AGE DETERMINATION AND GROWTH STUDIES OF BAGRUS BAYAD IN THE NOZHA-HYDRODROME.

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ABSTRACT

Age determination and growth studies of *Bagrus bayad* were made from the examination of vertebrae of 778 fish, taken from the Nozha-hydrodrome during commercial fishing in 1968—1970. Direct observation of the centre of vertebrae revealed the presence of clear annual rings, which were shown to be true year marks, when checked by the usual tests of validity. Body-vertebra relationship was characterised by two straight lines meating in an obvious inflection at a total body length of 440 mm., and appropriate corrections were made in all calculations.

Sizes attained at previous ages were calculated for separate sexes and the means of observed and calculated lengths for corresponding ages compared well. The mean length and weight of males at corresponding ages were less than that of females. For both sexes, growth in length was greatest during the first three years and abrupt decrease was observed in the fourth year. Growth in Weight, on the other hand, was small in the first year, and rapidly increases with age reaching maximum increment in the 6th year of life.

INTRODUCTION

The fact that many fish show rings on such skeletal structures as scales, otoliths, fin spines, opereularbones and vertetrae has been known for a long time (Le Cren, 1947; Lewis, 1949; Jones & Hynes, 1950; Appelget & Smith, 1951; Sneed, 1951; ....etc.). In many cases these rings have been shown to be annual in formation and thus provide a very useful method for assessing fish ages. However, in tropical and subtropical fishes the interpretation of age presents many difficults.

For this reason, it was necessary to study carefully the annual marks on the vertebrae of *Bagrus bayad*, and to check the results obtained by the usual tests of validity. So, the present work is an attempt to demonstrate the use of vertebrae for studying the age and growth of **B. bayad** in the Nozha-hydrodrome. A good knowledge of these biological aspects is very essential in the management of the existing fishery.

Material and Mothods

The vertebrae of **B. bayad** were collected from the commercial catch of the Nozha-Hydrodrome during two fishing periods (from October 1968 to April 1969, and from October 1969 to March 1970).

The total fish length is considered as the distance from the tip of the snout to the end of the caudal fin, without the caudal filaments. For each fish the total and standard lengths were measured, the sex was recorded, and the 3rd, 4th and 5th abdominal vertebrae were taken for age determination and growth studies.

The vertebrae were boiled in water for 20-25 minutes to remove the tissue which adhered to the centre, then cleaned with water and put to dry in air. Vertebrae were examined under reflected light with a binocular microscope at a magnification of (6.3 x).

Age Determination

In the present work the vertebrae of 778 fish, ranging in length from 12 to 84 cm, were used in age determination and growth studies of **B. bayad** in the Nozha-hydrodrome. The abdominal vertebrae were chosen as they are, by far, the largest and show the concentric stratification most clearly. The examination of vertebrae revealed the presence of two alternating zones. In reflected light, the broad white or opaque zone correspond to the rapid growth of the summer. This gradually fades into a narrow dark or translucent winter zone, which ends abruptly with a sharp line of discontinuity between it and he next summer zone. This sharp line marking the end of the winter band is always taken as the annual ring, that represents the end of the year's growth.

The true year marks are complete rings concentric with the rim of the vertebrae. This ring may vary in width from little more than a line to what could properly called a zone and is usually accompanied by a ridge on the surface of the centrum. However, some vertebrae have dark bands, which can not be interpreted as true year marks. These accessory marks are fainter than the true annual rings and do not have any depression on the surface like that which characterize the true rings. Moreover, the false marks do not run completely round the vertebrae or are much interrupted.

The examination of vertebrae, especially those of young fish, revealed some difficulties in the interpretation of age for the first two annual rings. In many of the vertebrae the first two winter rings were just a change over from one broad zone to another. The abrupt ending, characterizing the true winter rings, are not clearly seen. This may be due to the fact that young fish continue their feeding activity during winter, although at a relatively lower rate than in other seasons.

