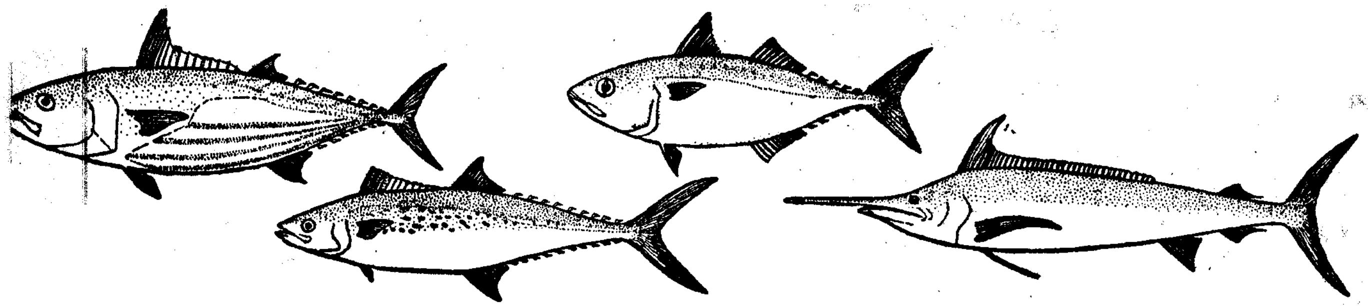


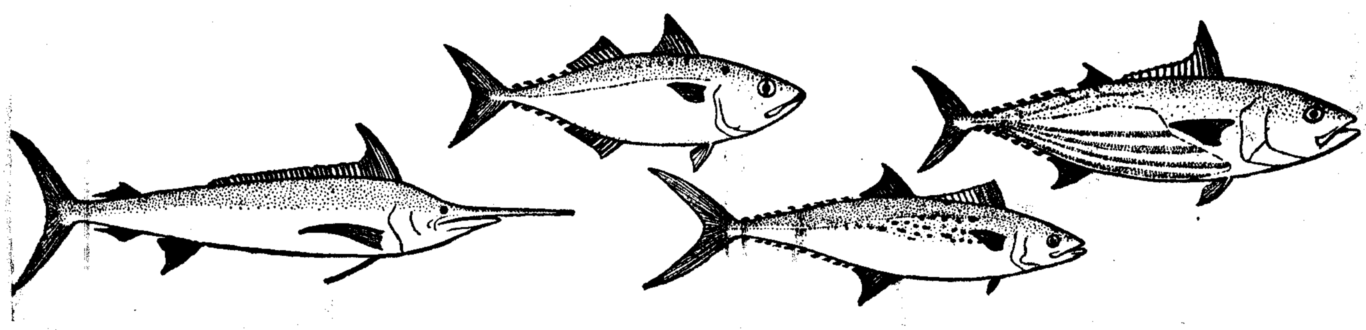
SYMPOSIUM ON SCOMBROID FISHES

PART II

MARINE BIOLOGICAL ASSOCIATION OF INDIA

MANDAPAM CAMP

S. INDIA



PROCEEDINGS OF THE

SYMPOSIUM ON SCOMBROID FISHES

HELD AT MANDAPAM CAMP FROM JAN. 12-15, 1962

PART II

SYMPOSIUM SERIES I

MARINE BIOLOGICAL ASSOCIATION OF INDIA

MANDAPAM CAMP

S. INDIA

PRINTED IN INDIA
AT THE DIOCESAN PRESS, MADRAS—1964. C8787

FECUNDITY OF THE OCEANIC SKIPJACK *KATSUWONUS PELAMIS* (LINNAEUS) OF MINICOY*

By G. RAJU**

Central Marine Fisheries Research Institute, Mandapam Camp, India

INTRODUCTION

ONE of the requisites in fishery biology is that of securing reliable estimates of population sizes. This can be estimated if the total annual egg production by all the females in the population, the average annual number of eggs produced by each female in the population and sex ratio of the population are known. A knowledge of the fecundity which can be defined as the average number of eggs produced per year by each female is a necessity in such studies. Recent contributions on the fecundity of fishes are by June (1953), Lehman (1953), Mac Gregor (1957), Otsu and Uchida (1959), Pillay (1958), Sarojini (1957), Simpson (1951), and Yuen (1955). The purpose of the present paper is to record extensive data on the fecundity of the oceanic skipjack, *K. pelamis* and to study its variation in relation to the size of the fish.

