Bull. Fish. Res. Stn., Sri Lanka, Vol. 29, pp115-125, 1979

Use of Length-Weight Relationship in Grading Processed Beche-de-mer

By

M. S. M. SIDDEEK[1] and K. SACHITHANANTHAN[2]

Introduction

Holothurians belonging to the species *Holothuria scabra* are collected by diver—fishermen and processed for export. There is an active fishery for these animals in Palk Bay and Gulf of Mannar, off the North-Western Coast of Sri Lanka.

Processing involves cleaning the animals, evisceration, boiling, clearing the scum from the external surface, boiling again and drying. The dried product is elongated and cylindrical in shape and its size is directly related to the size of the live animal, viz., if smaller live animals are processed the products are smaller and if larger live animals are processed the product is larger. Traditionally the processed product is graded by the fishermen, according to size, girth and appearance. Broken, damaged or spoilt product is usually rejected. The traditional system of grading is not based on any standardized method.

Usually the sizes overlap into the adjacent grades, with the same size appearing in more than one grade. Even though the weight of the product is not taken into account for grading, there is an overlapping of weight, with product of the same weight appearing in more than one grade.

TABLE 1

Traditional System of Grading Beche-de-mer

Grade	*Size in Cm.*
SSFO	more than 11
SFO	10 - 11
FO	10 - 11
O	9 - 10
1	9 - 10
2	8 - 9
3	6 - 8
4	Less than 6

The absence of a standardized method of grading has led to unwarranted variation in sale prices and sometimes in loss of foreign exchange for Sri Lanka. In this paper an attempt is made to present a method to grade processed Beche-de-mer by using the length-weight relationship.

[1] Fisheries Research Station P. O. Box 531, Colombo 3.
[2] Department of Zoology, University of Jaffna, Tirunelvely,

10—A 45286 (80/03)

Method

Length and weight of processed Beche-de-mer in well dried form (oven dried at 105°C–110°C, to get constant weight) is determined to the accuracy of one-tenth of a centimetre in length, and one-thousandth of a gram in weight respectively. A graph is drawn with Log W against Log L, where—

W = weight in gm.
L = length in cm.