Moreover, the central area of the vertebrae of some young fish may be so expanded that it cover most of the area of the first annual growth. A similar observation was found by Lewis (1949), who distinguished expanded and non-expanded conditions in the centra of the Northern Black Bullhead (Ameuirus spp.). Bishai and Abu-Gideiri (1965) also found the same condition in the vertebrae of *Synodontis* spp.

Carefull examination of the vertebrae of **B. bayad** have shown that in all fishes the 3rd annual ring is darker, broader and more clearly observed than that of the 2nd year. This is most probably due to a change in the feeding habits and feeding activities of the fish of that age during winter months (Hashem, 1977)

In the adult fiah some of the annual marks look like duplicated rings (Fig. 1) This most probably indicates the presence of a spawning mark, which lies close to the annual mark forming together a double ring. Therefore, the spawning marks are conspicuous by their close proximity to the true annual rings.

It has to be mentioned that in some fishes, the otoliths and opercular bones were also tried for age determination, but they have proved to be unreliable. This agrees with the finding of many investigators (Elster, 1960; Bishai and Abu-Gideiri, 1965; Bishai, 1970; ....etc), who found that the growth were clearly visible on the vertebrae of many African freshwater fishes, whereas no clear rings were found on the otoliths or opercular bones of these fishes. So, it can be concluded that the growth rings are clearly visible on the vertebrae of **B. bayad** and that they are the most reliable parts of the skeleton for age determination.

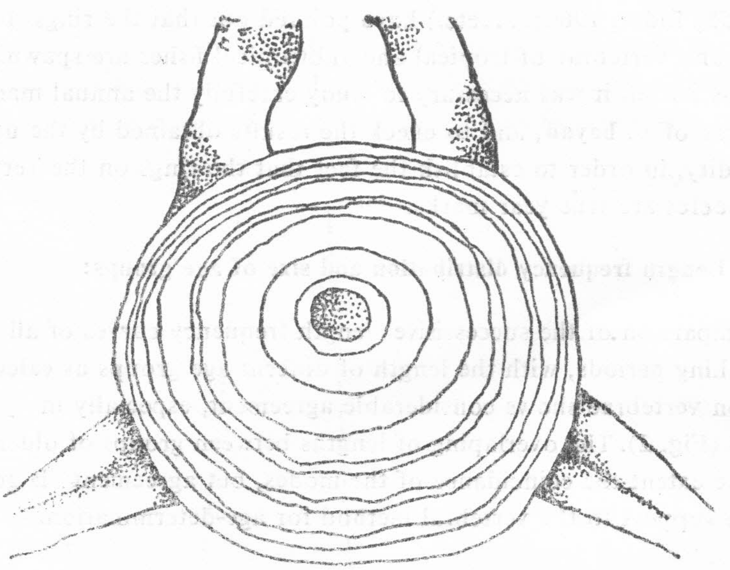

Fig.(1)- Diagram for a vertebra of **Bagrus bayad**, 70 cm.T.L. and 2710 gm. in weight, caught in 16/2/1969, showing the centrum and 6 annual rings, some of which are of the duplicated nature.

Validity of Vertebrae for Age Determination

Many investigatros (Graham, 1929; Lewis, 1949; Applegate and Smith, 1951; ......etc.) found that the marks on the vertebrae of many fish peiecs are true year marks. Other investigators (Holden, 1954/55; Garrod & Newell, 1958; Elder, 1960;....etc.) have pointed out that the rings formed on scales and vertebrae of tropical and subtropical fishes are spawning marks. For this reason it was necessary to study carefully the annual marks on the vertebrae of **B. bayad**, and to check the results obtained by the usual testes of validity, in order to establish the fact that the rings on the vertebrae of that species are true year marks.

(1) — **Length frequency distribution and size of age groups:**

Comparison of the successisive length frequency curves of all fish in the two fishing periods, with the length of differnt age groups as calculated from rings on vertebrae shows considerable agreement, especially in younger age groups (Fig. 2). The overlaping of lengths between groups of older ages mask to some extent the coincidance of the modes, but agreement is good enough to give suppoit to the vertebral method for age-determination.