MATERIAL AND METHODS

A total of 63 specimens of skipjack collected from the pole and line fishery with live-bait at Minicoy during the period May 1958—April 1959, with fully mature gonads but with no signs of previous spawning in the immediate past were studied for fecundity. The total length and the weight of each specimen were recorded. The ovary was carefully dissected out of the body cavity and preserved in 5% formalin.

Each ovary preserved in 5% formalin after wiping with a towel and weighed to the nearest 0.01 gm. As a preliminary step random samples of ova from each ovary were taken out and the diameter frequency determined, from which the mode of the most mature group of ova was found out. Fecundity estimates were made using ova samples from the anterior, central and posterior portions of both the right and left gonads of a single specimen. The results showed that there was not much difference in the relative numbers per unit weight of ovary between the anterior, central and posterior regions. The chi-square test also showed (P=0.8) the similarity in the distribution of ova in the two gonads. All the fecundity estimates made in this study were based on ova samples taken from the central region of the left gonad.

Each sample of ova thus taken was dried for a few minutes on a filter paper and then weighed to the nearest 0.001 gm. It was then kept in a stoppered bottle containing Gilson's fluid for about a fortnight. After shaking the bottle containing the ova in Gilson's fluid and thereby making the ova uniformly distributed in the fluid, a known amount of fluid with the ova was pipetted out and all the ova of the most advanced group in the samples were counted. The number of ova in the weight of the ovaries by the number of those ova in the samples and dividing them by the weight of sample taken. In the present study the term fecundity is rather restricted to the number of the most mature group of ova present in the ovary.

* Published with the permission of the Director, Central Marine Fisheries Research Institute, Mandapam Camp.

* Present address: Central Institute of Fisheries Education, Bombay 1.

Relation Between Fecundity and Fish Length

In Fig. 1 the fecundity observations of 63 specimens are plotted against their respective fish lengths. The regression line is fitted by the method of least squares of the form Y=a+b L (where Y is the number of ova in the most advanced mode in thousands, L the length of the fish in mm. and a and b constants). This is described by the equation Y=−1004.94+2.713 L. It is seen from Fig. 1 that for any one length of fish the fecundity varies considerably. The total sum of squares for