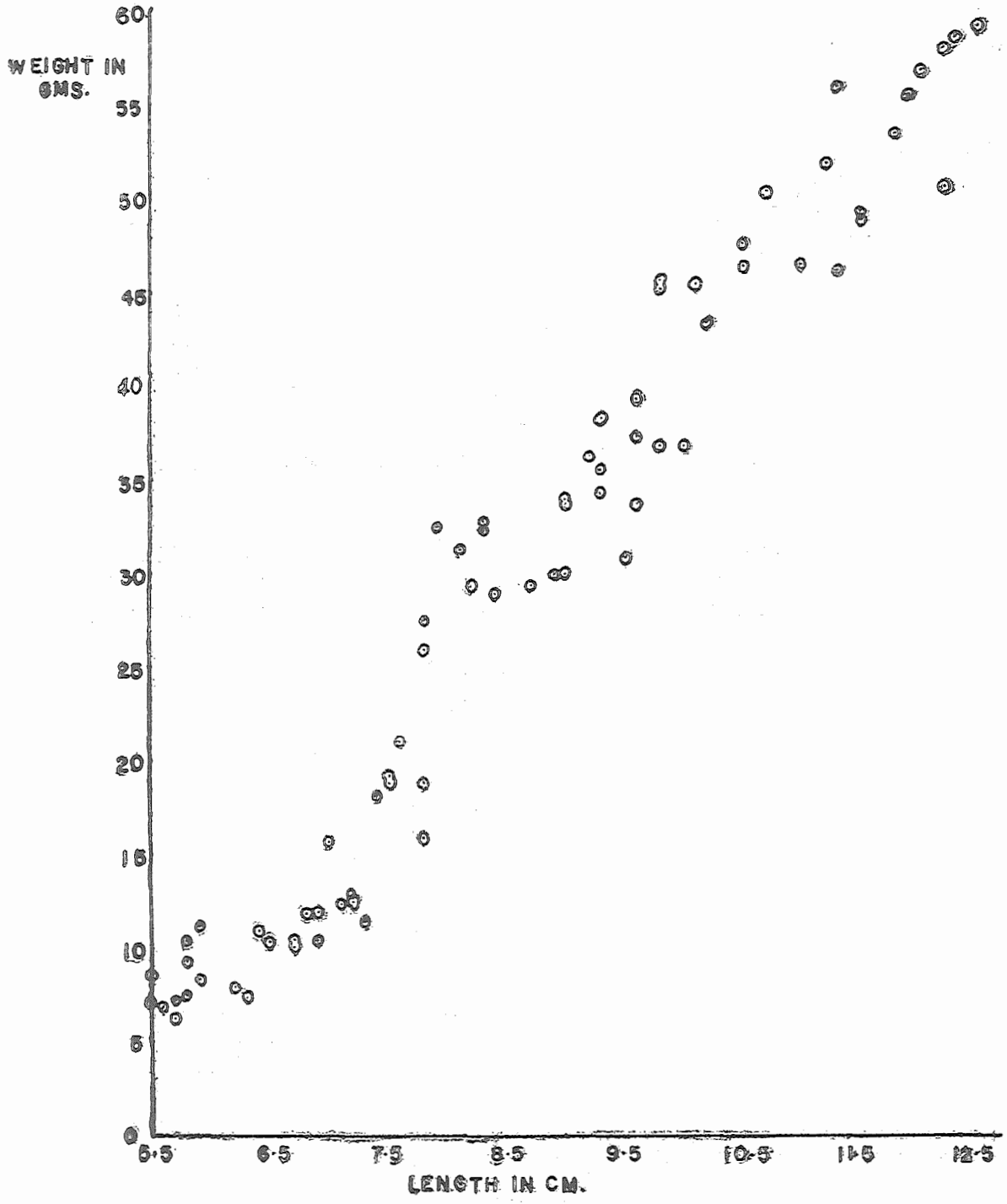

Fig. 1— Seatter diagram of weight vs. length of proeessed Bechc-de-mer.

Length-Weight Relationship

A scatter diagram plotted for weight vs. length appeared to consist of two discontinuous distributions, sigmoid in shape, one accounts for length between 5.5 cm. and 7.3 cm. and the other accounts for length between 7.8 cm. and 12.5 cm. (Fig. 1).

A general formula $W = a L b$

where W = weight in gm.

L = length in cm.

a and b are constants,

is tried to explain each distribution. Above formula is equivalent to the linear equation :

$$\text{Log } W = \text{Log } a + b \text{ Log } L.$$

Hence a linear regression between Log W vs. Log L is tried for each distribution. The lengths L, and the weights W, with their respective logarithms are arranged according to length groups of 0.1 cm. The values are given in Table 2A and Table 2B.

Test of linearity is done for the data Log L vs. Log W, for distribution A (length between 5.5 cm. and 7.3 cm.) and distribution B (length between 7.8 cm. and 12.5 cm.) respectively. To do this, 'F' test (Dixon, Massey, 1957) is used. The values obtained for each distribution are given in Table 3.

From Table 3, for distribution (A),

$$F = \frac{0.00455}{0.00267} = 1.7041 \text{ with } n_1 = 14, n_2 = 10.$$

Since the tabulated F value for $n_1 = 14$, $n_2 = 10$ is 2.886, which is higher than the value 1.7041, the calculated value is not significant at 5 per cent. level.

For distribution (B),

$$F = \frac{0.00134}{0.00113} = 1.1858 \text{ with } n_1 = 27, n_2 = 14.$$

Since the above F value is less than the tabulated F value 2.338, it is not significant at 5 per cent. level. Hence the relationship between Log W vs. Log L could be explained by a linear equation (Fig. 2).

