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Observations on Fishes of the Family Galaxiidae Part II

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Plates XVIII-XXVII

In Part I of these Observations (Scott, 1936), devoted to a taxonomic survey of the family, with descriptions of new species, the hope was expressed that in succeeding parts it would be found possible to consider the Tasmanian Galaxiidae described prior to 1936. The present contribution contains some biometric observations on the widely distributed *Galaxias* (*Galaxias*) *attenuatus* (Jenyns), relating chiefly to frequency distribution of standard length, including seasonal variations; rate of growth; variation of proportions with growth; growth-gradients; extra-aqueous viability. Non-metrical observations on this species are reserved for a subsequent communication.

CONVENTIONS AND ABBREVIATIONS

(*a*) *Unit of Measurement.* Except where otherwise expressly noted, all linear dimensions are recorded in millimetres; and, save in a few cases in which such procedure might result in uncertainty or confusion, considerable typographic economy is achieved by the systematic omission in the body of the paper of the unit of measurement.

(*b*) *Criteria of Length.* Total length (from tip of snout to tip of normally extended caudal fin; between parallels), and standard length (from tip of snout to hypural fan; between parallels) are designated by **LT**, **LS**, respectively.

(*c*) *Groups of Material.* PC, NPC, TT denote, respectively, metrically examined material from Punchbowl Creek, from Tasmanian localities other than Punchbowl Creek, from all Tasmanian localities.

(*d*) *Mathematical Conventions and Abbreviations.* Length-classes are designated by value of midpoint of relevant interval (*e.g.*, 45 = class-value of 40 – 50). b = fractional coefficient (in simple heterogony formula $y = bx^k$). (f) = frequency in a class-interval. h = width of class-interval. k = growth-coefficient (in simple heterogony formula $y = bx^k$). Md = median: in series with even number of terms Md is taken as arithmetic mean of bracketing terms; and is not weighted. M_o = mode; throughout crude, not weighted in short series. n = number of individuals. N_s = survival-sequence number. Q, Q_1, Q_3 = quartile deviation, first quartile, third quartile, respectively. S_k = measure of skewness (Pearson's approximate formula $S_k = \frac{3(\bar{x} - \text{Md})}{\sigma}$ used). V = coefficient of variation $\left(V = \frac{\sigma}{\bar{x}} \times 100 \right)$. $\bar{x}$ = arithmetic mean. σ = standard deviation = $\sqrt{\frac{\Sigma (x - \bar{x})^2}{n}}$: no substitution of n - 1 for n in small series (Huxley *et al.*, 1927).

Material and Localities

Material examined comprises upwards of sixteen hundred specimens, representing some thirty Tasmanian, and several extralimital, localities. It may conveniently be enumerated under the four headings noted below: The addition of an asterisk indicates that in the series thus marked *G. (G.) attenuatus* (Jenyns) occurs in association with *G. (G.) truttaceus* Cuvier.

(*a*) *Punchbowl Creek, Launceston.* 41 series. Locality indicated by C in accompanying map (Fig. 1). Series 11, 6/2/34; 27, 7/5/34; 36, 22/7/34; 44, 24/11/34; 45, 25/11/34; 46, 2/12/34; 55, 6/1/35; 61, 10/2/35; 70, 10/3/35; 73, 74, 7/4/35; 81, 18/8/35; 89*, 8/11/35; 90*, 10/11/35; 91*, 24/11/35; 92*, 15/12/35; 104, 16/2/36; 113, 27/9/36; 114, 4/10/36; 115*, 18/10/36; 117*, 22/11/36; 119, 31/12/36; 123, 124*, 125*, 126*, 127, 128, 31/1/37, 14/2/37, 7/3/37 (two examples on each date); 129*, 21/3/27; 132, 6/4/37; 133-138, 18/4/37, 9/5/37, 13/6/37 (two examples on each date); 139, 25/7/37; 141, 142, 10/9/37; 143, 26/9/37; 144, 6/10/37. Where two series are entered under one date, the first is from *Larnoo* section, second from Reserve section.

