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A NOTE ON THE FECUNDITY OF LEMON SOLE

by

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Summary

Methods employed in the estimation of fecundity in lemon sole are described. Preliminary results indicate that data on gutted weight, ripe gonad weight, age, and length can all be used to predict fecundity. Fecundities between flatfish species are compared and lemon sole appears to be one of the less fecund flatfish.

Introduction

The only published data on the fecundity of the lemon sole (Microstomus kitt (Walbaum)) are those given by Fulton (1891), who examined two females from the Firth of Forth. These fish, one of 38 cm and the other of 32 cm, had estimated fecundities of 672 000 and 150 228 respectively.

In order to obtain more precise knowledge of the fecundity of the lemon sole a large number of ovaries were collected during 1970. Of these, 88 have so far been examined. This paper describes the methods employed in the investigations and the results obtained to date.

Material and Methods

1) Collection of ovaries and associated data

Lemon soles spawn off the east coast of Scotland between May and October with maximum spawning in July and August (Rae 1964). Accordingly, samples of lemon sole were obtained from commercial vessels fishing off the east coast of Scotland during July and August 1970. Ovaries were removed from ripe female fish which could be identified by the presence of a noticeably swollen area along the righthand lateral margin of the body. Ovaries found to contain hyaline eggs were not used in the estimation of fecundity. In addition to these samples, a number of immature and spent ovaries were also obtained.

The gutted weight, gonad weight and length were also recorded for each fish from which ripe ovaries were obtained. In addition, samples of scales were collected for subsequent age determination.

The ovaries were preserved in Gilson's fluid for several months. The eggs were then separated from ovarian membranes and connective tissue.

2) Determination of the size of the eggs to be counted for the estimation of fecundity

The diameters of the eggs from a number of immature, ripe and spent ovaries were measured. Because the eggs assumed irregular shapes when preserved in Gilson's fluid the maximum diameter was recorded. Figures 1a and 1b indicate that spent and immature ovaries contain eggs with similar diameter distributions, almost all the eggs having diameters equal to or less than 0.12 mm. Comparison of these results with those obtained from ripe ovaries (Fig 1c) suggests that eggs of diameters equal to or greater than 0.12 mm are likely to be shed in the spawning season and hence only these should be counted when estimating fecundity in the lemon sole.

3) Separation of the eggs to be counted

The eggs from each of the ripe ovaries were passed through a series of sieves which separated the small eggs from the ones to be counted. The effectiveness of the separation technique was checked by obtaining diameter frequency distributions for the "small egg" and "large egg" fractions of a number of ovaries. An example of such a frequency distribution is given in Figure 2. It can be seen that the procedure separates the eggs into two groups, one with diameters equal to or less than 0.12 mm and the other with diameters mostly greater than this size. This is in good agreement with the criteria proposed above.

4) Assessment of fecundity

The large eggs from each fish were put in a flask and water was added to make up a volume of 500 ml. A sample 0.5 ml was removed from the flask with a Stempel pipette while the eggs were being kept in suspension by the use of a vertical agitator. The eggs in this sample were counted and reference was made to Table 1. This determined the total number of subsequent subsamples to be taken to achieve an accuracy of ± 4%. (The theory underlying this procedure is given below Table 1).

The total number of eggs for each fish was then determined from the equation

$$F = \frac{MV_f}{V_s}$$

where F = fecundity
M = mean number of eggs per 0.5 ml subsample
V_f = volume of flask
V_s = volume of subsample

5) Validation of the method for assessing fecundity

Eggs at different stages of development and of different sizes have different densities and therefore tend to settle from suspension in water at different rates. Unless, therefore, the agitation of the eggs while taking the subsamples produces a random distribution of eggs throughout the suspension, inaccurate results could be obtained.

In order to test the accuracy of the method of estimation, the eggs in each 0.5 ml subsample were transferred to a flask containing Gilson's fluid after they had been counted. In this way a known number of eggs was built up and on two occasions the estimation procedure described above was applied to these eggs. The results are shown in Table 2 where it can be seen that, in both cases, the estimated number was within 4% of the true number.

