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Growth of the Lobster, *Homarus Americanus*.

ARATA TERAQ. (Introduced by Raymond Pearl.)

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Among the workers on the growth of the lobster, credit is due to Hadley<sup>1</sup> for giving the best data yet available. The object of the present paper is to analyze Hadley's data mathematically and make some comments upon it.\*

It should be borne in mind that there remains something to be desired in Hadley's data. First of all, the material for the females is relatively poor, not only in deficiency of larger specimens but also in the sense that the growth curve abruptly shows linearity immediately after reaching the sexual maturity, if one assumes his time basis to be correct. And yet it is almost beyond doubt that his record of the males covers all the stages up to the oldest one, although his estimation of the age coupled with actual observation is trustworthy up to 6 years only.

It should first be noted that it is impossible to get by mathematical analysis any definite idea about the true age of the larger specimens out of the data at our disposal. First, taking all of Hadley's estimates of the age of the males for granted, a logarithmic parabola of the form,

$$y = a + bx + cx^2 + d \log (x-a)$$

was fitted by least squares. The constants, shifting the origin at  $-1$ , were as follows:

$$y = -739.62 + 0.67x - 0.0039x^2 + 562.03 \log (x + 20) \quad (1)$$

where  $y$  represents the length of the males in millimeters and  $x$  the age of the same in 60-day units. On the other hand, a logarithmic parabola fitted to the observations on the males up to 6 years (*i. e.*, over the period of definite observation as distinguished from estimates of age) gave the following result:

$$y = 2.51 + 5.69x - 0.00098x^2 + 38.44 \log x \quad (2)$$

where  $x$  and  $y$  represent the same variables as in (1) with the origin at  $-1$ . The maximum age of the males obtained from the equation (1) is 35.196 years, whereas the largest males, measuring 568 mm. in length, would be less than 15 years old in case their growth followed curve (2) further than 6 years.

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\* I am greatly obliged to Dr. John R. Miner for help in the matter of computation of the constants.

Turning now to another possible way of approaching the problem we may consider the lengths of the males in reference to the stages (ecdyses) equally spaced, there is seen to be an unmistakably logistic trend to the curve, as shown in Fig. 1, though in detail the fit is not particularly good. Computing the approximate values of the constants, we have

$$y = \frac{650}{1 + e^{4.38 - 0.178x}} \quad (3)$$

where  $y$  represents the length of the males in millimeters and  $x$  the ordinal number of the stages. The observed and calculated values of  $y$  are given in Table I.

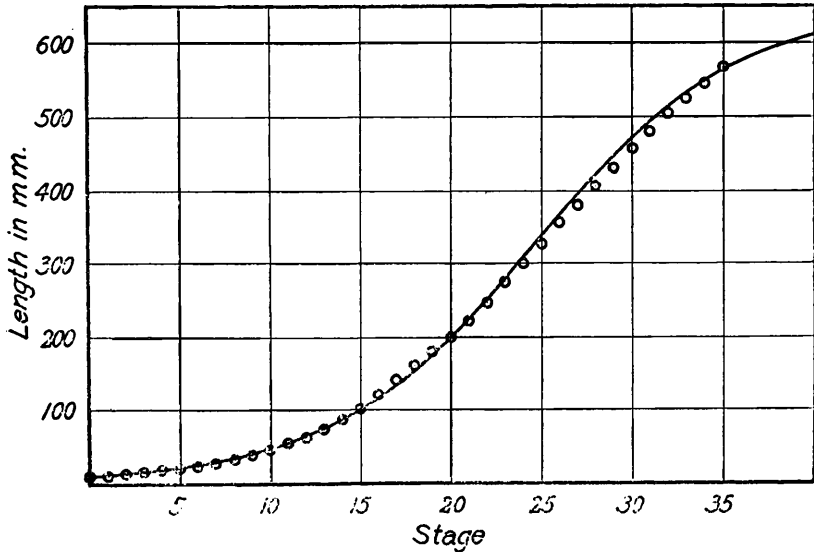


FIG. 1. Growth curve of male lobster. Abscissae = stages.

In this curve the abscissae represent biological rather than temporal age. What the time intervals are between the successive developmental stages is not known except for the early stages, but what is most certainly known is that they are not equal throughout the whole period of growth. In short Fig. 1 and Table I have no definite, known relation to time whatever. They represent growth only in terms of biological age. What the results show is that if it be assumed that each successive moult of a lobster represents an equal advance in its biologic age, the growth of the body in length follows approximately a logistic curve. Over the period of definite observations of temporal age (6 years) the growth in length of body does not follow a logistic course when plotted against time,

TABLE I.  
*Growth of the Lobster.*

Stage <i>x</i>	Observed <i>y</i>	Calculated <i>y</i>	Stage <i>x</i>	Observed <i>y</i>	Calculated <i>y</i>
0	8.2	8.02	18	162.0	153.81
1	9.6	9.55	19	180.0	175.72
2	11.4	11.39	20	200.0	199.51
3	13.5	13.57	21	222.0	224.99
4	16.0	16.16	22	247.0	251.90
5	18.8	19.23	23	275.0	279.92
6	22.5	22.74	24	300.0	308.63
7	26.5	27.13	25	327.0	337.60
8	32.0	32.16	26	356.0	366.37
9	37.9	38.08	27	380.0	394.50
10	45.0	45.00	28	406.0	421.57
11	53.0	53.07	29	431.0	447.26
12	62.0	62.44	30	457.0	471.28
13	73.0	73.26	31	480.0	493.44
14	86.0	85.69	32	505.0	513.66
15	102.0	99.85	33	525.0	531.89
16	121.0	115.88	34	546.0	548.17
17	141.0	133.85	35	568.0	562.39

but instead a logarithmic parabola. For this difference in the form of the growth curve in the lobster, when body length is plotted against (a) temporal and (b) biologic age, I have at present no explanation, but the fact seems worthy of record.

<sup>1</sup> Hadley, Philip P. 1906. 36th Ann. Rep. Comm. Inland Fish, Rhode Island, 153-226, pls. xxvi-xxxvii and xl. The same data are quoted in Herrick, Bul. U. S. Bur. Fish., 1911, xxix, 747.

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### Study of Alpha and Beta Units of an Anti-Paratyphoid Bacteriophage.

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Under the influence of a fresh, sewage filtrate we isolated a lytic agent for an old laboratory strain of *B. paratyphosus A*, in the S cyclostage. This filtrate, which was first active in F<sub>3</sub>, was enhanced to a high titer by alternate feeding and filtration in series. When tested by the plate method against the homologous culture there first appeared only large plaques. Later (F<sub>6</sub>), the filtrate gave small plaques in addition to the large. With continued propagation there was a tendency for the large plaques to be replaced by the small.