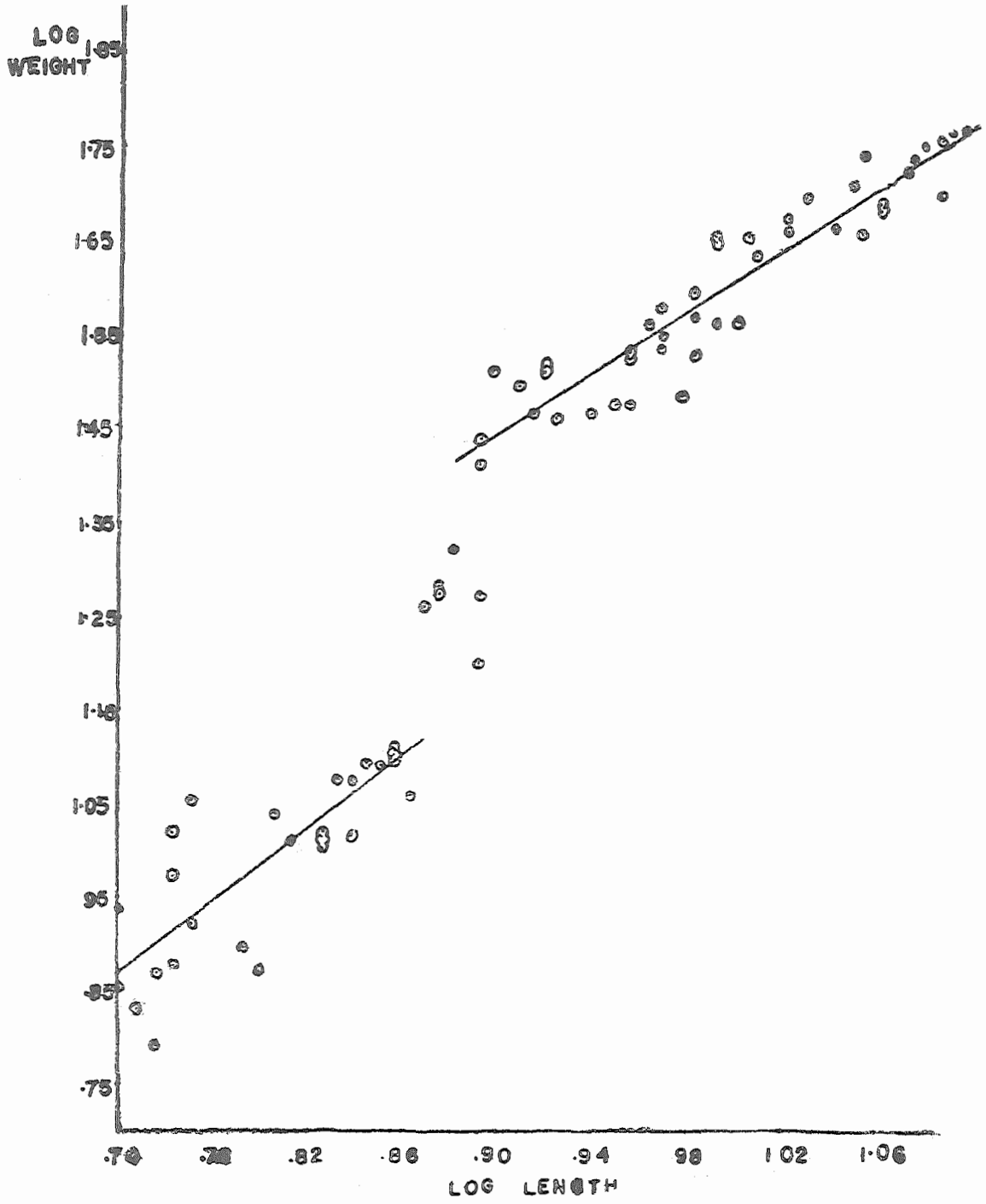

Fig. 2—Relationship of Log Weight to Log Length of processed Beche-de-mer.