Results

Scatter diagrams of fecundity against length, gutted weight, ripe gonad weight and age are shown in Figures 3-6 respectively. Linear regression lines were fitted to all sets of data except the one for fecundity against length where a log-linear relationship was fitted.

All the regressions were significant at the 0.1% level. The parameters for each of the regression lines are shown in Table 3 together with their associated standard deviations. The residual variances around each of the fitted regressions are also included in Table 3. These were compared using

Bartlett's test for homogeneity of variance and no difference could be detected between them.

Conclusions

Information on gutted weight, ripe gonad weight, age and length can all be used to predict the fecundity of lemon sole. The homogeneity of the residual mean squares about each of the regressions indicates that the accuracy of prediction is approximately the same for all of them.

There appears to be an almost proportional relationship between fecundity and gutted weight in lemon sole. Such a relationship has also been found for plaice (Pleuronectes platessa, Simpson 1951), long rough dab (Hippoglossoides platessoides, Bagenal 1957), witch (Glyptocephalus cynoglossus, Bagenal 1963) and flounder (Platichthys flesus, Cieglewicz and Musial 1964). A convenient way to compare fecundities between flatfish species, therefore, is to compare the constants of proportionality estimated for the relationship between fecundity and gutted weight. These values are given in Table 4. A value for common dab (Limanda limanda) was also estimated from the data given by Bohl (1957) by first calculating the fecundity of dabs for various lengths and then dividing these values by the corresponding weight at length. It can be seen from Table 4 that, on this basis, the lemon sole is one of the less fecund flatfish.

References

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Bohl, H.	1957	Die Biologie der Kliesche (Limanda limanda L.) in der Nordsee. Ber. dt. wiss. Kommn. Meeresforsch. 15(1), 57 pp.
Cieglewicz W. and Musial R	1964	The fecundity of the flounder in the Gdansk Bay. ICES C.M. 1964, Baltic-Belt Seas Comm. Doc. (64) (mimeo), 5 pp.
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Hoffman, E.	1971	The fecundity of the flounder (Platichthys flesus L.) in a Danish fjord. ICES C.M. 1971, Demersal Fish (Northern) Comm. Doc. F24 (mimeo), 6 pp.
Rae, B. B.	1965	The lemon sole. Fishing News (Books) Ltd, London, 106 pp.
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Table 1 Theoretical number of samples to be taken for different mean sample values to maintain a 4% accuracy

Mean number in sample (M)	No. of samples required (N)	Mean number in sample (M)	No. of samples required (N)
20	31	175	4
40	16	200	4
60	10	225	3
80	8	250	3
100	6	275	3
125	5	300	2
150	5	325	2

The theory underlying the construction of the table is as follows:

Let X = percentage accuracy of estimation = $\frac{100\ (\text{standard error of mean})}{\text{mean}}$

M = mean sample value

N = number of samples

$$\text{Standard error of mean} = \frac{\text{standard deviation}}{\sqrt{N}}$$

Assuming that the samples are drawn from a Poisson distribution, we note that:

$$\text{standard error of mean} = \frac{\sqrt{M}}{\sqrt{N}} = \sqrt{\frac{M}{N}}$$

$$\text{Thus } X = \frac{100\sqrt{\frac{M}{N}}}{M}$$

$$\text{Hence } N = \frac{10^4}{MX^2}$$

In practice the number of eggs in the first sample taken is used as an estimate of M and is used to establish N.

