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On the use of the floating mean method and shrimp investigations

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1. INTRODUCTION.

Many investigators, mainly in Germany and in the Netherlands, made contributions to the better understanding of the growth of Crangon crangon (L.) : Havinga (1930), Meyer (1935), Tiews (1954), Boddeke (1962a, 1962b, 1966a and 1966b) and Meixner (1969). The method of Tiews (1954) concerning the determination of a growth curve for shrimps can be considered as very accurate. This method consists in correlating the total length with the number of segments from the entennular exopodite. The method results however in a rather long measuring time, preventing the treatment of a large number of shrimps in a short space of time.

The first objective of this study was to elaborate a simple and a more rapid method permitting the construction of growth curves for shrimps. The Petersen method appeared in earlier studies (Havinga 1930 and Schockaert 1968) as a difficult way to determine growth curves because of the irregularity of the length frequency distributions on which it is based. The introduction of the "floating mean method" can reduce this irregularity to a large extent.

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The second objective was a further study on the phenomenon of sex-change of shrimps by using the results of the combined Petersen-floating mean method.

2. MATERIAL AND METHODS.

2.1. Sampling procedure.

The material consisted of shrimps caught by the R.V. "Hinders" on the fishing ground "Westdiep", off the Belgian coast. The catch resulting from a 15 minutes haul was sampled on 5 fixed stations (figure 1), once a month, during the period September 1971-May 1972.

The catch took place during daytime using the otter trawl (mesh size 9 mm), except for the months September and October 1971 and May 1972 during which the beam trawl was used.

Measurements of total length (L) (i.e. from the top of the scaphocerite till the end of the stretched uropods) were carried out on 250 shrimps taken at random of every haul. The subsample of 250 shrimps was representative for one hour fishing as preliminary studies proved.

2.2. Preparatory calculations.

The frequence, F_{L_i}, of all the shrimps with a length L_i in 1 fishing hour can be expressed by :

$$F_{L_i} = f_{L_i} \cdot \frac{V\ catch}{V\ sample} \cdot 4$$

in which : V catch = Volume of total catch of 15 minutes fishing

V sample = Volume of subsample (250 specimens)

f_{L_i} = frequence of length L_i in a subsample of 250 shrimps.

A conversion from beam trawl to otter trawl was carried out for the months September and October 1971 and May 1972 (Maton and Verhoest, 1963).

The average aL_i resulting from the 5 monthly values of F_{L_i} (one value F_{L_i} per length L_i per sampling point) can be formulated as :

$$aL_i = \frac{\sum_5 F_{L_i}}{5}$$

2.3. "Floating mean" or "moving average".

The method of the "weighted moving average of order 3" was applied to the aL_i values as follows :

$$\frac{aL_{i-1} + 2aL_i + aL_{i+1}}{4} = bL_i$$

The floating mean or moving average reduces the small variations in a series of numbers without eliminating the general trends. The reason for giving the respective weights 1,2 and 1 was based on the following argument. A histogram for aL_i-values in classes of 2 mm can be developped in two ways :

$\ldots, (aL_{i-2} + aL_{i-1})/2, (aL_i + aL_{i+1})/2, \ldots$ and

$\ldots, (aL_{i-1} + aL_i)/2, (aL_{i+1} + aL_{i+2})/2, \ldots$

The average for both histogram-values with L_i is equal to bL_i. Equalizing $\sum_i bL_i$ to 100 % permits the expression of all the bL_i-values in percentages (bL_i-%).

3. RESULTS.

3.1. Growth curves.

The values of bL_i-% were plotted on figure 2 on a monthly basis. Flowing curves were obtained, rejecting the irregular variations of a normal frequence distribution.

The possibility was tested for constructing growth curves by means of the application of the Petersen method on the "peaks" and "humps" of the monthly floating mean curves (figure 3). "Humps" may be considered as non-developped "peaks" due to the close presence of a higher peak (Buchanan-Wollaston and Hodgson 1929).

The model of Tiews (1954) was taken as a guideline for drawing the definite growth curves.

The regression of L to t and the coefficient of correlation r were calculated for each growth curve (table 1).

Table 1 - Growth curves for shrimps.