(2) — **Calculated and empirical lengths of the age groups:**

Comparison of the calculated lengths at any annulus and the observed length for fish of that age at time of capture shows good agreement. for example the a erage empirical length of the O-age group by the end of the growing season was about 20cm. which agrees with the calculated length obtained for the first year growth.The same thing was observed for the lengths of other age groups.

(3) — **Growth histories of year classes:**

Comparison of growth rates of fish collected in different calender years shows close agreenent. The calculated lengths of separate age groups obtained from the first fishing period compare closely with those from the second fishing period. Also, the average empirical lengths of the corresponding age groups in the two fishing periods show close agreement Of course, some discrepancies are present, but this was most probably due to selectivity in sampling.

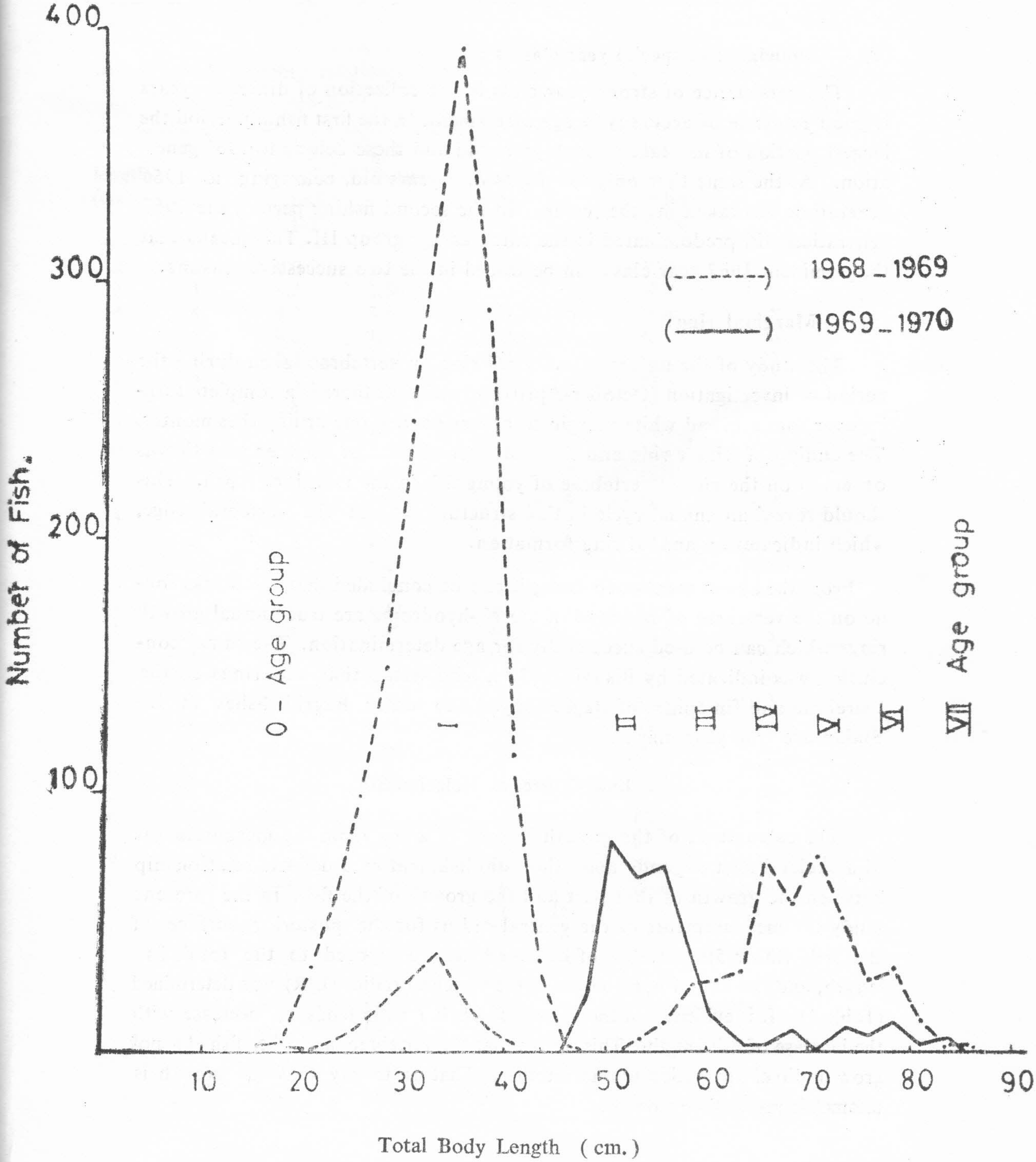

Fig 2 : Lengih frequency of commercal catch of Bagrus bayad from the N. hydrodrome in the two tishing periods.

(4) — **Abundance of special year classes :**

The persistance of strong year class in the collection of different years is good evidence of accuracy in age assessment. In the first fishing period,the largest portion of fish taken was 2 years old and these belong to 1967 generation. At the same time only few fishes of 3 years old, belonging to 1966 generation was taken in the catch. In the second fishing period, the 1967 generation still predominated in the catch as age group III. This means that the dominent 1967 year class can be traced in the two successive seasons.

(5) — **Marginal ring:**

The study of the nature of marginal ring on vertebrae taken during the period of investigation (October-April) showed that there is a complete turningover fom a broad white margin to a dark narrow one druing thes months. The ending of winter ring and the first start of the fast summer growth was observed on the rim of vertebrae of young fish in the month of April. This should reveal an annual cycle in the structure seen at the vertebral edge, which indicates an annual ring formation.

