Bull. Inst. Oceanogr. & Fish. ARE, 12, 1986: 199 - 213.

THE VALIDITY OF MINUTE SCALES OF *Solea vulgaris* CHAB. FOR AGE DETERMINATION.

Kh. A. HUSSEIN.
Institute of Oceanography and Fisheries, Alexandria, Egypt.

ABSTRCT

Growth of **Solea vulgaris** was reflected on its minute scales in the form of successive addition of sclerites. Three age groups could be distinguished for the obtained samples. Each age group was characterized by an optimal number of sclerites which could be used as indication for the age of **S. vulgaris.**

The relationship between fish length and scale radius showed that the scales did not appear simultanuously on the whole body. The largest scales covering the mid body region appear at first followed by the moderate size scales in the most anterior body region. The smallest scales are formed at the last stage of scale appearance on the posterior region.

INTRODUCTION

Solea vulgaris is commercially one of the valuable fishes. Previous investigations concerned mainly with the biology and production of such fish in the Egyptian waters (El-Zarka, 1963 and El-Zarka and Koura, 1965). El-Gharbawy (1977) determined the age of Mediterranean Sea **S. vulgaris** by using the otoliths.

Several techniques were introduced for the intepretation of annual rings deposited on the otoliths of soles (John Lawson, 1948; Christansen, 1964; Gergory and Jow, 1976).

Scales of **S. vulgaris** were not used before, neither for age determination nor for the comparison with other bony structures. The main goal of this investigation was to find a reliable method for determining the age of **S. vulgaris** in temperate climate zone where the deposited annual rings on otolith are not clear.

MATERIAL AND METHODS

The material (178 samples) was obtained from the market during February, March and April, 1986. Total fish length was measured in millimeters, scales from the anterior, mid and posterior body regions (dorsal side) were gently

removed by forceps. Scales were arranged on slides, mounted in Canada Balsam, covered with a glass cover and examined under a binocular microscope. Length (from nucleus to anterior margin) and width (across the nucleus) were measured by means of an eye-piece-micrometer (100 divisions). Sclerites on both sides of the nucleus were precisely counted at a magnification of X 100 and the average number was deduced. Otoliths removed from the skull were treated according to the technique developed by Schneppenhein and Freytag (1980).

RESULTS

The scales of the collected samples of S. vulgaris were minute, ctenoid and fringed with well developed spines like ctenii projecting backwards from the posterior sector of the scale (Fig.1). Scales were elongate with clear continous sclerites going parallel on both lateral sides of the nucleus, whereas the anterior sclerites were discontinuous (Fig.2). The radius (from nucleus to margin) significantly differed throughout the body. Scales taken form the most posterior region (caudal region) were the smallest, the radius varied from 0.86 to 1.87 mm for corresponding total fish length 140 to 250 mm, respectively. Scales taken from the mid region were the largest, radius varied from 1.30 to 2.30 mm for corresponding total fish length of 140 to 250 mm, respectively. Scales taken from the most anterior body region (Just after the head) measured a comparatively less radius value than those taken from the mid region, but still larger than the scales covering the posterior region. The radius of anterior scales measured from 1.27 to 2.07 mm corresponding to 140-250 mm total fish length respectively (Table 1).

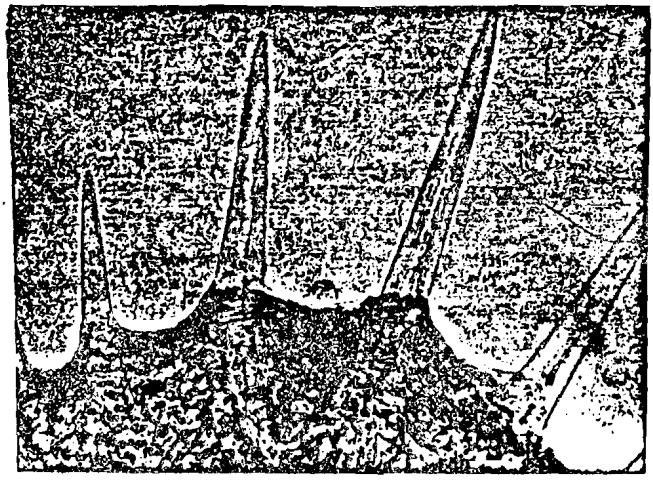

Fig. (1)
The well-developed spines projecting backwards on the minute scales of S. vulgaris.