Line Y	n_p(1)	Regression (2)	r	(3)
A	6	L = 0.063 t + 64.69	0.96	70-A-f
B	8	L = 0.063 t + 58.08	0.98	70-B-f
C-1 C-2	10	L = 0.072 t + 50.97	0.92	70-A-m 70-A-m +71-A-f
C-3	4	L = 0.158 t + 42.75	0.98	71-A-f
D	9	L = 0.090 t + 40.42	0.99	70-B-m
E-1	6	L = 0.156 t + 29.01	0.93	71-A-m
E-2	8	L = 0.041 t + 39.24	0.81	71-A-m
F-1 F-2	8	L = 0.163 t + 20.55	0.99	71-B-m +71-B-f 71-B-f
F-3	8	L = 0.045 t + 31.50	0.68	71-B-m

(1) n_p : amount of peaks and humps used for the curve.

(2) t : time in days ; t = 1 for September 1st, 1971.

(3) shrimp class according to Tiews.

A = first spawning (born in January-February)
B = second spawing (born in April-June)
m = males
f = females.

Figure 3 is very similar to the results of Schockaert (1968). The mutual differences are clearly due to differences in the water temperature during the periods studied. Schockaert noted a mean water temperature of 1.1° C for the period January 1963- March 1963 with a minimal value of 0.6° C. These extremely low temperatures undoubtly delayed the growth of the shrimps of classes 62-B and 63-A. The observations for the period January 1971-March 1971 show higher values, with a mean temperature of 3.6° C and a minimum of 2.8° C. This explains why some of Schockaerts' curves have a lower position than the corresponding curves in figure 3.

The curves 71-A-f and 71-B-f are also in correlation with Boddeke's results (1966b).

The results confirm the utility of the Petersen method for determining growth curves of shrimps, as well as for males as for females. Havinga (1930) already used this method but only obtained satisfactory results for females. He performed a separation between males and females, based on external sex-characteristics. Havinga reported that he could follow the monthly shifts of the peaks in the length frequence distributions of males up to a length of about 46 mm. The progress of the growth curves could not be further followed because males greater than 50 mm were almost absent.

3.2. Sex change of *Crangon crangon* (L.).

Boddeke (1961, 1962a, 1962b and 1966a) indicated the sex change of *Crangon crangon* (L.). An identical phenomenon was already stated for *Pandalus montagui* Leach (Leloup, 1936) and recent investigation (Fréchette, Corrivault and Couture, 1970) reported the sex change of *Argis dentata* Rathbun.

Indeed, male shrimps with a length of 42-46 mm change into females during the period August-September. The egg development starts in the gonads and the endopodites of the first pleopods grow out to an egg-bearing length. Boddeke (1962a) also indicated the possibility of a second sex change in the period February-March. The important conclusion of these observations is the fact that undersized males really become consumption shrimps (Boddeke, 1962a).

The former investigations lead to an adaption of the growth curve model of Tiews. In this new concept line A must be a mixture of the classes 70-A-f and 69-A-m and line B of the classes 70-B-f and 69-B-m.

In this respect floating mean curves were constructed for egg-bearing females (f')(figure 4). If sex change does not take place, no growth curves for egg-bearing females may be found to coincide with growth curves for males. If, on the other hand, sex change really occurs the contrary is very probable. The growth curves for egg-bearing females are calculated in table 2.

Table 2 - Growth curves of egg-bearing females.

Line Y'	$n_{pf'}$ (1)	Regression (2)	r
A'	7	L = 0.084 t + 64.05	0.78
B'	10	L = 0.074 t + 57.51	0.92
C'-1 C'-2	11	L = 0.069 t + 51.11	0.83
C'-3	2	L = 0.217 t + 41.70	-
D'	8	L = 0.105 t + 37.65	0.91
E'-2	6	L = 0.074 t + 32.50	0.60
F'-2	4	L = 0.136 t + 25.71	0.98

(1) $n_{pf'}$: amount of peaks used for the curve.
(2) t : time in days ; t = 1 for September 1st, 1971.

Two χ^2-tests (Spiegel, 1961) were calculated in view of finding a significant difference between pairs of curves (table 3).

Table 3 - Results of the χ^2-tests.

Pairs of curves Y - Y'	χ_a^2 (1)	n_a (3)	p_a.100% (4)	χ_b^2 (2)	n_b (3)	p_b.100% (5)
A-A'	0.487	6	0.5	0.102	4	0.5
B-B'	0.519	9	0.5	0.073	6	0.5
C-1 C'-1 C-2 C'-2	0.928	10	0.5	0.011	7	0.5
D-D'	0.751	7	0.5	0.073	5	0.5
E-2 - E'-2	0.529	5	0.5-1.0	0.092	2	2.5-5.0
F-2 - F'-2	0.229	3	2.5-5.0	0.087	3	0.5-1.0

(1) χ_a^2 : between the points pf' of line Y' (egg-bearing females) and the corresponding growth curve Y of all the shrimps.