(*b*) *Other Tasmanian Localities.* 42 series. Localities shown by A-B, D-Z, a-b, d-e. Series 4*, Kelso (A), 22/12/33 (R. Slater); 8, marsh near Low Head (B), 22/1/34 (R. Green); 13, East Risdon (D), 17/2/34 (V. V. Hickman); 14 and 15, River Tamar, at Launceston (E), 9/3/34 and 12/3/34; 17*, Cox's Creek, Wynyard (F), 29/3/34 (J. Harrison); 18*, North Esk, at St. Leonards (G), 29/3/34 (A. L. Meston); 26, River Tamar (H), 18/4/34 (J. Tyler); 28*, Franklin (I), 26/4/34 (A. B. Gaul); 37, creek at Kimberley (J), 3/9/34 (A. Knowles); 38*, 39*, 40*, River Tamar (H), 17/9/34 (whitebait); 41*, Upper Scamander (K), 18/10/34 (A. E.

Elms); 42, South Esk, at Launceston (L), 20/11/34; 43*, Cox's Creek, Wynyard (F), 24/11/34 (J. Harrison); 50, creek at *Heazleton*, Ulverstone (M), 23/12/34; 51, Button's Creek, Ulverstone (N), 24/12/34; 52* and 53*, Cox's Creek, Wynyard (F), 27/12/34; 54*, Clayton Rivulet (C), 31/12/34; 58, Kelso (A), 29/1/35 (R. Slater); 72*, Devonport (P), 14/3/35 (A. Smith); 76, Meredith River (Q), 21/4/35 (G. V. Colchester); 82, Button's Creek, Ulverstone (N), 28/8/35; 83, creek at *Heazleton*, Ulverstone (M), 29/8/35; 84, Beattie's Creek, Forth (R), 31/8/35; 85, Don River (S), 31/8/35; 86*, creek at Spreyton (T), 1/9/35; 93, Young Town (U), 28/12/35 (R. Gardam); 95*, creek about 4 miles south of Sorell, West Coast (V), 2/1/36 (A. L. Meston); 103, Kelso (A), 17/4/35 (R. Slater); 106, North Esk, at Killafaddy (X), 20/1/35; 107, Button's Creek, Ulverstone (N), 25/12/35; 108*, Latrobe (Y), 14/9/35 (whitebait); 109*, Big Eel Creek, near Temma (Z), 6/2/36 (S. L. Larnach); 110* and 111*, Mella (a), 17/4/36 and 28/4/36 (B. Burnley); 118*, Stony Creek, near Swansea (b), 2/12/36 (G. C. McKinlay); 120*, Pieman River, at mouth (d), 23/1/37 (A. L. Meston); 140, Welcome River (e), 30/12/36 (A. L. Meston).

(*c*) *Extralimital Material.* Material from Flinders Island (not included in map, and conveniently dealt with in this section), and from several Australian and South American localities, has also been examined.

(*d*) *Tank-Series.* Specimens from various localities, the most important being Punchbowl Creek, Launceston, have been kept alive in observation tanks over a period of three years.

In Table I a dagger indicates the series is bimodal or plurimodal. Values for these series are as follows. (a) **LS.**—Series No. 13; modal classes 75, 95 [4]: 15; 75, 85, 95, 105 [2]: 41; 85, 95, 105, 115 [1]: 54; 45, 55 [7]: 58; 175, 185 [1]: 76; 105, 115 [2]: 109; 75, 95, 105 [1]: 113; 55, 65 [2]: 119; 45, 55 [7]: 135; 45, 55 [2]. (b) **LT.**—15; 85, 95, 115 [2]: 17; 55, 95 [3]: 58; 195, 205 [1]: 70; 55, 65 [15]: 76; 115, 125 [2]: 109; 95, 105, 125 [1]: 113; 65, 75 [2]: 114; 65, 75, 85 [3]: 127; 55, 65 [7]: 136; 45, 55 [8]: 140; 85, 105 [4].

Specification of LS, LT

LS, **LT** have been determined for 62 Tasmanian series, comprising 1415 individuals, from 24 localities [1]: this material is specified, first, by series (min., max., $\bar{x}$, Md, M_o, σ) in Table I, secondly, in three groups, below.

[1] This represents nearly 90% of Tasmanian specimens. Material not subjected to metrical examination consists essentially of tank-series, whitebait-series, and series consisting of only a single individual: further, several Punchbowl series collected otherwise than by trapping, though actually measured, are here excluded from consideration in order to secure a more representative, more nearly random, sampling of the stream-population.