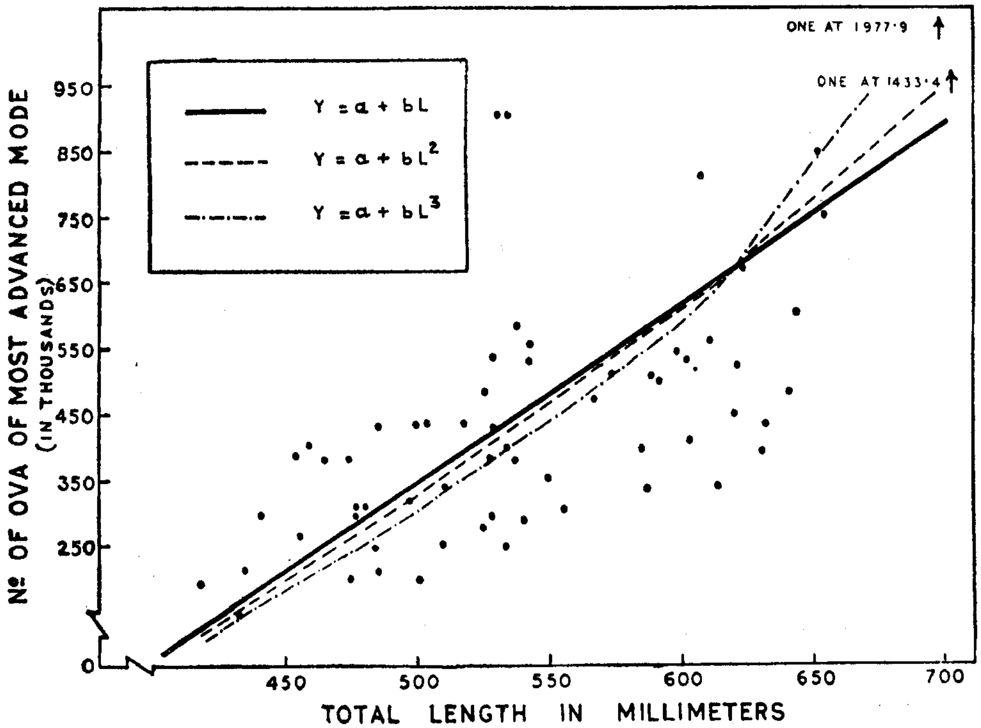


Fig. 1. Fecundity-length relationship for 63 skipjack from Minicoy. Fecundity-length regression lines of different formulae are also drawn for comparison.

the fecundity values was 5036,420. The deviations from the regression was found to be 3043,221. Thus regression removes only 2093,199 i.e. 41.56% of the total variation. Still the other 58.44% of the variation remains unexplained.

Relation Between Fecundity and Fish Weight

In Fig. 2 are plotted the 63 fecundity estimates against their respective fish weight. In all these studies the weight of the fish is the whole weight of the fish minus the weight of the gut contents. By the method of least squares the relationship between the fecundity and weight is described by the equation Y=−67.69+67.01 W (where Y=the estimated number of ova of the most advanced mode in thousands and W=the weight of the fish in pounds). The standard error of estimate is 22.5 thousands of ova and the coefficient of correlation is 0.789.

The deviation from regression was 1888,886. The variation removed by regression is 3147, 534 i.e. 62.48% of the total variation. Thus the weight of the skipjack appears to be a better indication of its fecundity than the length.

Fecundity and Condition Factor

Mac Gregor (1957) tested the very good correlation of the fecundity with fish weight by the use of ' K '—the condition factor. The same is attempted in this paper for 63 skipjack. The

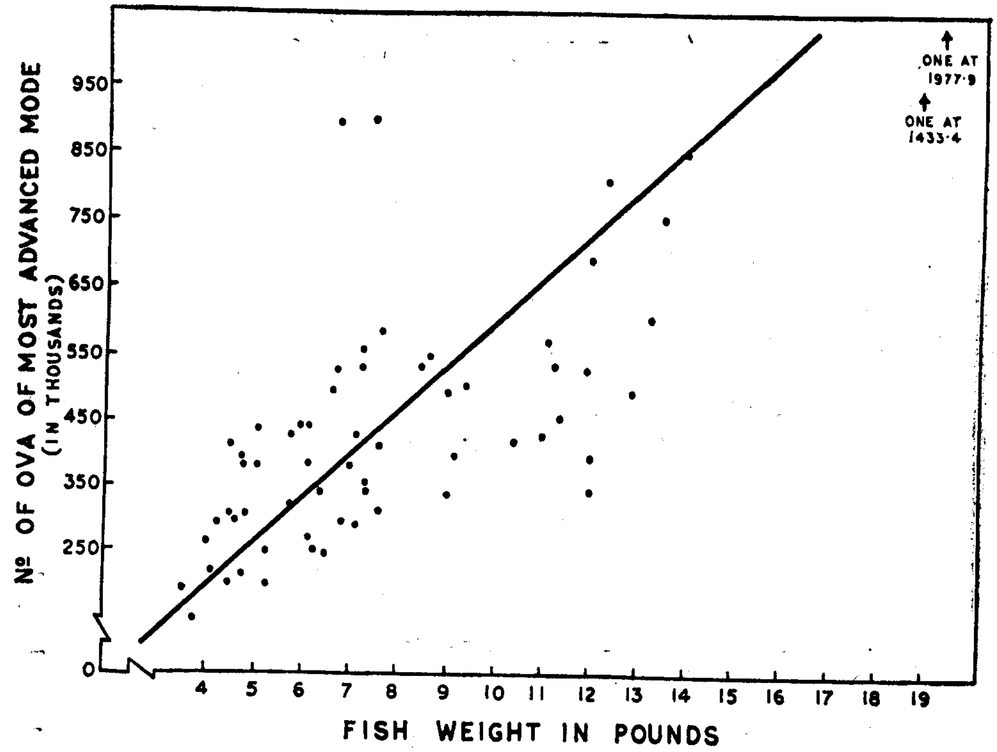


Fig. 2. Fecundity-weight relationship of 63 skipjack from Minicoy.

condition factor (K) employed in the present study was obtained by dividing the weight of the fish in ounces by the cube of the respective fish length in mm. and multiplying it by 10^9 to get a three digit whole number.