From the above mentioned facts, it can be concluded that the marks found on the vertebrae of **B. bayad** in the N.-hyodrome are true annual growth rings which can be used successfully for age determination. The same conclusion was indicated by Bishai (1970), who stated that the rings on the tverebrae and fin spines of **Bagrus bayad** and other Bagrid fishes in the Sudan are true year marks.

Body-Vertebra Relationship

The calculation of the growth history of a fish from the mesaurements of a skeletal part depends upon the establishment of a definite relationship between the growth of that part and the growth of the fish. In the present study the measurements of the ventral radius for the posterior surface of the 3rd, 4th or 5th vertebra of **B. bayad** was compared to the total fish length, and the rate of body length to the vertebral radius (L/R) was determined (Table 1). It is evident that the values of (L/R) ratio tends to decrease with the increase of fish length. This means that the vertebrae and the fish do not grow in direct proportion to one another. That is to say that the growth is allometric rather than isometric.

Table (1) Body-vertebra relationship of *B. bayad* from the Nozha-Hydrodrome during 1968-1970.

Total length (cm)	No. of Fish	Av. vertebral radius (6.3x)	L/R Ratio	Total length (cm)	No. of Fish	Av. vertebral radius (6.3x)	L/R Ratio
12	1	8.0	1.50	49	2	37.5	1.31
13	1	8.7	1.50	50	5	38.4	1.30
14	4	9.3	1.51	51	5	39.8	1.28
15	5	9.8	1.53	52	1	40.0	1.30
16	1	10.5	1.51	53	6	41.2	1.29
17	3	11.3	1.50	54	4	42.5	1.27
18	4	11.8	1.53	55	11	42.6	1.29
19	5	12.2	1.55	56	6	44.1	1.27
20	5	12.8	1.57	57	17	45.1	1.26
21	7	14.0	1.50	58	8	46.0	1.25
22	9	15.2	1.45	59	8	47.8	1.23
23	8	15.4	1.49	60	7	48.5	1.24
24	6	16.2	1.48	61	6	49.8	1.22
25	8	17.0	1.45	62	5	50.4	1.23
26	16	18.0	1.41	63	4	52.0	1.21
27	19	19.0	1.42	64	5	54.0	1.19
28	20	19.8	1.42	65	10	55.0	1.18
29	14	20.8	1.40	66	6	56.0	1.19
30	25	21.9	1.37	67	7	56.8	1.18
31	22	21.8	1.42	68	10	58.4	1.17
32	39	22.7	1.41	69	13	59.1	1.17
33	21	23.7	1.39	70	13	60.6	1.16
34	30	25.0	1.36	71	9	61.3	1.16
35	36	25.5	1.37	72	9	62.9	1.14
36	27	25.9	1.39	73	11	63.4	1.15
37	41	27.0	1.37	74	8	64.3	1.15
38	30	27.9	1.36	75	3	56.3	1.15
39	24	28.1	1.39	76	12	66.6	1.15
40	18	29.2	1.37	77	16	67.9	1.13
41	17	29.7	1.38	78	8	69.1	1.13
42	21	31.0	1.35	79	2	70.5	1.12
43	3	31.5	1.36	80	7	71.0	1.13
44	3	32.7	1.39	81	6	72.2	1.12
45	3	33.3	1.35	82	1	73.0	1.12
46	2	34.5	1.33	83	3	74.8	1.11
47	2	35.5	1.32	84	2	76.0	1.10
48	3	36.3	1.32	85	—	—	—