TABLE I.

Galaxias (G.) attenuatus (Jenyns)

SPECIFICATION OF LS, LT: 62 SERIES, 1415 INDIVIDUALS

Material		Standard Length = LS (mm.)						Total Length = LT (mm.)					
Series No.	No. of Individuals	Min.	Max.	$\bar{x}$	Md	M_0 (h = 10) No. of cases	σ	Min.	Max.	$\bar{x}$	Md	M_0 (h = 10) No. of cases	σ
8	4	96·1	119·6	108·7	109·5	115 [2]	8·96	110·1	134·2	123·1	124·1	115 [2]	9·21
13	16	55·0	113·0	90·9	95·8	†	15·44	63·0	130·0	104·0	110·5	115 [6]	17·62
14	10	67·5	97·9	87·1	90·2	95 [5]	8·34	78·0	109·9	99·1	102·6	105 [6]	8·91
15	9	53·2	109·3	86·6	86·2	†	16·79	61·7	124·2	98·9	99·0	†	17·97
17	12	44·1	96·5	68·4	67·4	85 [3]	15·32	50·7	109·0	70·3	76·7	†	17·30
18	5	54·5	64·0	59·2	60·0	65 [3]	3·34	62·9	73·0	68·1	68·6	65 [3]	3·56
26	3	64·1	80·1	70·5	67·2	65 [2]	6·93	74·2	90·8	80·7	77·0	75 [2]	7·26
36*	3	74·3	85·0	78·4	76·0	75 [2]	4·70	82·5	96·1	88·2	86·0	85 [2]	5·77
37	3	70·9	83·1	78·0	80·1	85 [2]	5·19	81·9	95·2	89·6	91·6	95 [2]	5·62
41	4	81·2	112·0	97·5	98·4	†	11·19	92·7	127·4	111·6	113·1	115 [2]	12·45
43	6	68·9	108·0	94·6	96·3	95 [3]	12·53	77·6	123·0	107·0	108·2	105 [3]	14·56
45*	21	36·1	47·0	42·4	42·6	45 [16]	2·71	41·1	52·6	48·3	48·4	45 [16]	2·84
46*	32	36·5	57·8	43·8	43·1	45 [22]	5·43	42·0	65·1	49·9	49·0	45 [19]	5·84
50	9	46·1	64·0	53·0	51·3	55 [6]	5·27	53·0	72·0	60·4	59·0	55 [6]	5·48
51	33	34·9	93·2	49·2	43·4	45 [13]	15·66	40·0	106·1	55·9	49·0	45 [16]	17·80
52	78	33·4	60·2	50·1	49·6	45 [40]	4·33	38·5	69·1	57·1	56·5	55 [51]	4·96
53	15	42·6	57·0	49·6	48·2	45 [9]	4·13	49·0	64·6	56·5	55·9	55 [10]	4·89
54	29	40·6	88·3	59·2	60·1	†	11·27	46·0	100·5	68·1	68·9	65 [8]	10·95
55*	85	38·0	81·9	48·7	47·8	45 [46]	8·10	43·5	92·2	55·4	53·8	55 [29]	9·12
58	2	172·0	185·0	178·5	178·5	†	6·50	192·0	207·0	199·5	199·5	†	7·50
61*	43	37·5	72·0	47·4	44·5	45 [27]	8·81	43·0	82·0	54·2	51·0	45 [19]	8·94
70*	48	36·0	87·0	55·5	55·4	55 [18]	10·04	41·5	99·0	64·3	62·6	†	11·05
73*	29	39·0	88·0	54·4	51·0	55 [12]	11·75	45·0	100·0	62·6	60·0	55 [13]	13·35