Table 2 Comparison of estimated number of eggs with true number of eggs

True number	Estimated number	$\left(\frac{\text{True-Estimated}}{\text{True}}\right)100$
19 680	20 231	+ 2.7
38 296	38 314	+ 0.05

Table 3 Parameters of regression equations

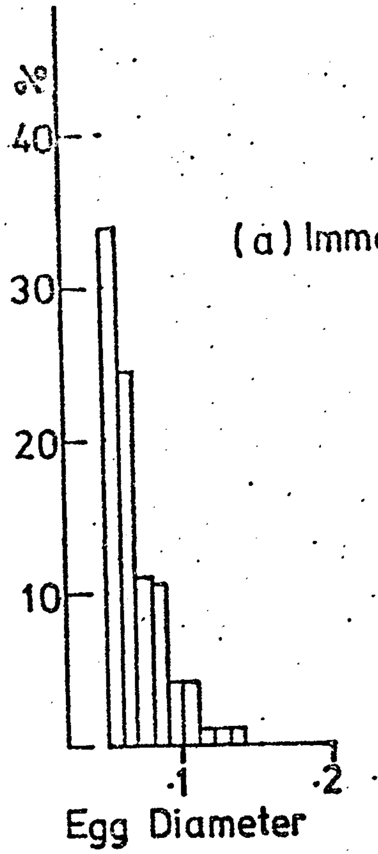
	n	Slope	Intercept	S.E. Slope	S.E. Intercept	Residual variance x10^{-4}
Fecundity:Gutted weight	88	471	-0.003	65	466	403 953
Fecundity:Gonad weight	88	5 345	56 741	558	4 541	491 396
Fecundity:Age	85(1)	36 475	-0.0007	4 099	11 090	528 175
Log_{10}Fecundity:Log_{10}Length	88	2 699	1.096	0.253	0.314	488 106(2)

(1) It was not possible to determine age for three of the fish examined.

(2) Calculated by estimating fecundity at each length from the log-linear equation, calculating the deviations of individual fecundity values from these estimates and then determining the sum of squares of the deviations.

Table 4 Number of eggs produced per gramme body weight

Species	Eggs/g	Reference
Plaice	150	Simpson (1951)
Lemon sole	470	Present paper
Witch	1 000	Bagenal (1963)
Long rough dab	630-1 600	Bagenal (1957)
Flounder	700-1 800	Cieglewicz & Musial (1964), Hoffman (1971)
Common dab	4 000	Bohl (1957)