The proportional relationship between the vertebral radii and fish length throughout their growth can be obtained by plotting the measured fish lengthes against the corresponding vertebral radii and finding a suitable line to fit the points. When the data were grouped by 10-millimeter intervals of fish length, and a straight line was calculated ($Y = 77.40 + 1.043\ x$), an intercept of about 77 mm was obtained (Fig. 3-A).

Comparison of the calculated curve with the empirical data indicates that the curve does not fit the data satisfactorily except in few instances. At the lower end of the size range (betwecn 12 & 22 cm.T.L.) the empirical points fall below the regression line. At the same time, the empirical points for the size range from 36 to 52 cm.T.L. fall above the line. The points for largest individulas also lie below the regression line.

Moreover, ossification of bony structures in fishes have to take place at a very early age and such a big intercept of the regression line (means late ossification of vertebrae) looks unreasonable, and resulted in over estimation of the calculated lengths for young age groups. Therefore, the body-vertebra relationship is devided into two regression lines.

For fish larger than 35 cm., the means of vertebral measurements were plotted against the total fish lengths and a regression line was calculated by the method of least squares; $Y = 13.653 + 0.9365\ X$

The straight line described the data very well.

Similar computations for fish smaller than 36 cm yielded a regression line of:

$$Y = 2.125 + 1.3076\ X$$

The two regression lines meat at an obvious inflection point corresponding to total body length of about 440 mm. (Fig. 3-B).

The presence of such a small intercept (21 mm.) in young fishes looks resonable. It is felt that late ossification of the vertebrae may cause this phenomenon since some workers have found that complete ossification of all vertebrae may not be obtained simultaneously. Yasuda (1940) showed that annular rings on the centrum were formed about 1.5 months later than on the otolith in **Scombrops** sp.. This phenomenon was also observed by Appelget & Smith (1951) in the channel catfish (**Ictalurus** sp.). So, it can be concluded that **B. bayad** may attain about 20 mm in length before the ossification of the vertebrae has to take place.