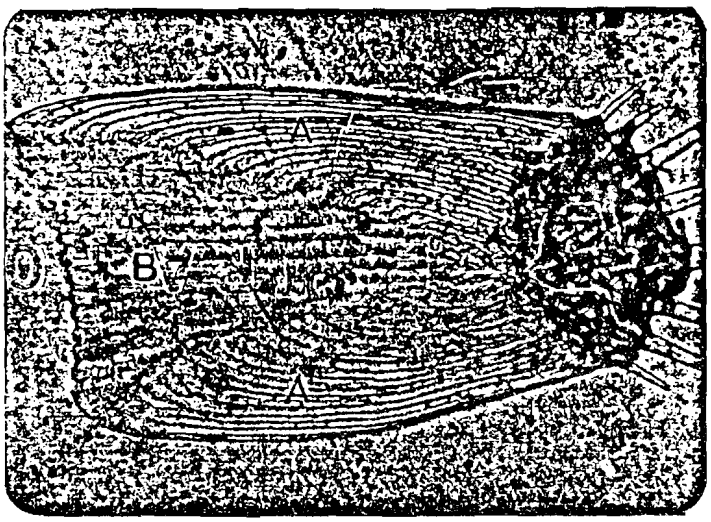

Fig. (2)
The continuous sclerites on the lateral sector (A), and discontinuous on the anterior sector (B).

The microscopic examination of the collected scale samples of S. vulgaris revealed that the average number of spines (ctenii) had increased with increasing the fish length (Table 1). Scales being appeared in the mid body region possessed about similar average numbers of spines. Those covering the posterior body region showed less numbers. The number of such spines was to some extent correlated with the scale size. Small scales showed few spines (Fif. 3). When the scale measurements were considerably large the number of spines consequently increased (Fig. 4). Some few samples of scales possessed larger numbers of spines than the bigger ones. On the other hand a wide range of the number of spines even in the same region of scale collection was noted.

A linear relationship seemed to be existed between fish length and scale radius. The listed data (Table 1) were graphically represented in Fig. 5. Using the least squares method, three straight lines corresponding to the three measurements taken for the three different body regions were obtained. The tail region (posterior) showed the smallest values of scale measurements and represented by the line fitted by the formula:

$$L = 70.8701 + 95.73\ S.$$

The second line was fitted by the formula:

$$L = 10.4208 + 112.32\ S,$$

TABLE 1

The fish length, fish number, scale radius, scale width, number of sclerites and spines in the three body regions of S. vulgaris.

Total fish length mm.	No. of fish	Anterior region				Mid region				Posterior region			
		Av. rad.	Av. width	Av. scl.	Av. spine	Av. rad.	Av. width	Av. scl.	Av. spine	Av. rad.	Av. width	Av. scl.	Av. spine
140	12	1.27	0.90	25	10	1.30	1.00	27	9	0.86	0.50	19	7
150	15	1.31	1.10	29	11	1.37	1.10	29	9	0.90	0.60	20	7
160	12	1.34	1.10	30	11	1.44	1.16	31	9	0.96	0.70	21	8
170	15	1.36	1.14	31	11	1.52	1.17	33	11	1.03	0.74	24	9
180	20	1.53	1.16	32	11	1.66	1.18	35	12	1.11	0.80	26	10
190	22	1.56	1.20	34	12	1.70	1.24	36	12	1.17	0.88	27	10
200	23	1.64	1.31	35	13	1.74	1.34	37	14	1.19	0.91	29	11
210	19	1.80	1.34	37	14	1.90	1.40	39	16	1.32	0.93	32	11
220	14	1.87	1.37	38	14	1.96	1.43	40	14	1.60	1.16	33	12
230	10	1.96	1.48	39	15	2.01	1.54	41	14	1.74	1.20	35	14
240	9	2.01	1.57	41	15	2.15	1.60	43	15	1.81	1.27	36	14
250	7	2.07	1.63	43	16	2.30	1.67	45	16	1.87	1.33	37	14