74*	25	41·6	71·9	51·2	50·0	45 [12]	7·24	48·0	82·0	58·5	58·0	55 [13]	8·06
76	6	98·0	124·0	109·6	110·0	†	8·87	113·5	145·0	126·3	126·0	†	10·60
81*	11	44·7	77·1	57·7	58·0	45 [4]	11·86	50·5	87·6	65·9	66·6	55 [5]	13·32
82	33	36·6	74·2	46·2	41·2	45 [15]	9·34	42·3	84·2	52·6	46·5	45 [23]	10·84
83	3	71·5	87·1	78·1	75·6	75 [2]	6·60	83·1	100·3	90·2	87·2	85 [2]	7·34
84	27	31·1	79·7	42·1	40·1	35 [13]	9·41	35·8	90·1	47·8	45·4	45 [24]	11·30
86	9	48·0	72·1	55·3	52·1	55 [4]	7·69	56·0	82·6	63·8	60·1	55 [5]	8·63
89*	33	33·5	51·5	40·4	39·0	35 [19]	4·72	38·8	58·5	45·4	44·0	45 [26]	5·34
90*	10	38·3	89·0	47·5	40·0	35 [5]	14·67	43·5	98·5	53·8	45·3	45 [6]	15·72
91*	55	34·1	88·8	43·1	41·5	35 [26]	9·45	39·5	99·0	49·3	47·2	45 [34]	10·74
92*	35	33·5	92·6	50·4	41·2	35 [16]	17·70	37·9	106·7	58·0	47·7	45 [19]	20·44
93	5	75·7	98·4	88·7	90·6	95 [3]	8·63	87·3	109·6	100·2	102·0	105 [3]	8·81
95	5	47·7	109·5	87·2	100·1	105 [3]	27·24	56·3	124·5	96·3	114·8	125 [2]	30·60
100	25	35·6	48·7	39·5	38·6	35 [19]	2·76	41·8	55·7	45·2	44·5	45 [23]	3·30
106	34	37·5	70·4	52·6	54·1	55 [16]	8·83	42·5	81·1	59·9	60·9	65 [13]	8·54
107	31	39·7	92·5	51·3	47·6	45 [20]	11·13	45·1	103·4	57·5	54·0	55 [18]	12·42
109	3	79·9	106·0	93·8	95·4	†	10·74	94·3	121·1	108·2	109·3	†	10·96
110	73	64·0	133·8	92·9	100·5	105 [17]	17·81	72·5	151·5	107·6	114·0	125 [15]	19·87
111	14	34·6	123·2	62·1	56·1	55 [4]	25·58	40·1	138·4	71·9	64·5	65 [5]	28·75
113*	5	53·5	79·0	64·2	65·2	†	9·23	62·0	89·0	73·3	74·5	†	9·29
114*	11	51·6	84·6	65·6	62·1	65 [4]	9·54	59·0	93·0	74·5	70·5	†	10·14
115*	43	34·4	90·1	42·5	39·7	35 [29]	9·98	40·3	104·0	48·6	45·2	45 [39]	11·32
117*	57	36·5	65·3	42·8	41·8	45 [36]	4·28	41·7	73·9	48·8	47·8	45 [39]	5·91
119*	16	40·3	65·5	51·2	50·3	†	6·92	46·2	74·5	58·7	57·6	55 [7]	7·88
123*	31	41·0	90·7	58·1	57·2	55 [14]	10·77	47·0	102·0	66·0	64·6	65 [14]	11·70
124*	43	37·5	80·8	47·3	44·5	45 [26]	7·73	43·9	93·0	54·1	51·3	45 [20]	8·94
125*	32	36·4	62·2	49·1	51·4	55 [16]	6·65	42·1	70·8	56·8	55·1	55 [16]	7·50
126*	21	35·1	65·0	42·1	42·5	45 [13]	6·84	41·0	74·1	50·4	48·0	45 [14]	7·32
127*	20	39·0	80·1	56·4	52·1	55 [9]	11·92	44·9	91·9	64·7	60·2	†	13·49
128*	32	36·0	46·0	40·1	39·0	35 [20]	3·13	41·5	52·6	46·1	45·0	45 [26]	3·17
129*	51	33·6	83·1	44·4	42·5	45 [27]	8·97	39·0	95·9	51·9	48·6	45 [25]	10·24
133*	17	45·1	66·5	54·7	53·3	45 [7]	7·00	51·8	76·2	62·4	60·7	55 [7]	7·79
134*	20	37·2	50·1	42·6	42·7	45 [14]	3·24	43·2	57·3	48·4	48·5	45 [14]	3·61
135*	5	43·2	63·1	53·4	52·8	†	7·66	49·6	71·9	61·3	61·2	65 [2]	8·44
136*	21	37·6	58·5	47·1	46·5	45 [11]	6·01	43·2	67·1	54·0	53·2	†	6·87
137*	7	38·7	47·0	44·1	44·6	45 [6]	2·48	44·3	54·0	50·3	50·4	55 [5]	2·79
138*	22	35·4	54·8	42·7	41·5	45 [12]	4·57	41·0	62·8	48·1	48·8	45 [17]	5·52
139*	13	42·7	67·5	48·9	47·6	45 [10]	6·63	48·4	77·0	56·2	55·0	55 [8]	7·47
140	12	59·9	107·4	87·2	91·2	75 [4]	13·98	69·0	121·0	99·1	102·8	†	15·35