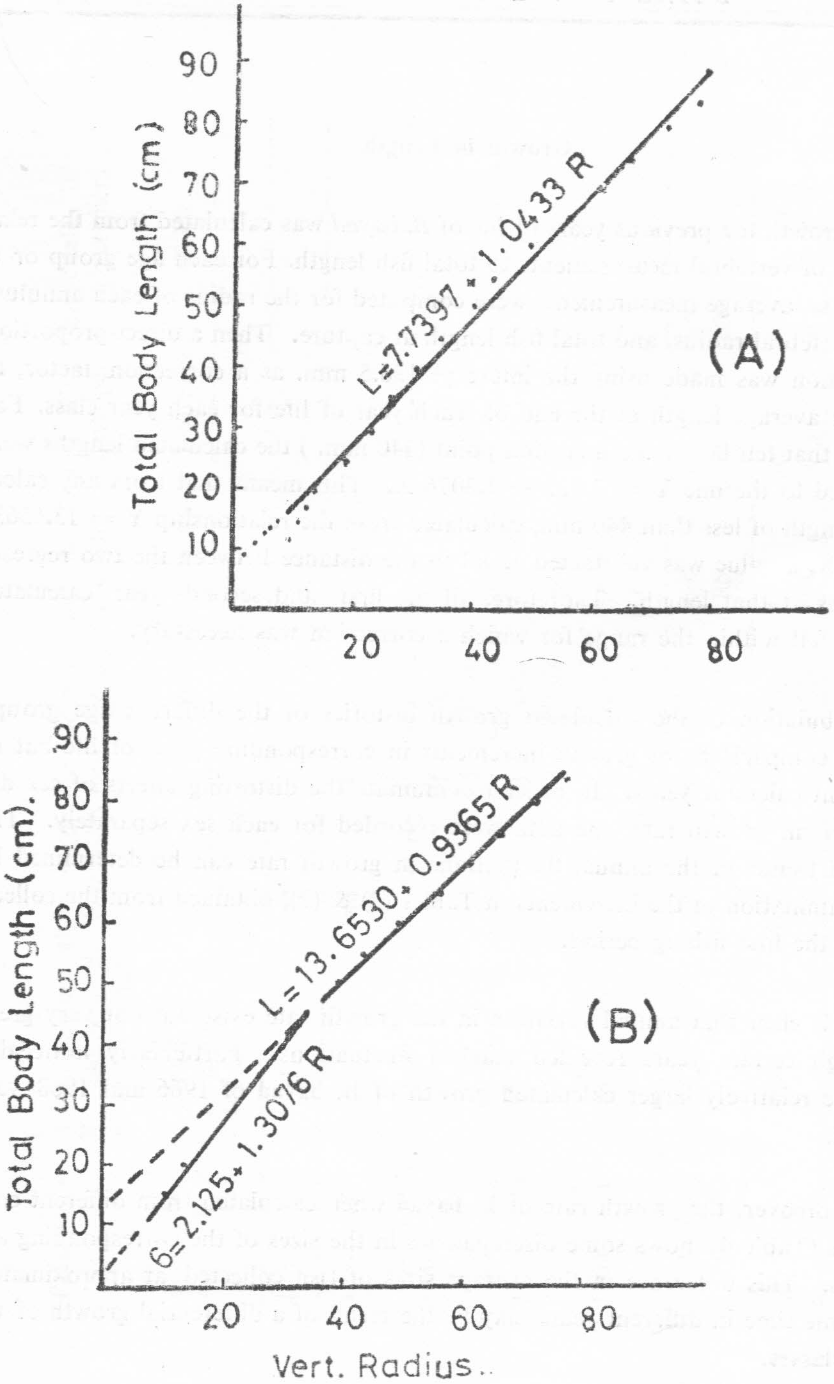

Fig: 3: Body–Vertebra Relationship of <u>Bagrus bayad</u> from the N. hydrodrome during 1970

Growth in Length

The growth for previous years of life of *B. bayad* was calculated from the relationship of vertebral measurements to total fish length. For each age group or a year class, average measurements were computed for the radius of each annulus, total vertebral radius, and total fish length at capture. Then a direct-proportion calculation was made using the intercept 136.5 mm. as a correction factor, to find the average length at the end of each year of life for each year class. For lengths that fell below the inflection point (440 mm.) the calculated lengths were corrected to the line $Y = 2.125 + 1.3076 X$. This means that from any calculated length of less than 440 mm, calculated from the relationship $Y = 13.6563$ $0.9365 X$, a value was subrtacted equal to the distance between the two regression lines at that length. Thorefore, all the first and second year calculated lengths fell within the range for which a correction was necessary.

Tabulation of the calculated growth histories of the different age groups permit comparisons of growth increments in corresponding years of life but in different calendor years. In order to eliminate the distorting effects of sex differences in growth rate, the data were recorded for each sex separately. The general trends in the annual fluctuations in growth rate can be determined by the examination of the increments in Tables (2) & (3), obtained from the collection of the first fishing period.

It is clear that annual variation in the growth rate exist but not very great although certain years revealed marked fluctuations. Particularly noticeable was the relatively larger calculated growth of **B. bayad** of 1966 and 1968 year classes.