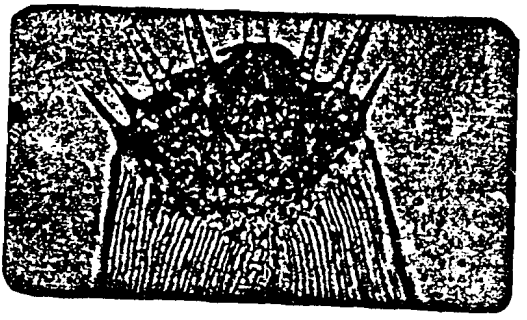

Fig. (3)
A scale of S. **vulgaris** (160 mm total length), with 8 spines.

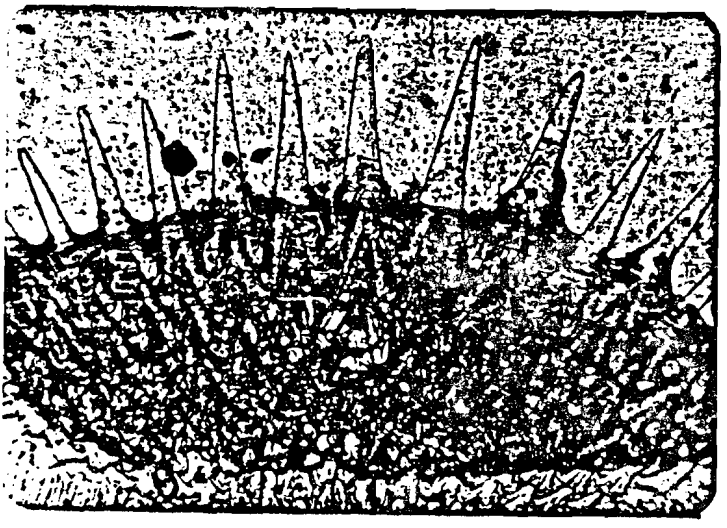

Fig. (4)
A scale of S. **vulgaris** (250 mm total length), with 16 spines

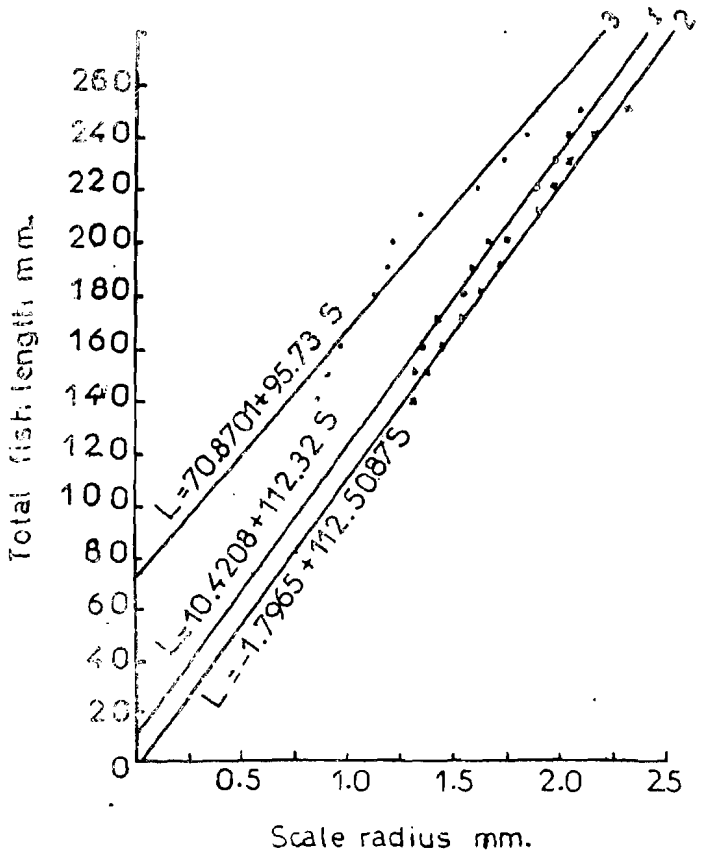

Fig. (5)
The relationship between scale radius (S), and total fish length (L) in the anterior (1), mid (2) and posterior (3) body regions.