In Fig. 3 the deviations (observed number of ova minus the calculated number of ova) of each of the 63 fecundity-length pairs are plotted against the respective ' K ' values of the fish. The regression line is fitted by the equation $d=a+bK$ (where K is the condition factor, d the deviation, a—the d—intercept and b the slope. This is described for the 63 fecundity-length pairs of skipjack by the formula $d=-196.43+0.259$ K. (Standard error of estimate Sd. K=28.0; the correlation coefficient between d & k=0.726). When this is added to the ' K ' values among the skipjack the resultant equation becomes $Y=-1201.37+2.713\ L+0.259\ K$. This increases the coefficient of correlation (r) from 0.645 to 0.679 and decreases the standard error of estimate (Syl) from 28.6 to 27.0.

In Fig. 4 the deviations of each of the 63 fecundity-weight pairs are plotted against the respective ' K ' values of the fish. The regression equation fitted by the method of least squares is $d=-266.96+0.352$ K (Standard error estimate Sd. k=22.9 ; the correlation coefficient between d & k=0.120). When this is added to the fecundity-weight regression as the correction factor the resultant equation becomes $Y=-334.65+67.01\ W+0.352\ K$. This slightly increases the coefficient of correlation from 0.789 to 0.792 and decreases the standard error of estimate from 22.5 to 21.9.

In Fig. 5 are plotted the regression lines of fecundity-lengths for the 63 skipjack adjusted for the K. values varying from 600-1000, on the basis of the formula deviation 0.259 K−196.43. It can be seen that when two fish are of the same length, a difference of 100 units of 'K' value results in a difference of ±25.9 thousands of ova in the most advanced mode.

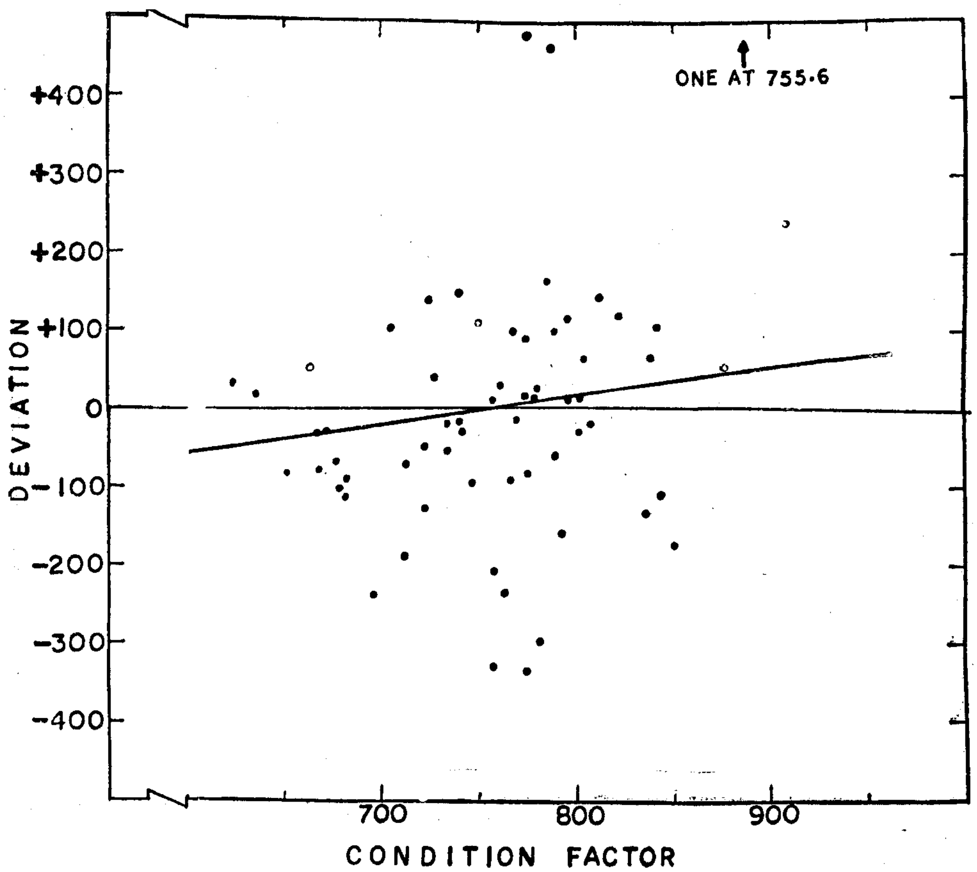


Fig. 3. Relation between the condition factor and the deviations in fecundity-length of 63 skipjack from Minicoy.