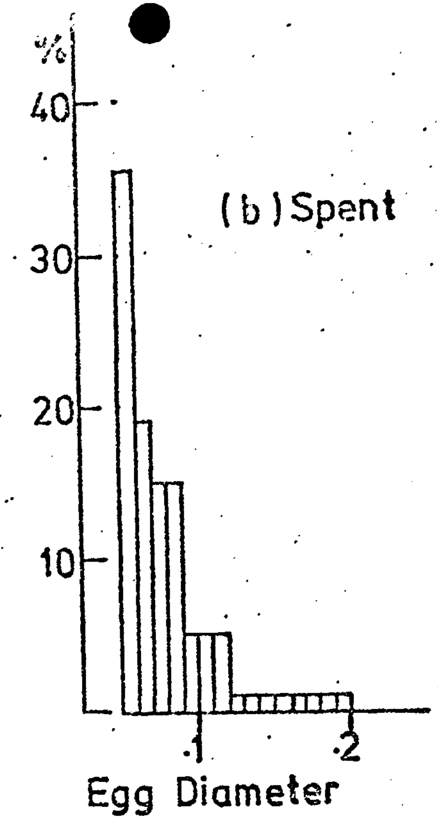
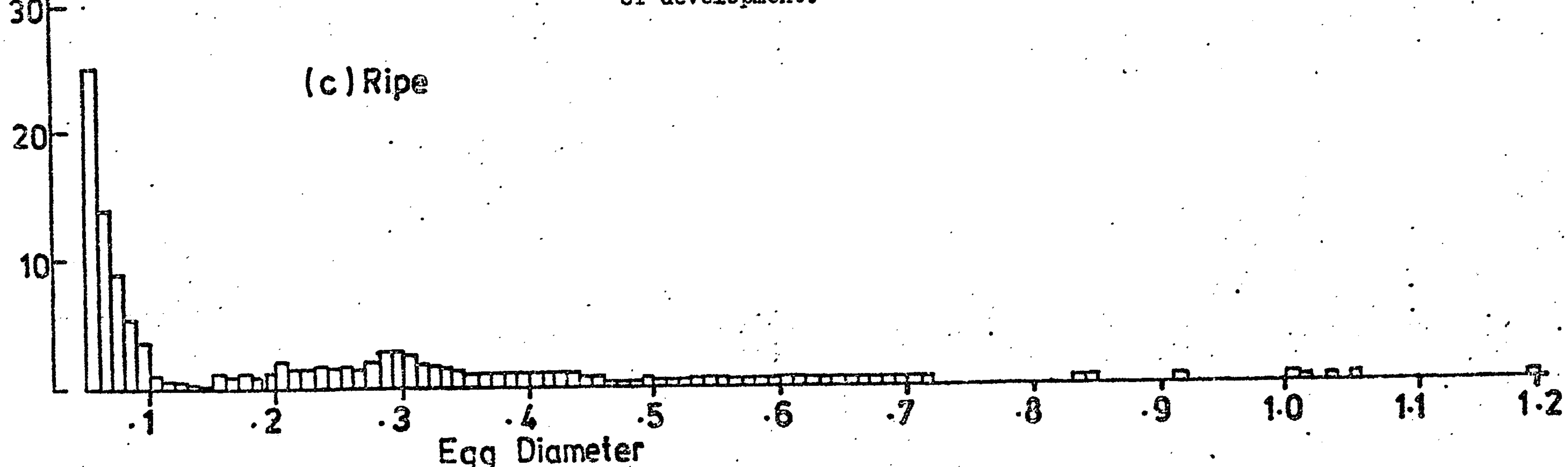


Figure 1. Egg diameter distributions of ovaries in various stages of development.