The linear equations obtained by the least square method are given below :

FOR (A) $\bar{Y}_X = -0.5857 + 1.9637X,$ $5.5 < L < 7.3$

with $r = 0.8171$

FOR (B) $\bar{Y}_X = -0.0235 + 1.6355X,$ $7.8 < L < 12.5,$

with $r = 0.9400$

where $X = \text{Log } L$

$\bar{Y}_X$ = average Log W for a value X,

and r = correlation coefficient

Therefore FOR (A) $W = 0.2596\, L^{1.9637}$ $5.5 < L < 7.3$

FOR (B) $W = 0.9475\, L^{1.6355}$ $7.8 < L < 12.5$

Average Log W value for each length is calculated using either of the above two linear equations, depending on the length. 95 per cent. confidence limits for each average Log W is calculated using the formula:

$$\bar{Y}_x \pm t\, S_{Y\cdot x} \sqrt{\frac{1}{n} + \frac{(x-\bar{x})^2}{(n-1)S_x^2}}$$

where $\bar{Y}_x$ = Average Log W as calculated from the linear equations.

t = t value at 95% confidence level for $n-2$ degrees of freedom.

$$S_{Y\cdot x} = \frac{n-1}{n-2}\left[S_Y^2 - bS_x^2\right]$$

$$S_Y^2 = \frac{1}{n-1}\left[\sum_i \sum_j Y_{ij}^2 - n(\bar{Y})^2\right]$$

$$S_x^2 = \frac{1}{n-1}\left[\sum_i x_i^2 - n(\bar{x})^2\right]$$

$$b = \frac{\sum_i \sum_j x_i Y_{ij} - \dfrac{\sum x_i \sum_i \sum_j Y_{ij}}{n}}{\sum_i x_i^2 - \dfrac{(\sum x_i)^2}{n}}$$

n = sample number

95 per cent confidence limits for each average weight is determined by converting the logarithmic limits to antilogarithmic limits. The values obtained are given in Table 4A and Table 4B.

New Method of Grading

The weight is taken into account in formulating the new method of grading. 95 per cent. confidence interval of the moisture free weights are grouped so that each group has a range between 5.7 gm. to 6.2 gm. This particular range is selected, to allow each group to have its moist length (length before oven drying) range, starting from a whole number or a whole number and a half unit.

The moisture free length interval for each group is determined and the corresponding moist length interval is ascertained. The grades are identified in terms of the lower limits of each moist length interval. For example Grade 6 consists of products, the moist length of which lie in between 6.0 cm. to 7.4 cm. The products, moist lengths of which are less than 6 cm. are grouped under Grade 5, and those of lengths more than 13.5 cm. are grouped under Group 13.5. The new method of grading is given in Table 5.

In addition to the new method, other parameters such as appearance, girth, damage, etc., need consideration in the assessment of the grades.

ACKNOWLEDGMENT

The authors are indebted to the Northern Province Fisheries Co-operative Societies Union Ltd., for their assistance in obtaining samples, to Mr. A. Thevethasan, Fisheries Inspector, Miss D. Chandrasegaram, Laboratory Assistant, and Mr. T. A. Rajapakse, Laboratory Assistant, for their assistance in the laboratory.

REFERENCES

DIXON, W. J. & MASSEY, F. J. (JR.)

1957—*Introduction to Statistical Analysis*, McGraw-Hill, New York. pp. 189–198.

SACHITHANANTHAN, K.

1972—South Pacific Islands—Beche-de-mer fishery, FAO, FI. DP/RA3/69/102/11/pp. 1–32.

SACHITHANANTHAN, K.

1974—Beche-de-mer of the South Pacific Islands—A handbook for the fishermen. *South Pacific Commission, Noumea pp. 1–29.*

SACHITHANANTHAN, K. et. al.