representing themeasurements taken for the scales laid on the most anterior region. Measurements of the largest scales removed from the mid region were fitted by the formula:

$$L = -1.7965 + 112.5087\ S.$$

The three fitted lines revealed three different values of the intercept on the Y - axis. Such values practically determine the size at which the scales were laid down in their sockets or appeared as buds in the skin. The most high value was 70.87 mm, deduced from the measurements of the scales laid down on the posterior body region. The next value was 10.42 mm and obtained from the line expressing the measurements of the scales taken from the most anterior body region. Scales removed from the mid region showed an intercept on the Y-axis with a negative sign of 1.79 mm.

Data represening the length and width of the scales taken from three different body regions (Table 1) were graphically represented in Fig. 6. Both measurements increased with the fish length. Scale measurements increased with the same proportion up to about 200 mm total fish length. Further increase of fish size showed signifcant difference between scale length and scale width. Therefore the increase in the scale dimensions is not proportionally regular throughout the life of fish.

It was obvious that the increase in fish length was reflected on the scales which showed increased number of sclerites. Annual rings were completely undetectable. The increase in the average number of sclerites deposited on the scales with increasing fish length (Table 1) was represented in Fig. 7. It was clear that the scales taken from the posterior region showed the least number of sclerites. A fish measuring 140 mm in total length deposited an average number of 19 sclerites. This number gradually increased with increase of fish length. It reaches an average of 37 sclerites for a fish of 250 mm total length. The anterior region showed larger scales containing larger average number of sclerites. On reaching a total fish length of 140 mm, the most anterior scales deposited on average 25 sclerites. Sclerites increased to 43 at a total length of 250 mm.

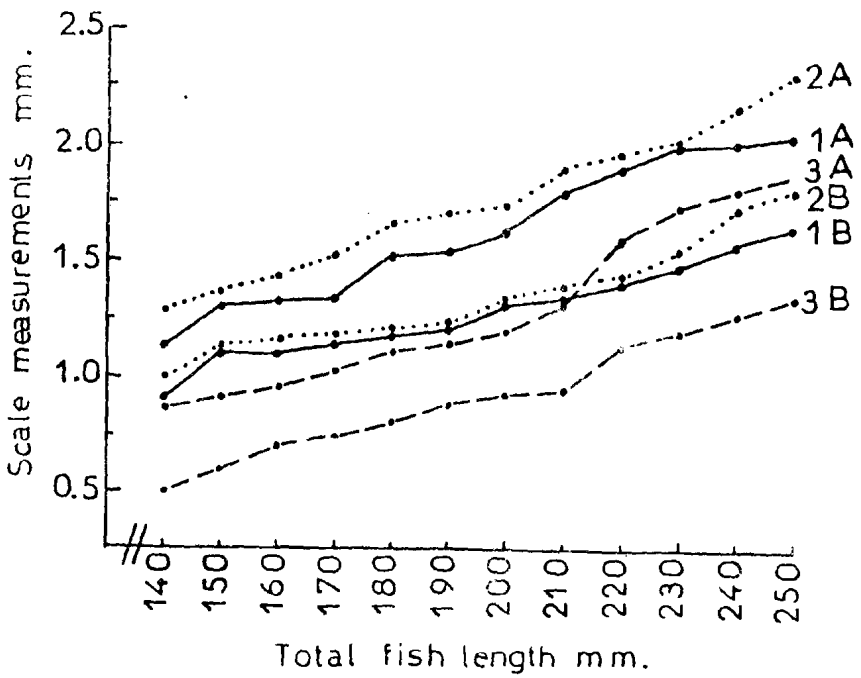

Fig. (6)
The increase of scale radius (A), and scale width (B) with increasing the fish length in the anterior (1), mid (2) and posterior (3) body regions.