Discussion

It has been observed by fishery workers that for fish of any species the fecundity increases with the size of the fish. One of the methods of estimating the number of females in a particular stock of fish is by dividing the total number of eggs produced by that stock during the spawning by the mean number of eggs spawned by a female. But, if the size composition of the stock of spawning female changes, the mean fecundity value will also change. Therefore, it is necessary for such estimates to have a knowledge of the relationship between the fecundity and the length or weight of the spawning females.

There has been some differences of opinion among various authors as to the exact nature of the relationships between fecundity and fish length. Lehman (1953) has shown that the relation between fecundity and length is linear in the American shad (*Allosa sapidissima*). But Franz (1910), Kisseleveitch (1923) and Clark (1924) are of the view that the fecundity increases in proportion to the square of the length. Simpson (1951) observed that for the fecundity of the plaice (*Pleuronectes platessa*) the straight line regression of fecundity and length cubed is considerably better than that of the fecundity and length squared or mere length. He also found that the data of Franz (*op. cit.*) fitted the cube of the length better than the square. Simpson (*op. cit.*) further stated that the egg production in an ovary is not a surface phenomenon and that the germinal epithelium is so folded as to fill the volume of the ovary. The number of ova is theoretically dependent upon

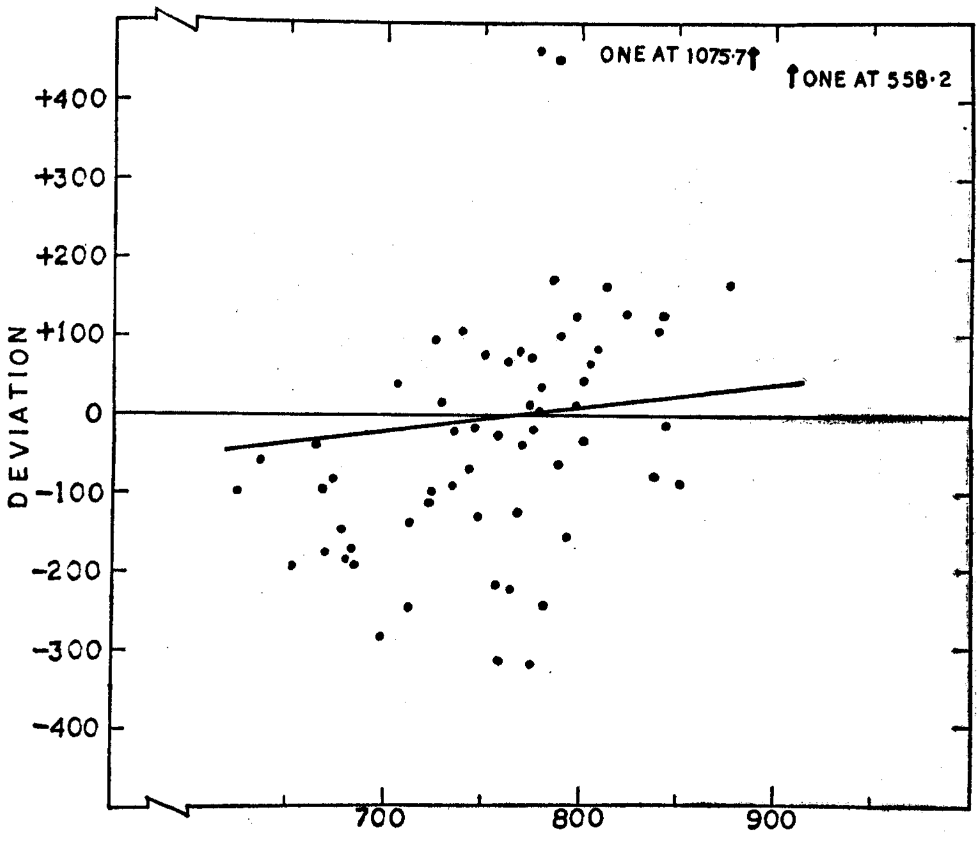


Fig. 4. Relation between condition factor and the deviation of fecundity-weight for 63 skipjack from Minicoy.