(2) χ_b^2 : between the lines Y' and the corresponding growth curves Y.

(3) n_a and n_b : degrees of freedom.

(4) p_a.100% : probability of significant variance between the points pf' and the corresponding growth curve Y.

(5) p_b.100% : probability of significant variance between the curves Y' and Y.

The curves C-3 and C'-3 were not tested because of the fact that there was only one degree of freedom.

The tests prove that there is no significant difference between the points pf' and the growth curves Y or between the curves Y' and the corresponding growth curves Y. This result confirms the thesis of Boddeke. The males changing into females during February 1972 (class 71-A-m), with a length of 46 mm, appear in the catches of March as fertile and egg-bearing females. The males from class 70-B change their sex in August-September 1971 (length about 44 mm) and appear in the December catches as egg-bearing females. For the same reason the classes 70-A-m, 69-A-m underwent sex change, respectively in February-March 1971, August-September 1970 and February-March 1970.

The corresponding peaks pf' of the curve F-3 did not appear because the males of class 71-B will only change into females during August-September 1972.

4. CONCLUSION.

The application of the floating mean method on the monthly length frequence distribution allows the use of the Petersen method to construct growth curves for shrimps (as well as for males as for females). The method also supports the hypothesis of Boddeke concerning the sex change of Crangon crangon (L.).

As this study is a preliminary approach of the use of the floating mean method in shrimps investigations, further long term and large scale research will be carried out.

5. SUMMARY.

The research aimed the utility of the floating mean method on the length frequency distribution, permitting the construction of accurate growth curves for shrimps.

The phenomenon of sex change of shrimps by using the combined Petersen-floating mean method was also investigated.

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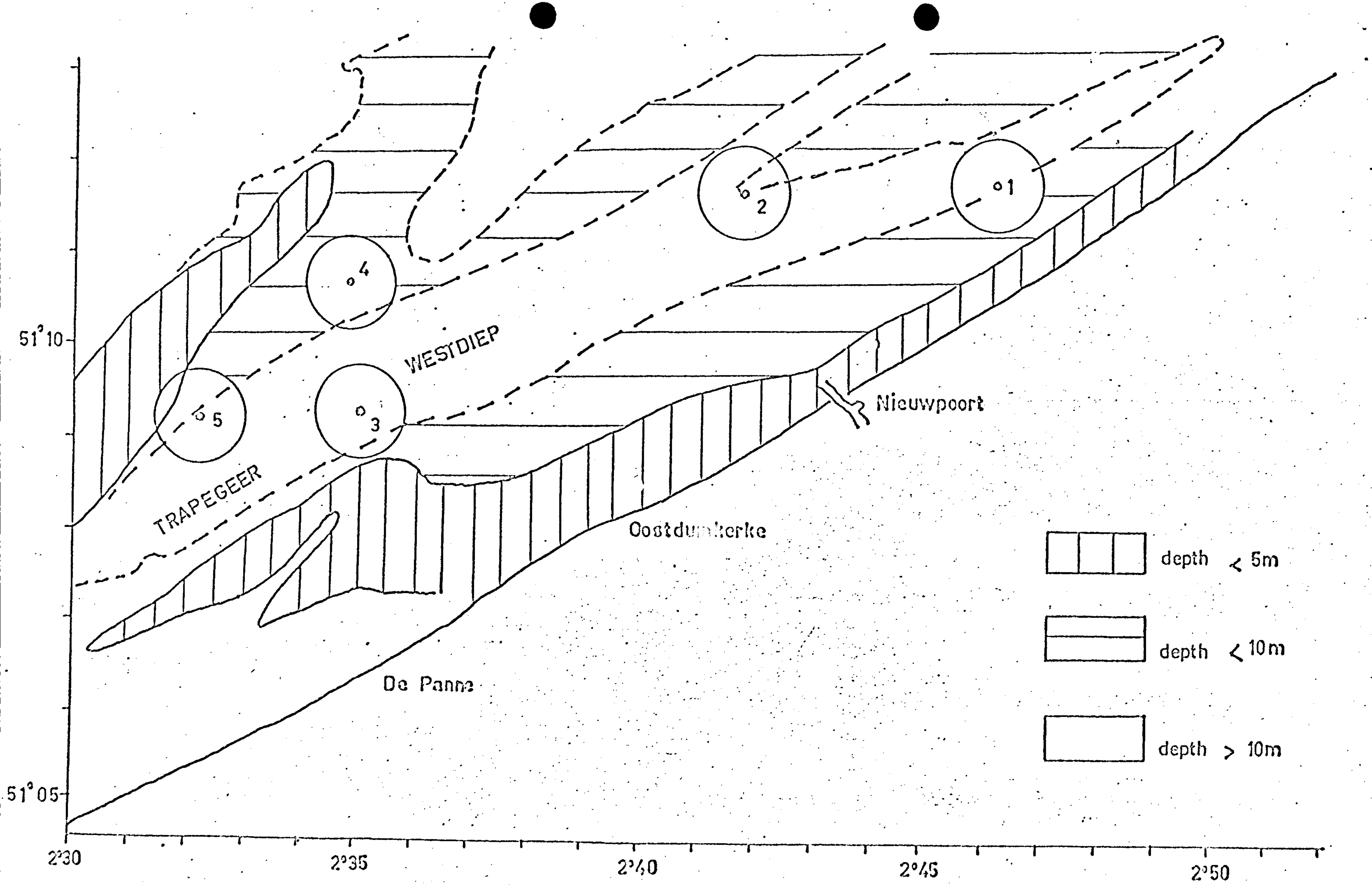