(*a*) *Punchbowl Creek.* PC[1] material comprises 32 series, 897 specimens. All series trapped. Statistics of **LS, LT** for separate series exhibited in Table I. For total PC material we have, as regards **LS**, min. 33·5, max. 92·6, $\bar{x}$ 47·94, Q_1 39·66, Md 43·93, Q_3 51·62, M_0 (with $h = 10$) 45 (429 cases), σ 10·445: as regards **LT**, min. 37·9, max. 106·7, $\bar{x}$ 55·02, Q_1 45·40, Md 50·23, Q_3 59·18, M_0 45 (397 cases), σ 11·865. **LS** deciles are 37·4, 39·0, 40·4, 42·1, 43·9, 46·4, 49·8, 53·8, 60·2.

This material is peculiarly appropriate for the investigation of frequency distribution, and, in spite of the absence of very small and of very large individuals, almost certainly provides, at least between the limits 33 $\leq$ **LS** $\leq$ 92, a more characteristic sample of the general population than that afforded by NPC and TT material.

Its more homogeneous and typical character is attributed, first, to the single source of the material;[2] secondly, to reasonably regular distribution over the various months of the season, and thirdly, and, in practice, most notably, to the method of collection, namely trapping,[3] which results in the elimination, or at least the great reduction, of the differential effects of angling and hand-netting, reliance on which methods commonly tends—partly on the ground of mere physical facility, and partly from conscious and unconscious selection

[1] The abbreviations PC (= Punchbowl Creek), NPC (= Tasmanian; Non-Punchbowl Creek), TT (= Total Tasmanian) denote only the metrically examined material, not the total material, from these localities.

[2] Punchbowl Creek, 3-4 miles long, rises among the hills westward of Young Town, and enters the North Esk River, here subject to a rise and fall of tide totalling about six feet, a few chains south of the southern boundary of *Ravenscraig*, the Scotch College estate, the northern side of which lies within 100 yards of the boundary (1935) of the City of Launceston.

Portion of the creek studied, approximately one mile, is conveniently divided into four sections, which, proceeding in direction of flow (eastward), are as follows. (1) First Reserve Section—in Punchbowl Reserve, about 230 yards long, above (west of) waterfall (about 30 feet high); no fish have been observed here. (2) Second Reserve Section—about 640 yards long, below waterfall; always with fish; material designated Reserve collected in this section. (3) *Larnoo* Section—about 540 yards long, running through Mr. H. W. A. von Steiglitz's estate *Larnoo*; greater part of material (specified as *Larnoo*) secured here. (4) *Queechy*; section—divided from (3) by large culvert beneath Penquite Road; about 340 yards long, in Mr. W. Fraser's estate *Queechy*.

[3] Very satisfactory results are obtained with a flywire minnow trap in the form of an open cylinder, about 2 feet long and 1 foot in diameter, fitted at either end with an inwardly directed cone, about 8 inches high, with the apex truncated to provide an entrance 1½-2 inches in diameter; bait (one or two worms) suspended from wire hook hanging down into middle of trap; attach 2 or 3 yards of cord to one end of trap for retrieving; immerse (bare submergence is usually advisable) for 5-10 minutes, with long axis in direction of flow of stream; a door for extraction of fish may be provided, if desired.

by the collector—to the collecting in unduly high proportions of individuals of large or moderate size (*cf.*, for instance, Regan's British Museum material, noted below).

(*b*) *Other Tasmanian Localities.*—NPC material comprises 30 series, 518 specimens, from 22 localities. Statistics of **LS**, **LT** for separate series exhibited in Table I.