Moreover, the growth rate of **B. bayad** when calculated from different collections (Table 4) shows some discrepancies in the sizes of the corresponding age groups. This difference in the average sizes of fish collected at approximately the same time in different years may be the result of a differential growth of the year classes.

Table (2) — Calculated growth in length (mm.) at the end of each year of life for the **Males** of **B. bayad** in the Nozha-Hydrodrome during the first fishing period. (Increment between brackets).

Year-class	No. of Fish	Length at capture (mm.)	Calculate length at the end of each year of life						
			1	2	3	4	5	6	7
1968	35	192	192						
1967	179	345	186	354 (168)					
1966	3	520	190	360 (170)	520 (160)				
1965	22	596	186	354 (168)	510 (156)	596 (86)			
1964	31	660	174	348 (174)	506 (158)	597 (86)	660 (68)		
1963	30	715	178	344 (166)	500 (156)	585 (85)	655 (70)	715 (60)	
1962	5	750	167	340 (163)	492 (152)	575 (83)	642 (67)	3043 (61)	750 (47)
Grand average calculated length			184	252	505	590	656	713	750
Grand Average increment of length			(184)	(168)	(156)	(86)	(69)	(60)	(47)
Sum of Average increments			184	352	508	594	663	723	770

Table (5) — Annual increment of growth in length (mm. & %) for the different sexes of **B. bayad** in the Nozha-Hydrodrome duing the first fishing period.

Age Groups	Males			Females		
	Calcul. length (mm.)	Annual increment (mm.)	Annual increment %	Calcul. length (mm.)	Annual increment (mm.)	Annual increment %
I	184	184	23.9	189	189	23.2
II	352	168	21.8	360	171	21.0
III	508	156	20.2	523	163	20.0
IV	594	86	11.2	621	98	12.0
V	663	69	9.0	698	77	9.4
VI	723	60	7.8	764	66	8.1
VII	770	47	6.1	815	51	6.3
VIII	—	—	—	850	35	—

Comparing the present results with those obtained in other localities, taki g into consideration the relation between total and standard lengths, (Y = (Y = 0.112 + 1.1877 x), it seems that the growth rate of **B. bayad** in the N.-hydrodrome is lower than that in the Niger or White Nile. Reynolds (1967) pointed out that **B. bayad** in the Niger attains a standard length of 120-200 mm. by the end of the first year. Bishai (1970) stated that **B. bayad** in the Sudan attains, by the end of the first year, an average standard length of 222 mm.

Growth in Weight

The weight corresponding to each calculated length can be computed from the general length-weight equation, $\log W = 5.8100 + 3.2477 \log L$ (Hashem, 1977 b) . Table (6) represents the annual increment of growth in weight (in gm. and %) for the males and females of **B. bayad** in the N.-hydrodrome during the first fishing period.

It is clear that the growth increment in weight of females is higher than that of males. Also, it is evident that for both sexes the growth increment in weight at the end of the first year is very small, then it sharply increases during the second and third years. The increase in the annual increments of weight for the males was interrupted by a small decline in the 4th year. This may be explained by the attainment of sexual maturation during that year. Beyond the 4th year the annual increments in weight for both sexes increased continuously reaching maximum value in the 6th year, after which it starts to decrease with further increase of age.

Table (6) — Annual increment of growth in weight (gm. & %) of males and females **B. bayad** in the N.- hydrodrome during the first fishing period, using the general length-weigh equation (log W = 5.8100 + 3.7477 log L).