Figure 1_ Position of the 5 stations

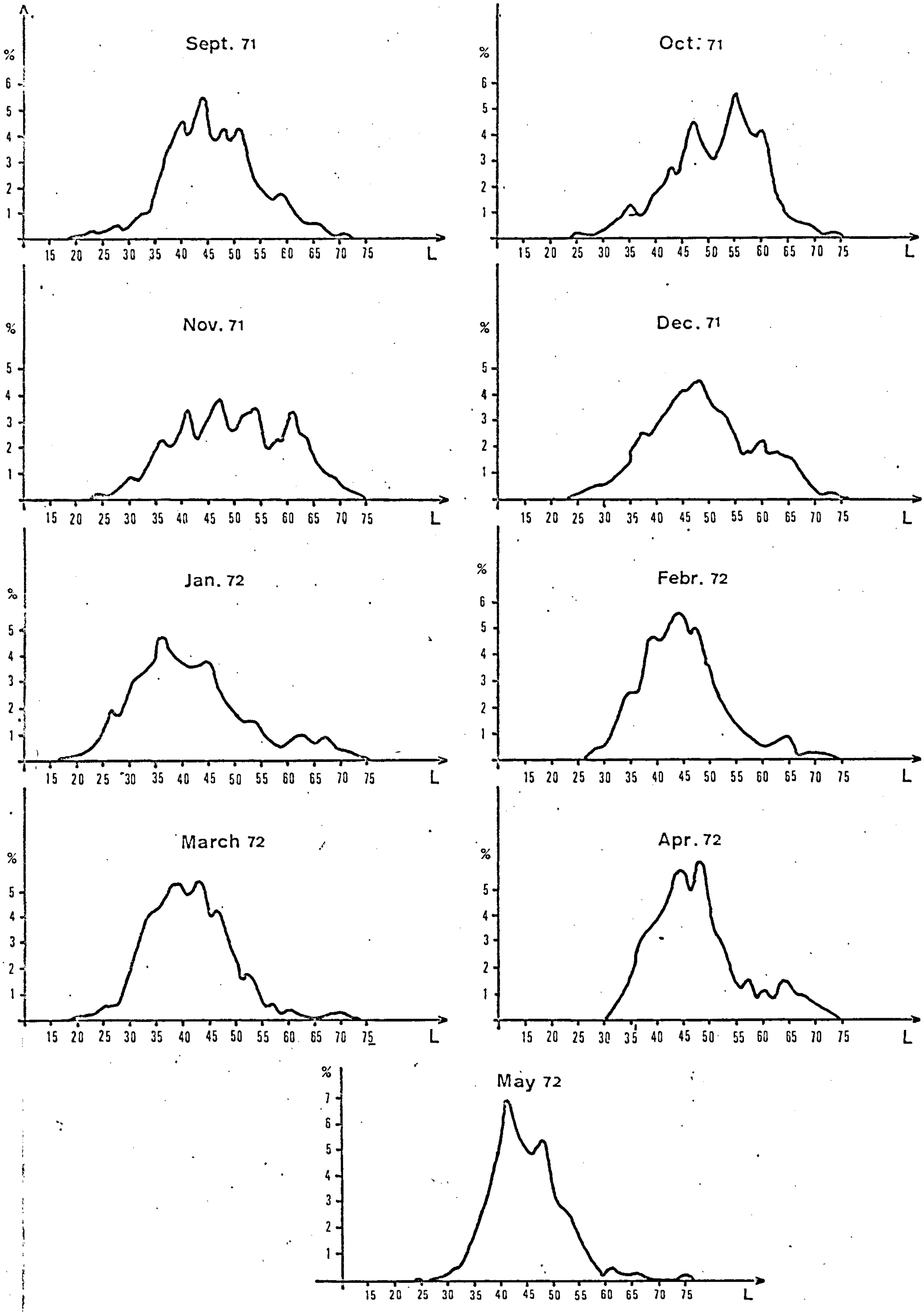

Figure 2 — Length frequency distributions during the period September 1971 — May 1972