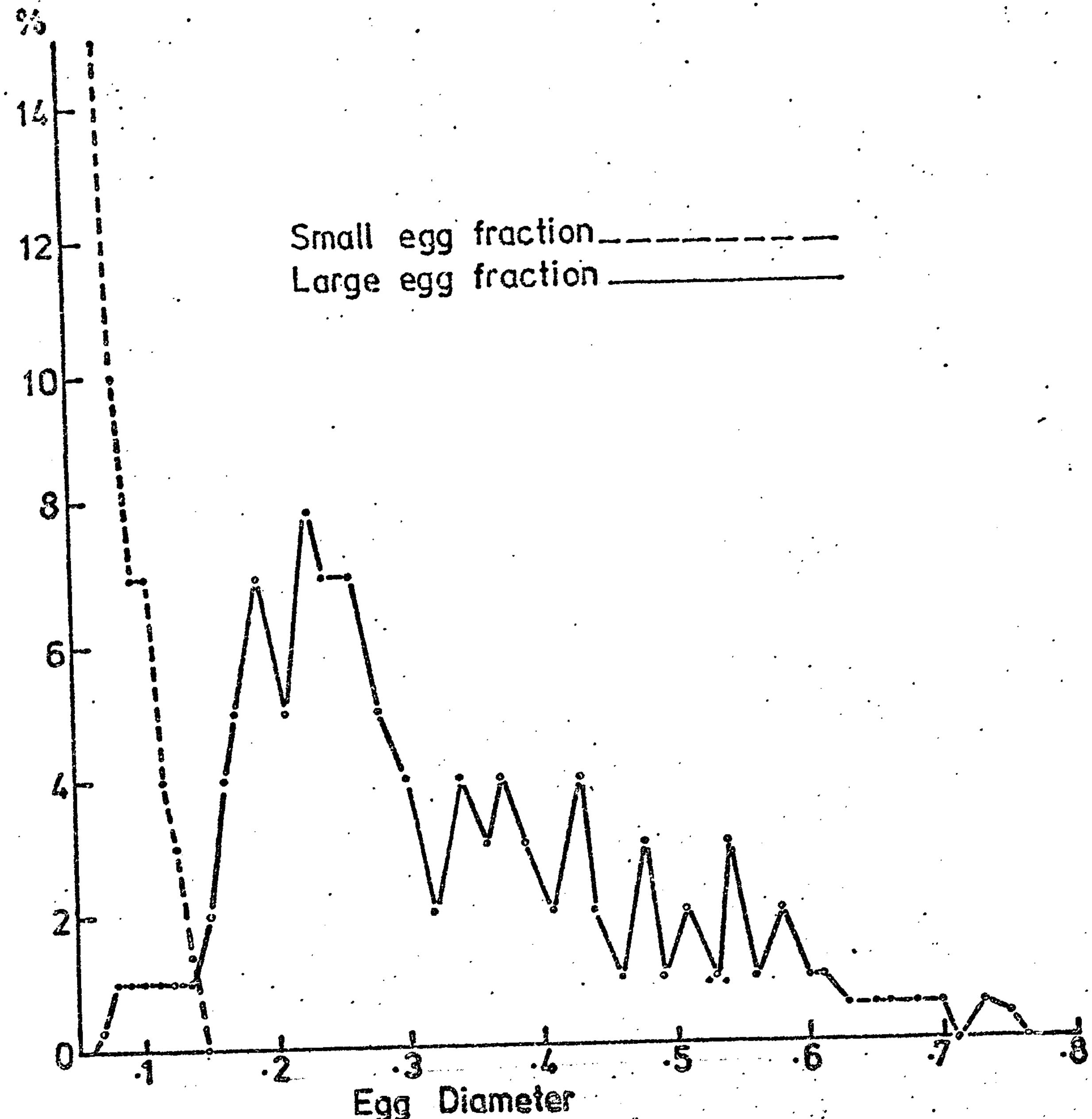
