.3861	19	0.3577	-	-
33	121	0.4601	9	0.3974	15	0.3612	1	0.3446
34	121	0.4788	3	0.4195	17	0.3674	1	0.3134
35	125	0.4918	9	0.4206	17	0.3656	1	0.3275
36	167	0.5077	4	0.4161	23	0.3790	1	0.3338
37	152	0.5122	8	0.4216	38	0.3705	1	0.3072
38	155	0.5059	5	0.4202	66	0.3565	2	0.3196
39	130	0.5073	2	0.4219	87	0.3538	1	0.3302
40	77	0.5033	2	0.4131	90	0.3507	-	-
41	70	0.5000	7	0.4284	61	0.3373	3	0.3396
42	19	0.4995	1	0.4256	37	0.3345	4	0.3372
43	4	0.4910	4	0.4155	22	0.3295	4	0.3469
44			1	0.4311	7	0.3382	2	0.3276
45			4	0.4273	10	0.3316	6	0.3331
46			7	0.4192	6	0.3493	1	0.3333
47			9	0.4342	5	0.3581	2	0.3462
48			8	0.4356	4	0.3150	-	-
49			7	0.4182	3	0.3188	-	-
50			1	0.3968	1	0.3719	1	0.3062
51			0		2	0.3422	3	0.3468
52			5		1	0.3356	-	-
53			9				1	0.3312
54			6				1	0.3249
55			2				1	0.3318
56			1				-	-
57							1	0.3175
58							-	-
59							1	0.3160
Total No.			427					
Av. K	1304	0.4910		0.4082	630	0.3523	71	0.3318
S.D.		±0.0387		±0.0298		±0.0308		±0.0168

Table 3. Seasonal variations of the coefficient of condition (K) for *Sphyraena* species

Species	Season	Number	K ± S.D
S. chrysotaenia	Spring	255	0.4927 ± 0.0377
	Summer	347	0.4806 ± 0.0270
	Autumn	343	0.5101 ± 0.0306
	Winter	273	0.5050 ± 0.0445
S. flavicuda	Spring	136	0.3990 ± 0.0239
	Summer	31	0.4206 ± 0.0196
	Autumn	89	0.4321 ± 0.0159
	Winter	69	0.4047 ± 0.0272
S. sphyraena	Spring	78	0.3337 ± 0.0218
	Summer	210	0.3378 ± 0.0256
	Autumn	162	0.3810 ± 0.0201
	Winter	109	0.3521 ± 0.0305

Table 4. Von Bertalanfy equations for growth in length and weight for *Sphyraena* species.

Species	Von Bertalanffy growth equations (Theoretical growth)	
	Growth equations in length	Growth equations in weight
S. chrysotaenia	$L_t = 27.14\ [\ 1 - e^{-0.390(t + 1.414)}\ ]$	$W_t = 116.78\ [\ 1 - e^{-0.391(t + 1.415)}\ ]^{3.33}$
S. flavicauda	$L_t = 44.58\ [\ 1 - e^{-0.296(t + 0.824)}\ ]$	$W_t = 443.73\ [\ 1 - e^{-0.294(t + 0.834)}\ ]^{3.27}$
S. sphyraena	$L_t = 55.27\ [\ 1 - e^{-0.123(t + 3.248)}\ ]$	$W_t = 604.33\ [\ 1 - e^{-0.123(t + 3.244)}\ ]^{2.92}$
S. viridensis	$L_t = 100.64\ [\ 1 - e^{-0.089(t + 0.825)}\ ]$	$W_t = 3428.92\ [\ 1 - e^{-0.088(t + 0.865)}\ ]^{2.93}$

the present study. This may be due to the interplay between a complex of genotype, body size, physiological conditions of the fish and environmental conditions (Wootton, 1990).

The coefficient of condition of *S. chrysotaenia* (K = 0.497) was higher than those of other *Sphyraena* species studied (K = 0.408, 0.352 & 0.332 for *S. flavicauda*, *S. sphyraena* & *S. viridensis* respectively). This means that *S. chrysotaenia* is in a better condition than the other *Sphyraena* species. Schmidt (1989) reported that for *S. barracuda* in Florida Bay, the mean K value was 0.497 ± 0.18. Also the present study estimates the value of 0.491 ± 0.039 for *S. chrysotaenia*. The K value increased with the length reaching its maximum value at a length of first maturity for *S. flavicauda* and *S. sphyraena* and just after the first maturation for *S. chrysotaenia* (Allam *et al.* in press) then decreased. The decreasing in K value with increasing length may be attributed to sexual maturation (Al-Ghais, 1993). Concerning the seasonal variation in K values for genus *Sphyraena*, it can be concluded that the lower values of K during spring and summer may be related to spawning activity (Allam *et al*. in press) while the rise in K values during autumn may

be due to higher feeding activity (Allam *et al.* 1999).