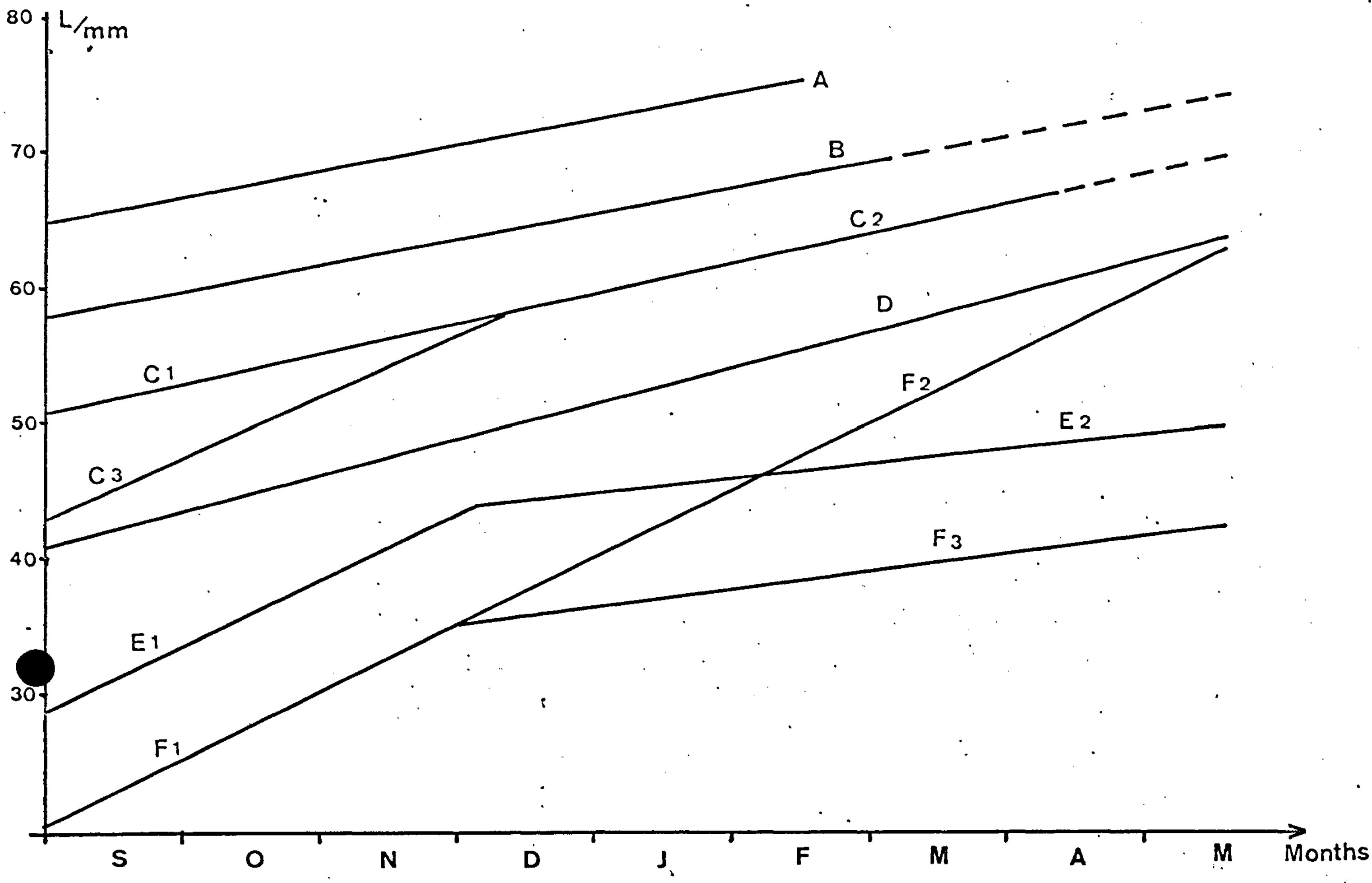

Figure 3 – Growth curves of all the shrimps