De Scummer for Beche-de-mer *Bull. Fish. Res. Stn., Sri Lanka, Vol. 26, No. 1 pp. 9–13.*

TABLE 2A

No.	*L*	*W*	*Log L* $= X_i$	*Log W* Y_{ij}	X_i^2	Y_{ij}^2	$X_i . Y_{ij}$
1	5.5	8.646	0.7404	0.9368	0.5482	0.8776	0.6936
2	5.5	7.122	0.7404	0.8526	0.5482	0.7269	0.6313
3	5.6	6.754	0.7482	0.8296	0.5598	0.6882	0.6207
4	5.7	6.206	0.7559	0.7928	0.5714	0.6285	0.5993
5	5.7	7.336	0.7559	0.8655	0.5714	0.7491	0.6542
6	5.8	7.539	0.7634	0.8773	0.5828	0.7697	0.5697
7	5.8	9.382	0.7634	0.9723	0.5828	0.9454	0.7423
8	5.8	10.403	0.7634	1.0170	0.5828	1.0343	0.7764
9	5.9	11.251	0.7709	1.0511	0.5943	1.1048	0.8103
10	5.9	8.360	0.7709	0.9222	0.5943	0.8505	0.7109
11	6.2	7.852	0.7924	0.8950	0.6279	0.8010	0.7092
12	6.3	7.420	0.7993	0.8704	0.6389	0.7576	0.6957
13	6.4	10.901	0.8062	1.0374	0.6500	1.0762	0.8364
14	6.5	10.243	0.8129	1.0103	0.6608	1.0207	0.8213
15	6.7	10.357	0.8261	1.0153	0.6824	1.0308	0.8387
16	6.7	10.004	0.8261	1.0000	0.6824	1.0000	0.8261
17	6.7	10.315	0.8261	1.0136	0.6824	1.0274	0.8373
18	6.8	11.865	0.8325	1.0745	0.6931	1.1546	0.8945
19	6.9	10.357	0.8388	1.0153	0.7036	1,0308	0.8516
20	6.9	11.903	0.8388	1.0755	0.7036	1.1567	0.9021
21	7.0	15.615	0.8451	1.1937	0.7142	1.4249	1.0088
22	7.1	12.313	0.8513	1.0902	0.7247	1.1885	0.9281
23	7.2	12.532	0.8573	1.0979	0.7350	1.2054	0.9412
24	7.2	12.653	0.8573	1.1021	0.7350	1.2146	0.9458
25	7.2	12.838	0.8573	1.1086	0.7350	1.2290	0.9504
26	7.3	11.409	0.8633	1.0573	0.7453	1.1179	0.9128

[Length L in cm, Weight W in grams; log L (X_i .) log W (Y_{ij}, Y_{ij}^2, X_i^2, Y_{ij} and $X_i . Y_{ij}$]