volume of the ovary which is a three-dimensional function and therefore expected to be better correlated to the cube of the length of the fish. Pillay (1958) and Sarojini (1957) found this to be true in their studies on *Hilsa ilisha* (Ham.) and *Mugil parisa* (Ham.) respectively. But Mac Gregor (1957) working on the Pacific Sardine (*Sardinops caerulea*) found that the correlations were not improved either by using the square or the cube of the length and therefore concluded that convenience rather than theoretical considerations should be the deciding factor in selecting one of the formulae to describe his data.

The line of the best fit (Least squares) for the 63 skipjack fecundity data on length are represented in Fig. 1 for each of the three different formulae. Table I gives the calculated number of ova in most advanced mode for skipjack of different lengths calculated by each of the three different formulae. In table II the Y intercepts (a) slopes (b), standard errors of estimate of Y (Syl) and (coefficient of correlation (r) of the four lines for the 63 fish) are given.

TABLE I

Comparison of calculated number of ova in most advanced mode for skipjack of different lengths by different formulae from Minicoy

No.	Total Length in mm.	Number of Ova (in thousands)		
		Y=a+bL	Y=a+bL²	Y=a+bL³
1.	400	80.3	114.1	109.9
2.	450	215.9	222.1	201.7
3.	500	351.6	342.7	317.6
4.	550	487.3	476.0	459.1
5.	600	622.9	622.1	628.8
6.	650	758.6	751.2	829.2
7.	700	894.2	952.3	1063.2
8.	750	1029.9	1521.2	1332.9

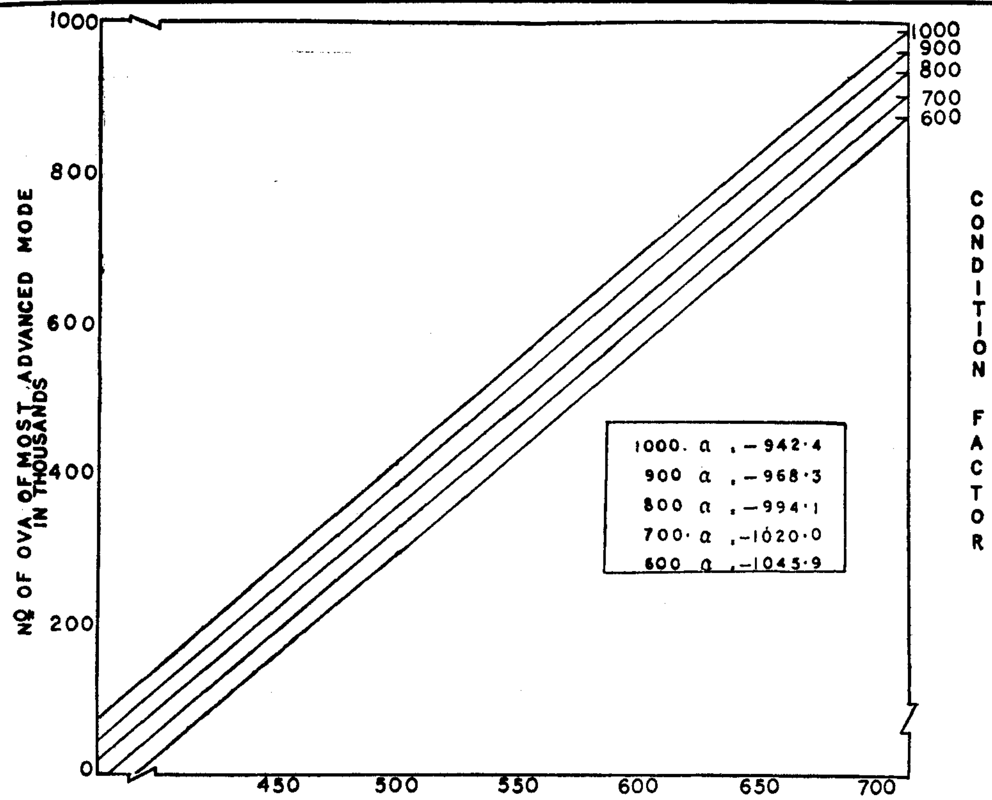


Fig. 5. Regression lines of fecundity of 63 skipjack from Minicoy.