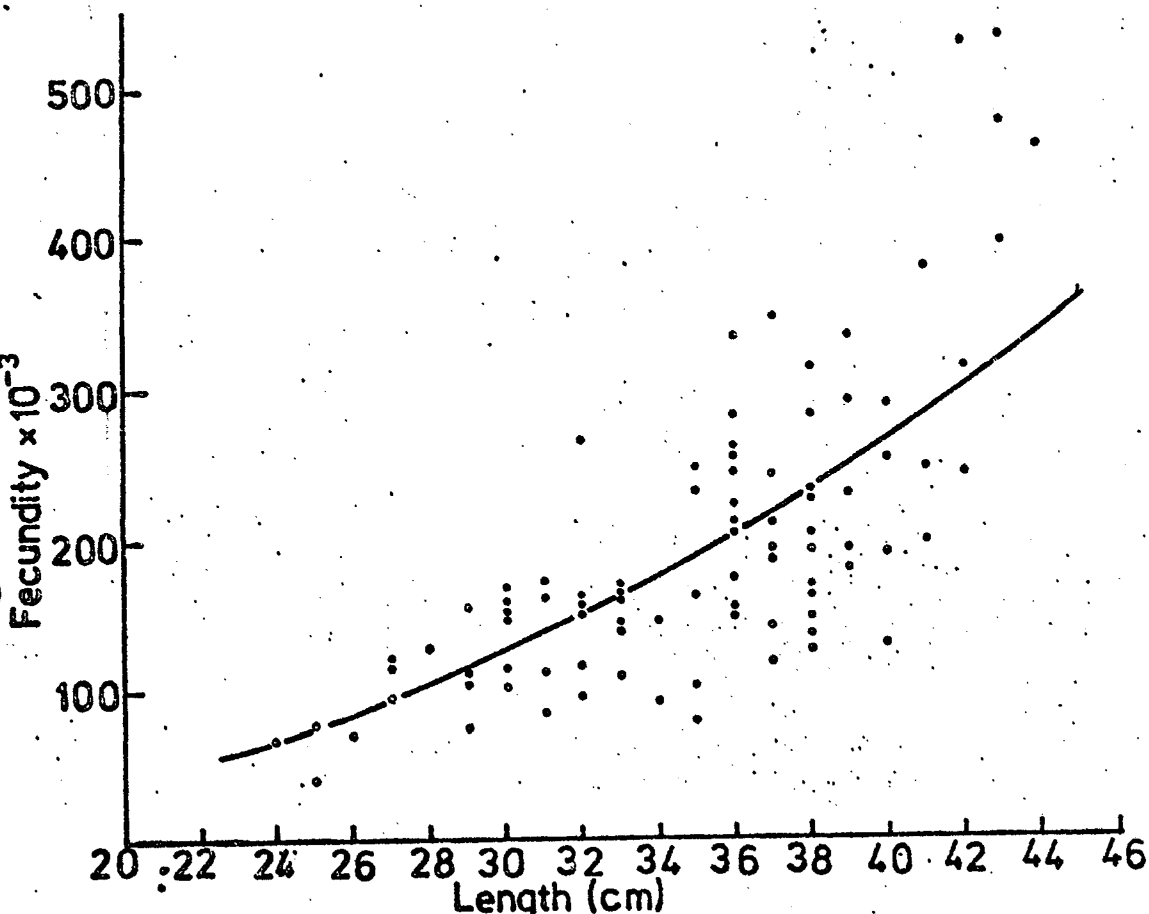