For total NPC material we have, as regards **LS**, min. 31·1, max. 185·0, $\bar{x}$ 63·98, Q_1 44·55, Md 53·89, Q_3 83·13, M_0 (with $h = 10$) 45 (147 cases), σ 25·222 : as regards **LT**, min. 35·8, max. 207·0, $\bar{x}$ 71·23, Q_1 50·96, Md 61·50, Q_3 92·67, M_0 55 (120 cases), σ 28·427. **LS** deciles are 38·6, 42·0, 46·4, 49·3, 53·9, 60·2, 76·4, 92·1, 104·6.

(*c*) *Total Tasmanian Material.*—TT material comprises 62 series, 1415 specimens, from 30 localities. Statistics of **LS**, **LT** for separate series exhibited in Table I.

For TT material as a whole we have, as regards **LS**, min. 31·1, max. 185·0, $\bar{x}$ 53·81, Q_1 40·50, Md 46·73, Q_3 57·06, M_0 (with $h = 10$) 45 (573 cases), σ 35·049: as regards **LT**, min. 35·8, max. 207·0, $\bar{x}$ 60·96, Q_1 46·05, Md 53·58, Q_3 65·16, M_0 45 (508 cases), σ 35·735. **LS** deciles are 37·7, 39·5, 41·5, 43·8, 46·7, 50·0, 54·4, 61·0, 83·3.

Comparison of PC, NPC, TT Material

These three groups of PC, NPC, TT material may profitably be compared by means of percentile curves [1]: those for **LS**, based on the deciles, are shown in Fig. 2.

Note general regularity of increase, proceeding to right of the ogive, of TT over PC values; with sharp ascent for max. value, largely traceable to influence of Series 58.

For PC, $Q_{LS} = 11·96$, $Q_{LT} = 13·78$; for NPC, $Q_{LS} = 38·58$, $Q_{LT} = 41.71$; for TT, $Q_{LS} = 16·56$, $Q_{LT} = 19·11$. High values of the interquartile intervals for NPC material are in part attributable to varied modes of collection, a factor whose influence in TT material is largely counteracted by the homogeneity of the numerically preponderant PC element.

[1] Percentile curve is here used for a curve having as ordinate the value of the percentile, and as abscissa the percentile index, p. The term is also often applied to a cumulative frequency curve, in which integrated frequency is represented by the ordinate, and values of the variable by the abscissa. It is more in harmony with mathematical convention to name a curve according to what is represented by the ordinate, and it is hence desirable (Holzinger, 1928) to restrict Percentile Curve to the connotation with which it is here employed.

Assuming—probably with a fair degree of accuracy—that specimens of $\bar{x}_{LS} \leq 60$ are one year old, or less; specimens of $60 > \bar{x}_{LS} > 75$ are in their second year; and specimens of **LS** > 80 are three years old, or more, we obtain from Fig. 2, by method of percentile ranks, the following results:—One year old or less: PC 89%, NPC 60%, TT 78%. In second year: PC 5%, NPC 9%, TT 8%. In third, or later, season: PC 4%, NPC 26%, TT 11%.

Observe also that approximate percentage of material with **LS** greater than max. of PC material is 20% for NPC, 9% for TT, material.

Extreme Variates.

(*a*) *Maximum.* The maximum length among the 50 specimens noted by Regan (1906, p. 369) is 170, recorded in the case of his No. 5, the type of *G. punctatus* Günther, from Eastern Creek, and his No. 21, a specimen from Tasmania, presented by Sir J. Richardson.

Clarke (1899, p. 80) observes of specimens of these species: 'They very seldom exceed a total adult length of 6 inches. The longest ever observed by me in either of the other colonies or New Zealand in an experience of forty-four years was barely 7 inches in length. Average length of adult fish, 4½ inches to 5 inches (total).'