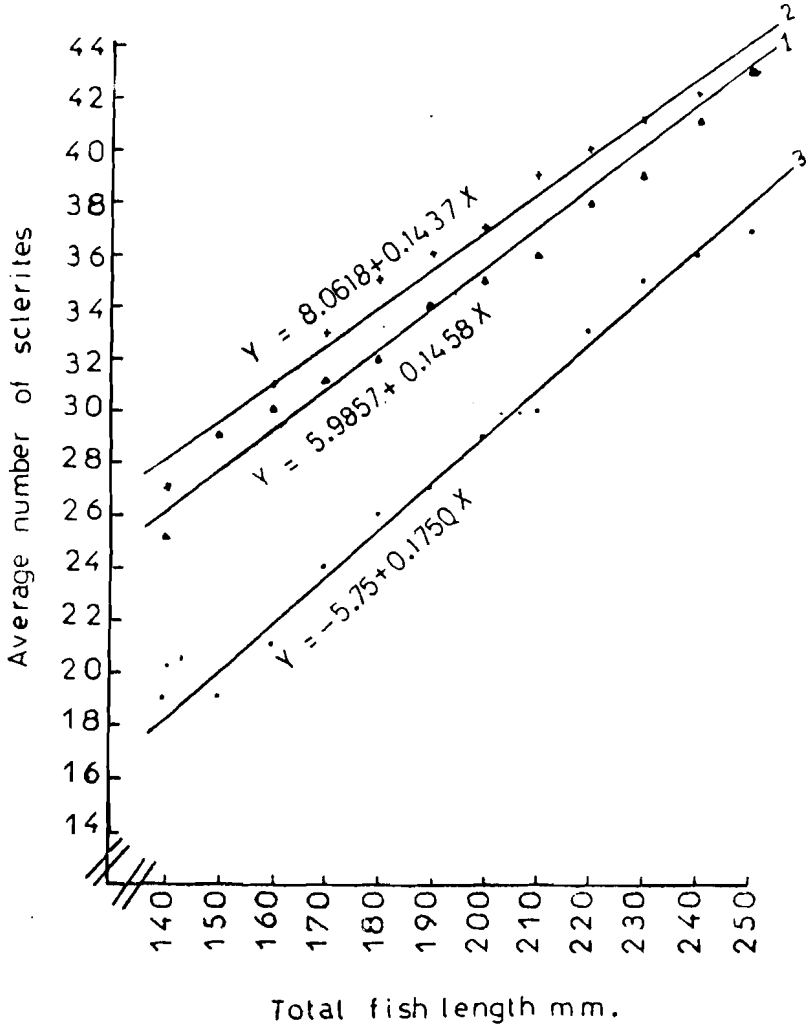

Fig. (7)
The relationship between the average number of sclerites and total fish length in the anterior (1), mid (2) and posterior (3) body regions.

A comparatively large average number of sclerites was observed on the scales taken from the mid region of the fish body. A minimum average number (27 sclerites) was counted when the fish measured 140 mm and gradually incraesed to a maximum of 45 sclerites for 250 mm total length.

The average numbers of sclerites formed in 1 mm of the scale width in the three different regions of the fish body are shown in Table 2. The mean number of sclerites formed in 1 mm in the anterior region was 54.2 $\pm$ 0.197, in the mid region, the mean number is 55 $\pm$ 0.335 sclerites. On the other hand, the average number of sclerites in 1 mm of the scale width in the posterior body region was 62.9 $\pm$ 0.8. This means that the sclerites of the posterior region were thinner than those formed in the anterior or mid regions which were nearly of the same thickness. In addition, the distances between sclerites were the same for all the body regions throughout the life of fish. Sclerites were also homogeneously distributed on both sides of the necleus, whereas the anterior part of the scale was occuppied by longitudinal radii, in-between, the sclerites were discontinuous.

The use of scales, as a preliminary step for the age determenation of **S. vulgaris** by using the specific number of scale's sclerites, otoliths were thoroughly examined. The samples were found to be formed of three age groups: Age group I, included fishes of 140, 150, 160 and 170 mm total length. The second age group (age group II), included fishes of 170, 180, 190, 200, 210 and 220 mm total length. Age group III, included fishes of 220, 230, 240 and 250 mm total length (Table 3).

The average calculated length of fishes which completed one year of their life (age group I) was 155 mm. They have an average number of 28.8 sclerites on the anterior scales, 30.0 on the mid scales and 20.8 sclerites on the posterior ones. The minimum number of sclerites differed from 25 in the anterior, to 27 in the mid, and 19 in the posterior body region of fishes of about 140 mm total length. Maximum number of sclerites for fishes of 170 mm total length were 31, 33 and 24 sclerites on the scales of anterior, mid and posterior body regions respectively.