TABLE 2B

No.	*L*	*W*	*Log L* $= X_i$	*Log W* $= Y_{ij}$	X_i^2	Y^2_{ij}	$X_i Y_{ij}$
1	7.8	27.551	0.8921	1.4401	0.7958	2.0739	1.2847
2	7.8	25.976	0.8921	1.4147	0.7958	2.0014	1.2621
3	7.9	32.552	0.8976	1.5126	0.8057	2.2880	1.3577
4	8.1	31.342	0.9085	1.4961	0.8254	2.2383	1.3592
5	8.2	29.469	0.9138	1.4693	0.8350	2.1588	1.3426
6	8.3	32.769	0.9191	1.5156	0.8447	2.2970	1.3930
7	8.3	32.418	0.9191	1.5108	0.8447	2.2825	1.3886
8	8.4	28.967	0.9243	1.4620	0.8543	2.1374	1.3513
9	8.7	29.355	0.9395	1.4678	0.8827	2.1544	1.3790
10	8.9	30.103	0.9494	1.4786	0.9014	2.1863	1.4038
11	9.0	33.745	0.9542	1.5281	0.9105	2.3351	1.4581
12	9.0	30.030	0.9542	1.4775	0.9105	2.1830	1.4098
13	9.0	34.047	0.9542	1.5321	0.9105	2.3473	1.4619
14	9.2	36.432	0.9638	1.5615	0.9289	2.4383	1.5050
15	9.3	38.345	0.9685	1.5837	0.9380	2.5081	1.5338
16	9.3	34.461	0.9685	1.5374	0.9380	2.3636	1.4890
17	9.3	35.614	0.9685	1.5515	0.9380	2.4072	1.5026
18	9.5	30.801	0.9777	1.4886	0.9559	2.2159	1.4554
19	9.6	33.775	0.9823	1.5286	0.9649	2.3366	1.5015
20	9.6	39.442	0.9823	1.5959	0.9649	2.5469	1.5677
21	9.6	37.321	0.9823	1.5719	0.9649	2.4709	1.5441
22	9.8	45.576	0.9912	1.6587	0.9825	2.7513	1.6441
23	9.8	45.109	0.9912	1.6544	0.9825	2.7370	1.6398
24	9.8	36.992	0.9912	1.5681	0.9825	2.4589	1.5543
25	10.0	36.973	1.0000	1.5678	1.0000	2.4580	1.5678
26	10.1	45.566	1.0043	1.6587	1.0086	2.7513	1.6658
27	10.2	43.403	1.0086	1.6375	1.0173	2.6814	1.6516
28	10.5	47.641	1.0212	1.6780	1.0428	2.8157	1.7136
29	10.5	46.360	1.0212	1.6662	1.0428	2.7762	1.7015
30	10.7	50.453	1.0212	1.7028	1.0597	2.8995	1.7529
31	11.0	46.540	1.0414	1.6679	1.0845	2.7819	1.7370
32	11.2	51.753	1.0492	1.7139	1.1008	2.9375	1.7982
33	11.3	55.942	1.0531	1.7477	1.1090	3.0545	1.8405
34	11.3	46.162	1.0531	1.6643	1.1090	2.7699	1.7527
35	11.5	48.963	1.0607	1.6898	1.1251	2.8554	1.7924
36	11.5	49.544	1.0607	1.6950	1.1251	2.8730	1.7979
37	11.8	53.563	1.0719	1.7289	1.1490	2.9891	1.8532
38	11.9	55.486	1.0755	1.7442	1.1567	3.0422	1.8759
39	12.0	56.929	1.0792	1.7553	1.1647	3.0811	1.8943
40	12.2	50.541	1.0864	1.7036	1.1803	2.9023	1.8508
41	12.2	57.821	1.0864	1.7621	1.1803	3.1050	1.9143
42	12.3	58.612	1.0899	1.7680	1.1879	3.1258	1.9269
43	12.5	59.407	1.0969	1.7739	1.2032	3.1467	1.9458

[Length L. in cm, Weight W in grams; log L (X_i), log W (Y_{ij}), X^2_i, Y^2_{ij} and $X_i Y_{ij}$.]

TABLE 3

[Test of linearity, Dixon and Massey 1957, (Introduction to Statistical Analysis), Values to calculate 'F']

	Source of Variation	*Sum of squares*	*Degree of freedom*	*Mean square*
A	Within groups	0.0267	10	0.00267
	Of regression line about sample mean	0.1701	1	
	Of group means about regression line	0.0637	14	0.00455
	Total	0.2338	15	
B	Within groups	0.0158	14	0.00113
	Of regression line about sample mean	0.4125	1	
	Of group means about regression line	0.0361	27	0.00134
	Total	0.4486	28	