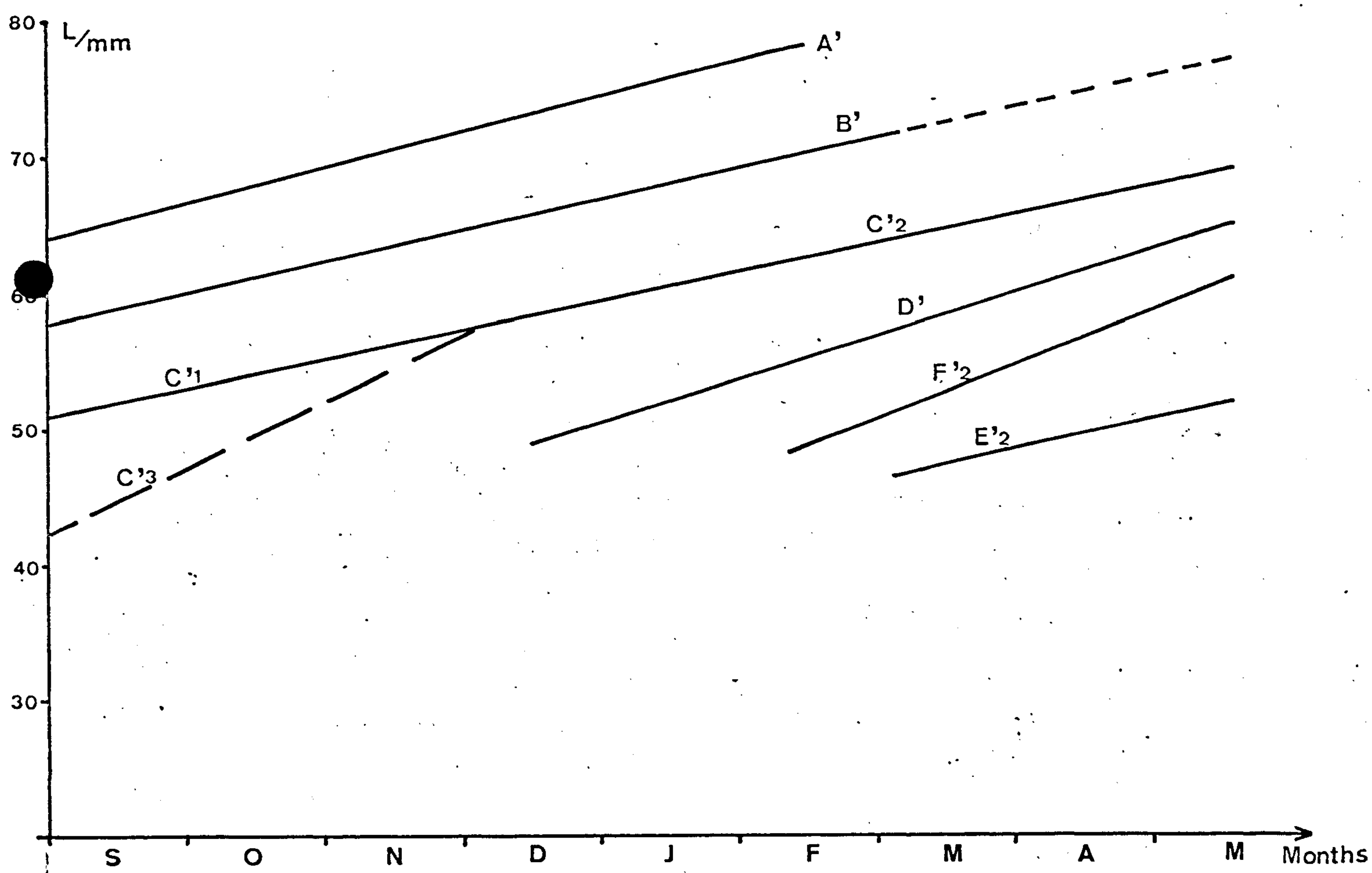

Figure 4 – Growth curves of the egg-bearing females .