Age group II covered a wid range of fish lengths extending from 170 to 230 mm with an average length of 200 mm. The number of sclerites on scales taken from the different body regions were 35, 37 and 29 sclerites respectively.

Minimum number of sclerites was counted from the scles of fishes of about 170 mm total length. They varied from 31 sclerites on the anterior scales, 34 on the mid to 25 ones on the posterior. Maximum number of sclerites was counted on the scales of fishes of 230 mm total length. Their number varied from 39 to 42 to 35 sclerites on the three different regions respectively.

Three years old fishes covered four length groups viz. 220, 230, 240 and 250 mm. The average calculated length of age group III was 235 mm.

TABLE 3

Distribution of age groups against fish length, number of fish and number of sclerites in the three body regions of S. vulgaris.

Total fish length in mm	Age group I					Age group II					Age group III				
	No. of fish	%	No. of scl.			No. of fish	%	No. of scl.			No. of fish	%	No. of scl.		
			Ant.	Mid.	Post.			Ant.	Mid.	Post.			Ant.	Mid.	Post.
140	12	25.5	25	27	19										
150	15	31.9	29	29	20										
160	12	25.5	30	31	21										
170	8	17.0	31	33	24	7	6.4	31	34	25					
180						20	18.3	32	35	26					
190						22	20.2	34	36	27					
200						23	21.1	35	37	29					
210						19	17.4	37	39	32					
220						12	11.0	38	40	33	2	9.1	38	40	34
230						6	5.5	39	41	35	4	18.2	39	42	35
240											9	40.9	41	43	36
250											7	31.8	43	45	37
	Av. scl.		28.8	30.0	20.8	Av. scl.		35.0	37.6	29.6	Av. scl.		40.3	42.5	35.5
	Average length = 155 mm					Average length = 200 mm					Average length = 235 mm.				

TABLE 2
The fish length, fish number, average scale width, average number of sclerites and the average per mm in the three body regions of S. vulgaris.

Total fish length mm	No. of fish	Anterior region			Mid region			Posterior region		
		Av. width	No. of scl.	Av. per mm	Av. width	No. of scl.	Av. per mm	Av. width	no. of scl.	Av. per mm
140	12	0.90	25	55.6	1.00	27	54.0	0.50	19	76.0
150	15	1.10	29	52.3	1.14	29	50.9	0.60	20	66.7
160	12	1.10	30	54.5	1.16	31	53.4	0.70	21	60.0
170	15	1.14	31	54.4	1.17	33	56.4	0.74	24	64.9
180	20	1.16	32	55.2	1.18	35	59.3	0.80	26	65.0
190	22	1.20	34	56.7	1.24	36	58.0	0.88	27	61.4
200	23	1.31	35	53.4	1.34	37	55.2	0.91	29	63.7
210	19	1.34	37	55.2	1.40	39	55.7	0.93	32	68.8
220	14	1.37	38	55.5	1.43	40	55.9	1.16	33	56.9
230	10	1.48	39	52.7	1.54	41	53.2	1.20	35	58.6
240	9	1.57	41	52.2	1.60	43	53.8	1.27	36	56.7
250	7	1.63	43	52.8	1.67	45	55.9	1.33	37	55.6
The Grand Average sclerites per mm		54.2 ± 197			55.0 ± 0.335			62.9 ± 0.800		

The average number of sclerites deposited on the scales varied from 40.3 to 42.5 to 35.5 according to location of scale (i.e. anter., mid. and pesterior regions). An overlap was obvious in the two lengths 220 and 230 mm, both might belong to age group II or age group III.

Often the largest scales had more sclerites than the smaller ones. Few numbers of small scales had more sclerites than the largest ones.

Separation of the samples into three distinguished age groups (I, II, and III) showed that the number of fishes belonging to each age group had the trend to be normally distributed. The frequency distribution of fish lengths and average number of sclerites are shown in table 3 and graphically represented in Figure 8. Peaks of hand fitted bell-shaped curves of the three different body regions could give the optimal number of sclerites representing each age group.