TABLE 4A

No.	*L*	*W*	*Log L* $=X_i$	*Calculated log W*	*95% limits of log W*	*95% limits of W*
1	5.5	8.646	0.7404			
2	5.5	7.122	0.7404	0.8682	0.8237—0.9127	6.663—8.179
3	5.6	6.754	0.7482	0.8835	0.8427—0.9243	6.961—8.400
4	5.7	6.206	0.7559			
5	5.7	7.336	0.7559	0.8987	0.8615—0.9359	7.270—8.627
6	5.8	7.539	0.7634			
7	5.8	9.382	0.7634			
8	5.8	10.403	0.7634	0.9134	0.8796—0.9472	7.578—8.856
9	5.9	11.251	0.7709			
10	5.9	8.360	0.7709	0.9281	0.8970—0.9592	7.889—9.104
11	6.0		0.7782	0.9425	0.9137—0.9713	8.197—9.360
12	6.1		0.7853	0.9564	0.9301—0.9827	8.513—9.610
13	6.2	7.852	0.7924	0.9703	0.9453—0.9953	8.816—9.892
14	6.3	7.420	0.7993	0.9839	0.9595—1.0083	9.110—10.190
15	6.4	10.901	0.8062	0.9974	0.9731—1.0217	9.400—10.510
16	6.5	10.243	0.8129	1.0106	0.9856—1.0356	9.674—10.850
17	6.6		0.8195	1.0236	0.9980—1.0492	9.955—11.200
18	6.7	10.357	0.8261			
19	6.7	10.004	0.8261			
20	6.7	10.315	0.8261	1.0365	1.0089—1.0641	10.210—11.590
21	6.8	11.865	0.8325	1.0491	1.0197—1.0785	10.460—11.980
22	6.9	10.357	0.8388			
23	6.9	11.903	0.8388	1.0615	1.0298—1.0932	10.710—12.390
24	7.0	15.615	0.8451	1.0738	1.0395—1.1081	10.950—12.830
25	7.1	12.313	0.8513	1.0860	1.0493—1.1227	11.210—13.270
26	7.2	12.532	0.8573			
27	7.2	12.653	0.8573			
28	7.2	12.838	0.8573	1.0978	1.0583—1.1373	11.440—13.720
29	7.3	11.409	0.8633	1.1096	1.0672—1.1520	11.670—14.190

[Length L in cm., Weight W in grams, log L (X_i), calculated log W, 95% confidence limits of log W, 95% confidence limits of W.]

TABLE 4B

No.	*L*	*W*	*Log L* $=X_i$	*Calculated log W*	*95% limits of log W*	*95% limits of W*
1	7.8	27.551	0.8921			
2	7.8	25.976	0.8921	1.4355	1.4135—1.4575	25.91—28.67
3	7.9	32.552	0.8976	1.4445	1.4234—1.4656	26.51—29.22
4	8.0		0.9031	1.4535	1.4332—1.4738	27.11—29.77
5	8.1	31.342	0.9085	1.4624	1.4430—1.4818	27.73—30.33
6	8.2	29.469	0.9138	1.4710	1.4523—1.4897	28.32—30.88
7	8.3	32.769	0.9191			
8	8.3	32.418	0.9191	1.4797	1.4619—1.4975	28.97—31.44
9	8.4	28.967	0.9243	1.4882	1.4710—1.5054	29.58—32.02
10	8.5		0.9294	1.4965	1.4800—1.5130	30.20—32.58
11	8.6		0.9345	1.5049	1.4892—1.5206	30.84—33.16
12	8.7	29.355	0.9395	1.5131	1.4980—1.5282	31.48—33.75
13	8.8		0.9445	1.5212	1.5067—1.5357	32.12—34.33
14	8.9	30.103	0.9494	1.5292	1.5152—1.5432	32.75—34.93
15	9.0	33.745	0.9542			
16	9.0	30.030	0.9542			
17	9.0	34.047	0.9542	1.5371	1.5237—1.5505	33.40—35.53
18	9.1		0.9590	1.5449	1.5320—1.5578	34.04—36.13
19	9.2	36.432	0.9638	1.5528	1.5402—1.5654	34.69—36.76
20	9.3	38.345	0.9685			
21	9.3	34.461	0.9685			
22	9.3	35.614	0.9685	1.5605	1.5484—1.5726	35.35—37·38
23	9.4		0.9731	1.5680	1.5562—1.5798	35.99—38.00
24	9.5	30.801	0.9777	1.5755	1.5640—1.5870	36.64—38.64
25	9.6	33.775	0.9823			
26	9.6	39.442	0.9823			
27	9.6	37.321	0.9823	1.5831	1.5717—1.5945	37.30—39.31
28	9.7		0.9868	1.5904	1.5792—1.6016	37.95—39.96
29	9.8	45.576	0.9912			
30	9.8	45.109	0.9912			38.59—40.62
31	9.8	36.992	0.9912	1.5976	1.5865—1.6087	39.24—41.29
32	9.9		0.9956	1.6048	1.5937—1.6159	39.89—41.99
33	10.0	36.973	1.0000	1.6120	1.6009—1.6231	40.53—42.68
34	10.1	45.566	1.0043	1.6190	1.6078—1.6302	41.19—43.40
35	10.2	43.403	1.0086	1.6261	1.6147—1.6375	41.82—44.10
36	10.3		1.0128	1.6329	1.6214—1.6444	42.46—44.83
37	10.4		1.0170	1.6398	1.6280—1.6516	
38	10.5	47.641	1.0212			
39	10.5	46.360	1.0212	1.6467	1.6346—1.6588	43.11—45.58
40	10.6		1.0253	1.6534	1.6410—1.6658	43.75—46.32
41	10.7	50.453	1.0294	1.6601	1.6473—1.6729	44.39—47.09
42	10.8		1.0334	1.6666	1.6534—1.6798	45.02—47.84
43	10.9		1.0374	1.6732	1.6596—1.6868	45.66—48.62
44	11.0	46.540	1.0414	1.6797	1.6656—1.6938	46.30—49.41
45	11.1		1.0453	1.6861	1.6715—1.7007	46.93—50.20
46	11.2	51.753	1.0492	1.6925	1.6775—1.7075	47.59—50.99
47	11.3	55.942	1.0531			
48	11.3	46.162	1.0531	1.6988	1.6833—1.7143	48.23—51.80
49	11.4		1.0569	1.7051	1.6891—1.7211	48.88—52.61
50	11.5	48.963	1.0607			