Sphyraena viridensis characterized by having a largest asymptotic length and weight (L_∞ = 100.6cm & W_∞ = 3428.92 g) in comparison with other *Sphyraena* species studied. Sanders and Morgan (1989) assigned a maximum asymptotic length of 148.4 cm for *S. jello* in the Gulf of Aden. The growth performance index (Φ) of *S. viridensis* (2.95) is the best in comparison with other *Sphyraena* species studied. The growth performance index of *S. jello* (Φ = 3.34) in Gulf of Aden (Sanders and Morgan, 1989) is better than *Sphyraena* species in the Egyptian Mediterranean waters.

Table 5. Calculated lengths (cm) at different years of life for different *Sphyraena* species in different regions.

Authors	Region	Species	Sex	L1	L2	L3	L4	L5	L6	L7	L8
De Sylva, 1963	Miami and Florida	*S. barracuda*	M	26.90	44.00	56.60	66.30	74.70	82.50	89.00	94.50
			F	27.10	42.90	55.80	66.70	75.30	83.30	90.00	94.70
Sanders and Morgan,1989	South Yemen, Gulf of Aden	*S. jello***	M+F	14.00	26.79	38.36	48.83	58.31	66.88	74.64	81.66
Wadie *et al.*, 1989	Mediterranean, off Alexandria	*S. sphyraena*	M+F	25.60	29.90	37.10					
		S. chrysotaenia	M+F	17.80	21.20	22.60	23.80	24.40			
Present study	Mediterranean, off Alexandria	*S. chrysotaenia*	M+F	16.54	19.94	22.33	23.84	24.91			
		S. flavicauda	M+F	18.68	25.33	30.14	33.89	36.80	38.65		
		S. sphyraena	M+F	21.66	26.01	29.39	31.81	34.26	36.67	38.57	41.17
		S. viridensis	M+F	14.69	22.42	28.38	34.88	40.54	44.97	49.67	54.46

Table 6. Estimated length–weight parameters for different *Sphyraena* species in different regions obtained by various authors

Authors	Region	Species	Sex	a	b
USING FORKED LENGTH					
Kulbicki *et al.* , 1993	**New Caledonia**	***S. barracuda***	**M+F**	**1.32 E-02**	**2.874**
	(Indo-pacific)	***S. flavicauda***	**M+F**	**1.95 E-03**	**3.192**
		S. forsteri	**M+F**	**1.11 E-02**	**2.914**
		S. jello	**M+F**	**2.50 E-03**	**3.245**
		S. novaehollandiae	**M+F**	**1.02 E-02**	**2.464**
		S. obtusata*	**M+F**	**1.25 E-02**	**2.472**
		S. putnamiae	**M+F**	**1.28 E-02**	**2.866**
		S. waittei	**M+F**	**1.61 E-02**	**2.808**
USING TOTAL LENGTH					
De Sylva, 1963	**Florida and Bimini**	***S. barracuda***	**M**	**1.56 E-06**	**2.84589**
			F	**2.67 E-06**	**2.92134**
Sander and Morgan,1989	**South Yemen, Gulf of Aden**	***S. jello***	**M+F**	**2.8 E-02**	**2.60**
Schmidt, 1989	**Florida Bay**	***S. barracuda***	**M+F**	**9.66 E-06**	**2.86633**
Taskavak & Bilecenoglu, 2001	**Mediterranean, Turkey**	***S. chrysotaenia***	**M+F**	**2.90 E-05**	**2.63200**
Wadie *et al.*, 1989	**Mediterranean, off Alexandria**	***S. sphyraena***	**M+F**	**6.45 E-03**	**2.8172**
		S. chrysotaenia	**M+F**	**2.02 E-03**	**3.3058**
Present study	**Mediterranean, off Alexandria**	***S. chrysotaenia***	**M+F**	**2.00 E-03**	**3.32561**
		S. flavicauda	**M+F**	**1.79 E-03**	**3.27033**
		S. sphyraena	**M+F**	**5.03 E-03**	**2.91576**
		S. viridensis	**M+F**	**4.49 E-03**	**2.93378**

* = S. chrysotaenia

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