There is an increase in the coefficient of correlation and decrease in the standard error of estimate, when the fecundity is fitted with the length, square of the length and cube of the length of the fish. The highest value of coefficient of correlation and lowest value of standard error of estimate were obtained for the 63 specimens of skipjack, without the application of *correction factor*, when the relation between the fecundity and fish weight were fitted by the method of least squares. Since for skipjack the weight is very nearly proportional to the cube of the length of the fish, more or less an identical or comparable relation is at least theoretically expected of the regressions between the fecundity and the cube of the length of the fish and fecundity and weight of the fish. It can be seen that the relationship between the fecundity and weight of the fish is somewhat closer to that of fecundity—(length)^3 relationship than either the (length)^2 or mere length relationship.

TABLE II

Comparison of the fecundity-length relationships among 63 skipjack collected at Minicoy during the period May 1958—April 1959, from the pole and line fishery with live-bait.

No.	Formula	a the Y-intercept (Thousands)	b the slope	SYL Standard error of Estimate (Thousands)	r coefficient of correlation
1.	$Y=a+bL$	−1004.94	2.713	28.6	0.645 (ryL)
2.	$Y=a+bL^2$	−292.26	0.00254	27.4	0.668 (ryL^2)
3.	$Y=a+bL^3$	−109.0	0.00000342	24.7	0.741 (ryL^3)

The better correlation or relationship between the fish-weight and fecundity is also reflected by the application of condition factor differences. When the condition factor value correction is applied to the fecundity length regressions, it improves the relationship as already pointed out with (the increase of coefficient of correlation and) decrease of standard error of estimate. Mac Gregor (1957) who observed the above fact in his sardine data, pointed out that ' the comparatively large improvement resulting from applying this ' K ' value correction to the fecundity-length correlation, the magnitude of the correlation coefficient and the positive slope of the regression of fecundity-length deviation on ' K ' value, all demonstrate that when two fish are of the same length, the heavier fish contains more ova '. The same appears to be true for the 63 skipjack from Minicoy island, observed in the present study. Likewise the positive slope of the regression of ' K ' value and fecundity-weight deviation suggest that when two fish are of the same weight the shorter fish will have a higher fecundity. But the very low value of ' r ' and the small improvement resulting from the application of this correction factor, to the fecundity-weight correlation caution too much reliance on this.

The only other recent information on the fecundity of skipjack for comparison with the present one is that estimated by the Inter-American Tropical Tuna Commission (Schaefer 1961). Among fourteen sets of skipjack ovaries in advanced stages of maturity collected near the mouth of the Gulf of California in 1959, from fish ranging in total length from 659 to 699 mm. they were found to vary with a rather wide range of number of ova in the maturing group from 407—1327 thousands. At Minicoy the fecundity was found to vary from 218.9 to 903.4 thousands among fish ranging in total length from 432 to 652 mm. Nevertheless, four specimens measuring 418, 432, 693 and 703 mm. in total length were obtained in which the fecundity was estimated to be 197.8, 151.9, 1433.4 and 1977.9 thousands respectively. The smallest skipjack that has had an apparently mature ovary measured 418 mm. in total length and the ordinary size at first maturity was observed at Minicoy to be around 400-450 mm. in total length. But Schaefer (1956) however observed that in Pacific a large number of skipjack do not mature below 600 mm. in total length. At Minicoy, unfortunately not many female skipjack above 600 mm. in total length could be obtained for fecundity studies during 1958-59.

To determine the annual number of eggs produced by each female it is necessary to determine the average number of eggs produced by each female and the number of batches produced in a year. The foregoing account gives a fairly good idea of the average number of eggs produced by each female, and its relationship to length and weight of fish but the number of batches produced by each female per year still remains problematical. From the study of the gonads of skipjack from Minicoy for spawning described elsewhere it was concluded that there are at least two spawning periods per year. Fractional spawning or spawning in batches appears to be characteristics of many species of tuna but the exact number of batches of ova shed could not be determined with accuracy in any of the tunas.