TABLE 4 B—(*Contd.*)

No.	*L*	*W*	*Log L = X_i*	*Calculated log W*	*95% limits of log W*	*95% limits of W*
51	11.5	49.544	1.0607	1.7113	1.6948—1.7278	49.52—53.44
52	11.6		1.0645	1.7175	1.7004—1.7345	50.17—54.26
53	11.7		1.0682	1.7235	1.7059—1.7411	50.80—55.09
54	11.8	53.563	1.0719	1.7296	1.7116—1.7476	51.47—55.92
55	11.9	55.486	1.0755	1.7355	1.7170—1.7540	52.12—56.75
56	12.0	56.929	1.0792	1.7415	1.7224—1.7606	52.77—57.62
57	12.1		1.0828	1.7474	1.7277—1.7671	53.42—58.49
58	12.2	50.541	1.0864			
59	12.2	57.821	1.0864	1.7533	1.7330—1.7736	54.07—59.37
60	13.3	58.612	1.0899	1.7590	1.7382—1.7798	54.72—60.23
61	12.4		1.0934	1.7648	1.7434—1.7862	55.39—61.13
62	12.5	59.407	1.0969	1.7705	1.7486—1.7924	56.05—62.00

[Length L in cms, Weight W in grams, log L (X_i), calculated log W, 95% confidence limits of log W, 95% confidence limit of W.]

TABLE 5

Grade	*Moisture free Weight interval*	*Moisture free Weight range*	*Moisture free Length interval*	*Moist Length interval*
5	Less than 6.66 gm	—	—	Less than 6 cm
6	6.66—12.83 gm	6.17 gm.	5.5— 7.0 cm	6.0—7.4 cm
7.5	12.83—18.89*gm	6.06 gm	7.1— 7.5 cm	7.5—7.9 cm
8	25.91—32.02 gm	6.11 gm	7.8— 8.4 cm	8.0—8.9 cm
9	32.02—38.00 gm	5.98 gm	8.5— 9.4 cm	9.0—9.9 cm
10	38.00—44.10 gm	6.10 gm	9.5—10.3 cm	10.0—10.9 cm
11	44.10—50.20 gm	6.10 gm	10.4—11.1 cm	11.0—11.4 cm
11.5	50.20—55.92 gm	5.72 gm	11.2—11.8 cm	11.5—12.4 cm
12.5	55.92—62.00 gm	6.08 gm	11.9—12.5 cm	12.5—13.4 cm
13.5	More than 62.00 gm	—	—	13.5 cm and over

* Observed moisture free weight corresponding to moisture free length 7.5 cm was taken since the linear equation could not be applied for this value.

[Grade, moisture free weight interval, moisture free weight range, moisture free length interval, corresponding moist length interval.]