Figure 2. Diameter frequency distribution of eggs from a ripe ovary after sieving.

Figure 3. Fecundity vs length.



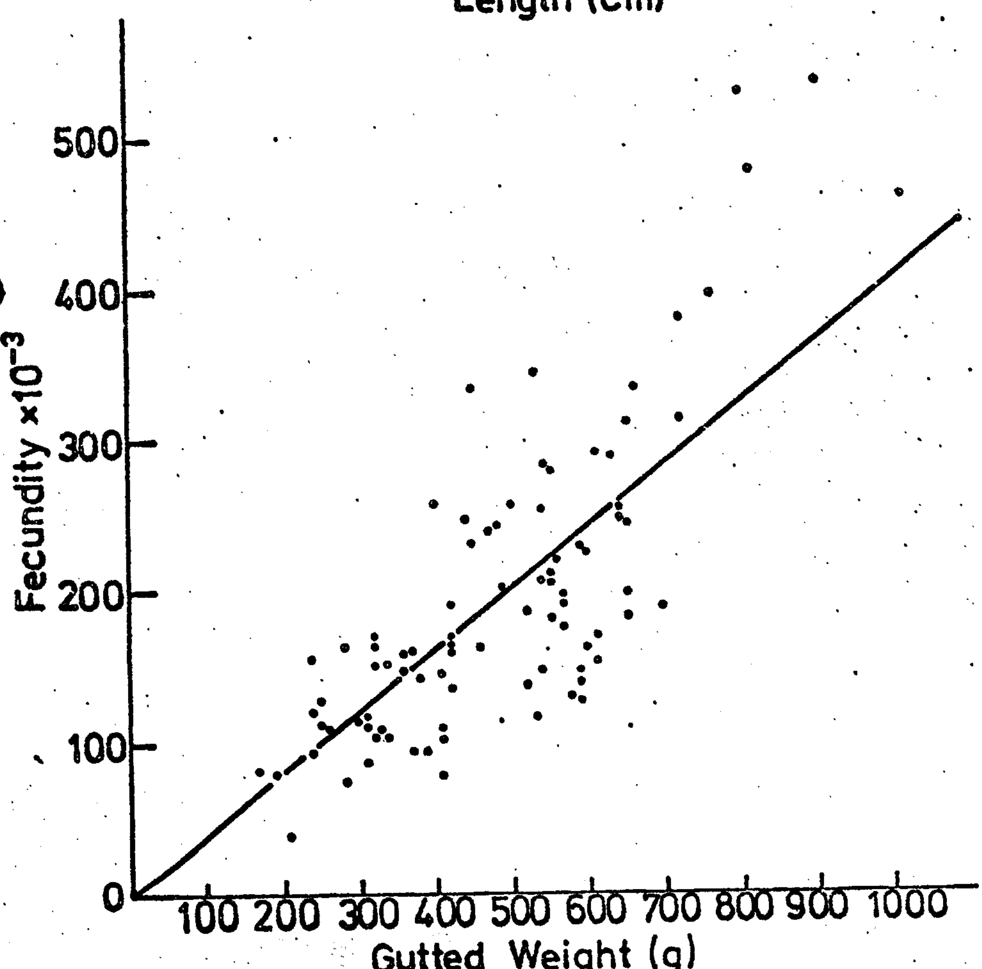
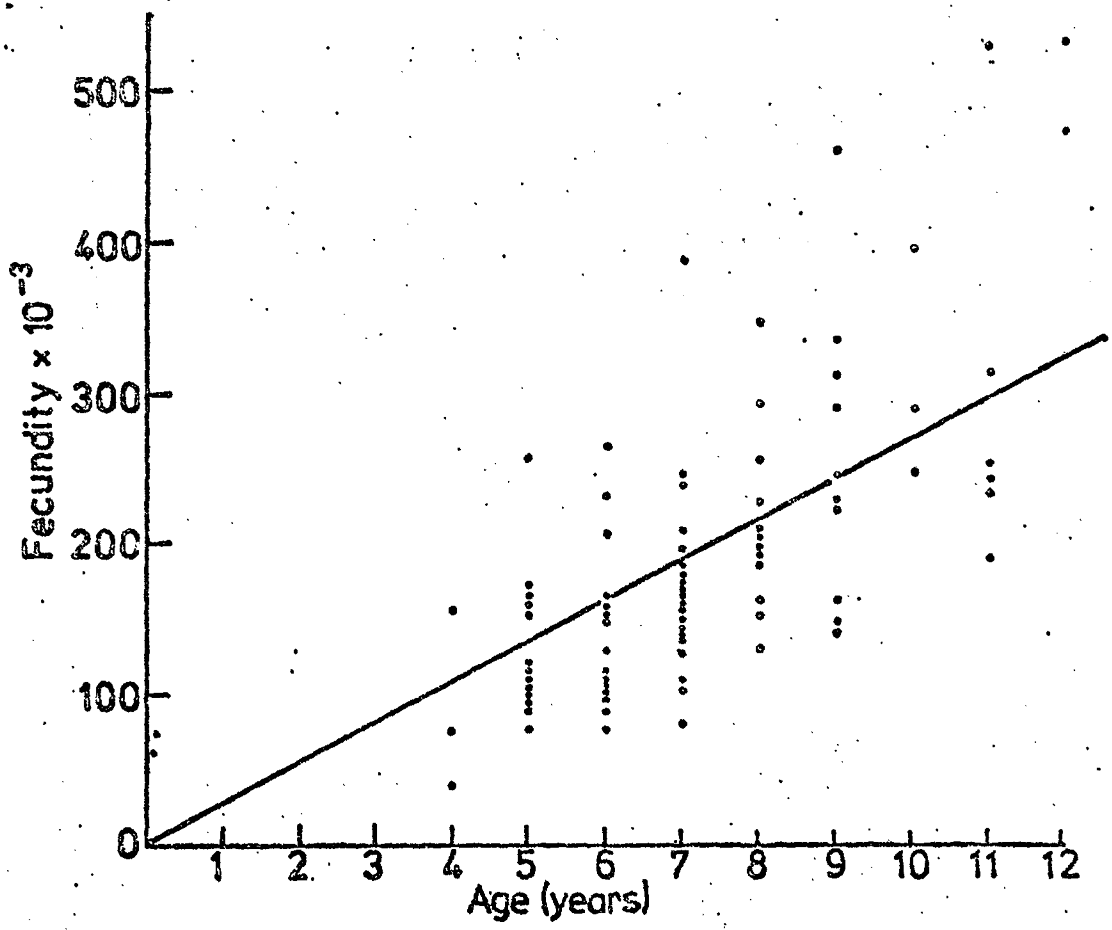


Figure 4. Fecundity vs gutted weight.