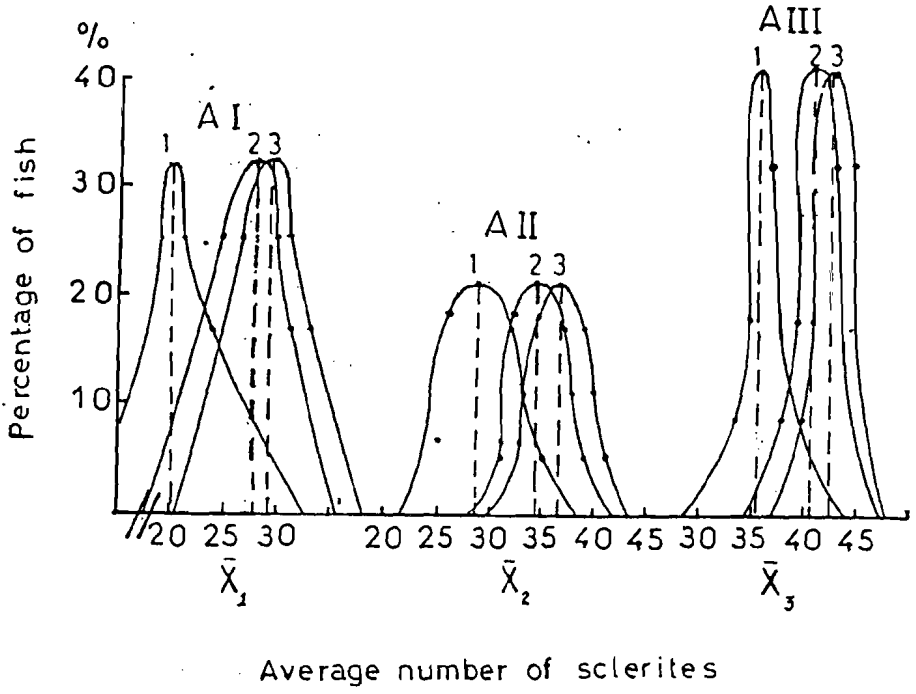

Fig. (8)
The normal distribution of the three age groups (AI, AII, AIII) of S. vulgaris and the corresponding optimal number of sclerites in the three body regions; 1 - posterior, 2 - anterior and 3 - mid.

DISCUSSION

In comparison with the otolith method, the sclerite method is more feasible and requires less expenditure of time and equipments.

The scale size of S. vulgaris differs from region to region on the same body, the mid region has the largest scales. Some authors were aware of the variability of scale size in different body regions, and some concluded that only scales from distinct body region could give comparable and reliable results in regard to age determination (Segerstrale 1933, Geyer 1939, and Einsele 1943). The openion of both Chugunov (1925) and Monastuirsky (1926) was that a through examination of the scales is demanded before applying any method. The importance of such procedure is substantial when looking at the present investigation. S. vulgaris presents a significant variability in the scale size and number of sclerites throughout the fish body. Largest scales are generally found on the mid body region. The smallest sclaes are mainly found on the most posterior region. The size variation becomes smaller between the scales taken from the mid region and those from the most anterior. The size of scales is primarily determined by its specific location on the fish body which should be identified for the purpose of age determination.

The determined values of the intercept of the lines expressing the relationship between the total fish length and scale radius on the three different body regions reveal that the scales of S. vulgaris do not appear simultaneously on the whole body. Fishelson (1966) explains the differences regarding the onset of scale formation by different ecological necessities of the species.

The largest scales apparently appear first on the mid region and show an intercept value of -1.79 on the Y-axis ($L = -1.7965 + 112.5087\ S$). The negative sign in the formula may due to the discrepancies in scale measurements. The smallest scales virtually appear on the posterior region after a considerable growth of the young, their onset is obviously delayed; ($L = 70.8701 + 95.73\ S$). Scales of comparatively moderate size appear on the anterior body region after about 10 mm total length as expressed by the fomula; ($L = 10.4208 + 112.32\ S$).

Generally the scales of bony fishes do not appear at once, their size and shape oftenly vary from part to part on the fish body (Werder and Soares 1985).