Age group	Males			Females		
	Cal. wt. (gm)	Increment of wt. gm	%	Cal. wt. (gm)	Inorement of wt. gm	%
I	35	35	1.0	38	38	0.9
II	288	253	6.9	310	272	6.2
III	950	662	18.0	1044	734	16.6
IV	1579	629	17.1	1824	780	17.7
V	2256	677	18.5	2667	780	17.7
VI	2990	734	20.0	3576	843	19.1
VII	3668	678	18.5	4410	909	20.6
VII	3668	678	18.5	4410	843	19.8
VIII	—	—	—	5057	647	—

So, it can be concluded that on the basis of growth in weight, it would be economically important to protect the fish from capture until at least their fourth year of life. By that time, the fish will reach a total length of about 50 cm. and a total body weight of about one kilogram which is a good marketable size for **B. bayad.**

Summary

The vertebral examination of **B. bayad** from the Nozha-Hydrodrome during 1968/1970, revealed the presence of two types of ulternating zones. In reflected light, the broad white zone correspond to the rapid growth of summer and the narrow dark zone corresponding to the slow winter growth. The winter zone ends abruptly, with a sharp line of discontinuity (annual mark) betweon it and the next summer growth.

The true annual marks are complete rings concentirc with the rim of the vertebra and is usually accompanied by a ridge on the surface of the centrum. Accessory marks on the other hand are fainter, without depression and do not run completely round the vertebrae.

In young fishes the first two winter rings are just a change over from one broad zone to another. The abrupt ending, characterizing the true winter rings are not clearly seen. This is most probably due to the fact that young fish continue their feeding activity during winter, although at a relatively lower rate than in other months. Moreover, the central area of the vertebrae in some young fishes may be so expanded that it covers most of the area of the first annual growth.

In **B. bayad** the 3rd annual ring is darker, broader and more clearly marked than the previous rings. This is most probably due to a change in the feeding habits and feeding activities of that age during winter.

In the adult fish, some of the annual marks have a duplicated appearance, i.e: two rings lying close together. This most probably indicates the presence of spawning marks, which lie in close proximity to the true annual marks, giving together the appearance of a double ring.

The rings on the vertebrae of **B. bayad** were shown to be true year marks, when checked by the usual testes of validity, and therefore they can be used successfully for age assessment.

Calculating the proprtional relationship between the vertebral radii and total fish length, a single regression line, having the intercept of 77 mm. does not fit the whole data satisfactorily. The empirical points for young and old fish fall below the regression line, while those of moderate ages fall above it. Moreover, it is believed that ossification of bony structures in fish have to take

place at a very early age. So, such a relatively large intercept is unreasonable, and resulted in an overestimation of the calculated lengths for young age groups.

Therefore, the body-vertebra relationship was divided into two regression lines, ($Y = 21.25 + 1.307\ x$, and $Y = 136.53 + 0.936\ x$), meating in an obvious inflection at a total body length of 440 mm. It is felt that a small intercept, as 21 mm. is a reasonable correction factor for young age groups.

The growth for previous years of life was computed by using the intercept 136 mm. as a correction factor, and for lengths that fall below the influction point (440 mm.) a value was substracted equal to the distance between the two regression-lines at that length. Therefore all the calculated lengths for the Ist and 2nd years were corrected to the line ($Y = 21.25 + 1.307\ x$).

Studying the growth histories of fish collected in different years revealed the presence of annual fluctuation in he growth rate, which may be the result of a differential growth of the year classes. Also, sexual variation in the growth rate of **B. bayad** is usually observed. The mean sizes of males are less than that of females at the corresponding ages.

The general growth rate of **B. bayad,** shows that the greatest growth in length happens during the first three years of life. In the 4th year, a marked drop in the growth rate is usually observed, due to the attainment of first maturity. After that the growth increments show slightly and regular decrease with further increase of age.

On the other hand, the growth in weight is small in the first year and rapidly increases with the increase of age, reaching high value by the end of the third year. Thenafter, the growth in weight slowly inereases reaching maximum increment in the 6th year, after which it begins to decrease with further increase of age.

It has to be concluded that on the basis of growth in weight, it would be economically important to protect the **B. bayad** from capture until at least their 4th year, after they have reached about 50 cm.T.L. and about one kilogram in weight.

Comparison of the growth rate of **B. bayad** in Egypt, with that in other African countries, shows that the growth rate of that species in the N.-hydrodrome is lower than that in the white Nile or in the Niger. This agrees with the general fact of decreasing growth rates of animals, living in higher latitudes of their geographical distribution.

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