Figure 5. Fecundity vs age.



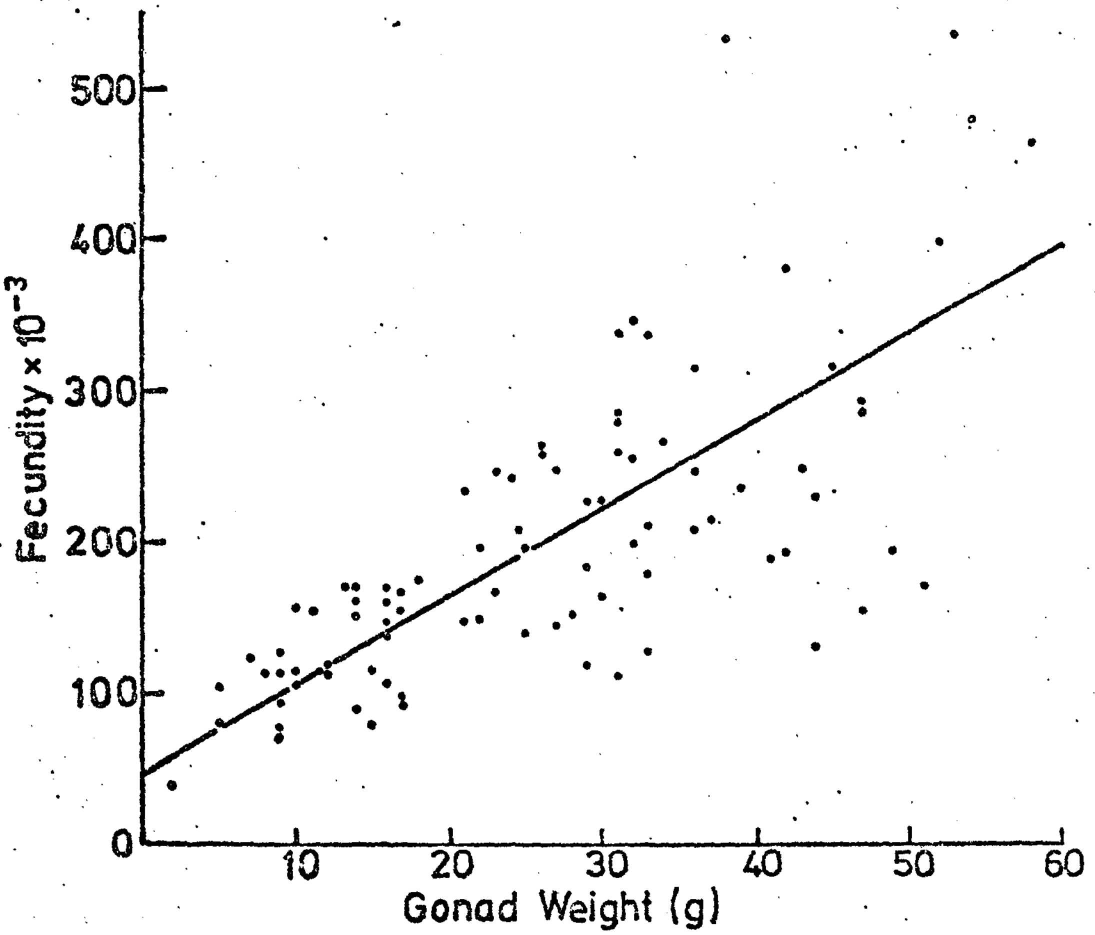


Figure 6. Fecundity vs gonad weight.