As the fish grow, the scale dimensions increase, such increase is not rigid throughout the fish life. The scale radius considerably increases more than the width. This difference may compensate the growth in fish length which is larger than the growth in fish width as an adaptation of the scale's feature to the change in fish dimensions.

Although the onset of the scale formation is not similar in different parts, the formed sclerites are nearly similar in number through the length intervals from 140 to 250 mm, the fish added about 18 sclerites on the scales taken from different regions. Graham (1929) shows that the rhythm of sclerite formation is obviously not influenced by the size of the scales nor by the length of the fish.

Assuming a constant rhythm of sclerite formation in all parts of the fish body, hence the lastest formed scales can never deposit numbers of sclerites equal to those deposited on the early formed ones. It could be concluded that the best scales for age determination of **S. vulgaris** are those with the highest numbers of sclerites as they are good representatives for fish growth and consequently for the fish age.

The optimal number of sclerite for each age group could serve a good base for age determination of **S. vulgaris.** If we take into consideration the suitability of large scales for age determination, the mid body region is accordingly suitable for the scale collection. The mean number of sclerites formed on the largest scales of age group I is abont 30 sclerites with an amplitude $\pm$ 3. Age group II was represented by a mean number of 37 sclerites with an amplitude $\pm$ 3 sclerites. Age group III could be detected at a mean number of 42 sclerites with an amplitude $\pm$ 3.

REFERENCES

Christansen, J.M., 1964. Burning of otolith. J. Cons. 29 (1): 73-81.

Chugunov, N.I., 1965. On the method of determination of age of sturgeons. Bull. Fish. 11 (cited in : Graham, 1929, p. 30).

Einsele, W., 1943.III. Uber das wachstum der Coregonen im voralpengebiet, insbesondere uber das verhaltnis von schuppen-und langenwachstum. Zeitschrift fur Fisherei 41 (1): 23-45.

El-Gharabawy, M.M., 1977. Biological studies on soles in the region of Abu-Kir Bay. M.Sc. Thesis, Fac. Scie., Alex. Univ. Egypt: 79-86.

El-Zarka, S., 1963. Acclimatization of Solea vulgaris (Linn.) in Lake Quarun Egypt. J. Cons. Perm. Int. Explor. Mer., 28: 126-136.

El-Zarka, S. and Koura, R., 1965. Seasonal fluctuations in the production of the important food fishes of the UAR waters of the Mediterranean Sea. Bull. Inst. Ocean. Fish.UAR, Notes and Memoires, No. 74: 1-67.

Fishelson, L. Von, 1966. Untersuchungen zur vergleichenden entwicklungsgeschichte der gattung Tilapia (Cichlidae, Teleostei). Zool. Jb. Anat. 83: 571-656.

Gergory, P.A. and T. Jow, 1976. The validity of otoliths as indicators of age of petrale sole from Calif. Fish. Game, 62 (2): p. 132.

Geyer, F., 1939. Alter und wachstum der wichtigsten cyprinden ostholsteinischer seen. (cited in: Einsele, 1943.)

Graham, M., 1929. Studies of age determination in fish. part II, Fishery investigations II, 11,(3): 1-50.

John Lawson Hart 1948. Age and growth rate in the Butter sole Isopsetta isolepis. Trans. of the Royal Society of Canada, Section 5: p. 65.

Monastuirsky, G.N., 1926. On the technique of determination the rate of growth of fish by measurement of the scales. **Siberian Ichthy. Lab. Krasnyarsk,** vol. 5 (4): 112-127.

Schneppenhein, R., and G. Freytag, 1980. Age determination by staining otoliths of Notothenia rosii marmorata with ninhydrin. **Cybium 3e Serie** 8: 3-15.

Segerstrole, C., 1933. Uber skalimetriche methoden zur bestimmung des linearen wachstums bei fischen. **Acta Zool. Fennica,** 15: p. 168.

Werder, U., and G.M. Soares, 1985. Age determination by sclerite numbers, and scale variations in six fish species from the central Amazon (osteichthyes, Characoidei). **Animal Res. & Dev. Inst. Sci. Co-op., Tubingen,** vol. 21: 23-46.