ACKNOWLEDGEMENTS

I am greatly indebted to Dr. S. Jones, Director, Central Marine Fisheries Research Institute, for guidance and constant encouragement during the course of this work. My thanks are due to Mr. S. K. Banerji, Research Officer (Statistics) for kindly going through the manuscript and offering valuable suggestions.

SUMMARY

1. The fecundity estimates of 63 specimens of skipjack obtained from the pole and line fishery with live-bait at Minicoy during the period May 1958—April 1959, are presented here.

2. Among skipjack ranging in total length from 418 to 703 mm. the fecundity was found to vary from 151.9 to 1977.9 thousands of ova in the most advanced mode.

3. The relationship between the fecundity and fish length regression was improved with the use of the square of the length of the fish and the cube of the length of the fish than its mere length in mm. with an increase of coefficient of correlation and decrease of standard error of estimate.

4. The correlation between the fecundity and fish weight was better than any of the length regressions.

5. The relationship between the fecundity and fish-length regression in particular was improved when the condition factor was applied as a correction.

REFERENCES

CLARK, FRANCES N. 1934. Maturity of the California sardine (*Sardina caerulea*), determined by ova diameter measurements. *Calif. Fish Game*, **42**, 49p.

FRANZ, V. 1910a. Die eiproduktion der schoole (*Pleuronectes platessa* L.) *Wiss. Meeresunters, Helgoland N.F.*, **9**: 59-141.

——— 1910b. Zur eiproduktion der schoole (*Pleuronectes platessa* L.). Nachtrage. *Ibid.*, **9** ; 217-24.

JUNE, FRED C. 1953. Spawning of yellowfin tuna in Hawaiian waters. *U.S. Fish Wildl. Serv. Fish. Bull.*, **77** (54) : 47-64.

KEISSELEVITCH, K. A. 1923. Materials on the biology of the Caspian Herrings-1. The fertility of the Volga Caspian herrings. *Astrachan Ichthy. Lab. Rep.*, **5** (1) : 15-55.

LEHMAN, BURTON A. 1953. Fecundity of Hudson river shad. *U.S. Fish Wildl. Serv. Res. Rept.*, **33**:1-8.

MAC GREGOR, JOHN S. 1957. Fecundity of the Pacific sardine (*Sardinops caerulea*). *Ibid.*, **121** (57) : 427-449.

OTSU, TAMIO AND RICHARD UCHIDA 1959. Sexual maturity and spawning of Albacore in the Pacific Ocean. *Ibid.*, **148** (59) : 287-304.

PILLAY, T. V. R. 1958. Biology of the Hilsa, *Hilsa ilisha* (Hamilton) of the River Hoogly. *Indian J. Fish.*, **5** (2) : 201-257.

SAROJINI, K. K. 1956. Biology of the grey mullets of Bengal—1. Biology of *Mugil parsia* Hamilton with notes on its fishery in Bengal. *Ibid.*, **4** (1) : 160-207.

SCHAEFER, MILNER B. 1956. Studies of the sexual development and spawning of yellowfin tuna (*Neothunnus macropterus*) and skipjack (*Katsuwonus pelamis*) in three areas of the Eastern Pacific Ocean, by examination of gonads. *Inter-Amer. Trop. Tuna Comm. Bull.*, **1** (6) : 281-320.

——————1961. Report on the investigations of the Inter-Amer. Tropical Tuna Commission for the year 1960. *Inter-Amer. Trop. Tuna Comm. Ann. Rept.* for 1960.

SIMPSON, A. C. 1951. The fecundity of the plaice. Ministry of Agriculture and Fisheries. *Fishery Invest.*, Ser. II, **17** (5) : 27.

SNEDECOR, GEORGE, W. 1956. Statistical methods. Ed. 5., Iowa State College Press, Ames. Iowa, 534.

YUEN, H. S. H. 1955. Maturity and fecundity of bigeye tuna in the Pacific. *U.S. Fish Wildl. Serv. Spec. Sci. Rept. Fish.*, 150.