The largest individuals I have encountered (Nos. 58/1, 2; **LS** 185·0, 172·0; **LT** 207·0, 192·0) were secured by Mr. Reg. Slater, in January, 1935, from a waterhole about 12 feet square, on his property *Paranaple*, Kelso, Northern Tasmania, and were, it is believed, two of a number placed there about four and a half years previously. The larger specimen was observed lying dead in the water, having apparently died a natural death, the smaller was netted alive. Other dimensions of these examples are (No. 58/1 noted first): head 31·0, 29·0; eye 6·0, 6·5; snout 7·25, 7·5; interorbital width 19·0, 14·0; depth of body 36·0, 30·0; thickness of body 28·5, 25·5; length to dorsal 139·0, 136·0; base of dorsal 20·0, 16·0; longest dorsal ray 20·5, 16·5; base of anal 30·0, 32·0; longest anal ray 21·5, 16·5; length of pectoral 21·0, 19·0; length to pelvic 90·0, 82·0; length of pelvic 20·0, 19·0; length of caudal peduncle, 16·0, 14·0; depth of caudal peduncle 15·0, 13·25.

Five next largest specimens are Nos. 110/7, 9, 29, 13 and No. 76/1, which have **LS** 133·8, 126·5, 126·0, 124·7, 124·0, and **LT** 151·6, 143·0, 143·5, 143·4, 145·0, respectively.

That the dimensions of Nos. 158/1, 2 are quite exceptional, is indicated by the magnitude of the interval separating No. 158/2 and No. 110/7 (interval for **LS** = 38·2, for **LT** = 40·5), resulting in the occurrence in the **LS** frequency table of 10-mm. classes for TT material (Fig. 6) of a hiatus (the only one present) extending over three length-classes: *cf.* also Table II.

(*b*) *Minimum*. The minimum length in Regan's material (which consists mainly of rather large specimens of average **LT** of the order of 80) is 55, occurring among 8 specimens of **LT** 55-60 from Magellan. This is far from small: of PC material 63 %, of TT 53 %, is of this length, or less.

McCulloch (1915), in giving an account of the immigration of *G.* (*G.*) *attenuatus* from the sea into a stream crossing the beach at Freshwater Bay, near Sydney, N.S.W., observed on 31st August, 1914, describes and figures immediately postlarval specimens, one of which is noted as having **LT** 38.

Minimum length among TT material is afforded by No. 84/12 (NPC), with **LS** 31·1, **LT** 35·8, the next smallest specimen being No. 52/73 (NPC), with **LS** 33·4, **LT** 38·5. Other dimensions of these examples are (No. 84/12 noted first): head 5·0, 5·5; eye 1·1, snout 1·4, 1·4; interorbital width 2·3, 2·0; depth of body 3·3, 2·8; thickness of body 2·5, 2·6; length to dorsal 21·4, 24·5; base of dorsal 3·9, 3·8; longest dorsal ray 2·2, 2·3; base of anal 4·5, 4·5; longest anal ray 2·2, 2·3; length of pectoral 3·0, 3·5; length to pelvic 15·5, 15·5; length of pelvic 2·5, 2·5; length of caudal peduncle 5·1, 3·5; depth of caudal peduncle 2·0, 1·6.

Other TT specimens of **LS** $<$ 34·0 are No. 92/18 (PC), **LS** 33·5, **LT** 37·9; No. 89/18 (PC), **LS** 33·5, **LT** 38·8; No. 129/1 (PC), **LS** 33·6, 39·0.

The difference in **LS**, amounting to 2·4, between No. 84/12 and the smallest individuals among PC material (Nos. 92/12, 89/18) is probably attributable to the collection of No. 84/12 at a locality (Beattie's Creek, near Forth, about 1·5 miles from sea) nearer the coast, and hence at an earlier stage in the inland migration.

Relative Value of LL, LT Criteria

As a measure of general length of a fish, **LS** is, of course, morphologically superior to **LT**, the latter dimension including a factor, length of caudal fin (**LT**–**LS**), relating merely to an appendage collinear with the main body-axis, and hence introducing an element subject to individual variation. Curiously enough, though the contrary might confidently be anticipated, the determination of **LS** is made in practice more readily and satisfactorily than that of **LT**, the posterior limit of the former, the hypural joint, being clearly indicated by a very nearly vertical line, normally emphasized by a narrow bar of dark pigment, whereas the latter, delimited posteriorly by the tip of the longest caudal ray, is sometimes determinable in preserved specimens only with some difficulty, on account of greater or lesser deformation and rigidity in the caudal fin, and always involves the spreading of the fin to a normal full fan (a matter of personal judgment), in order to obviate the error of arc that is otherwise introduced.

That the determination of **LS** is more consistent in actual practice than that of **LT** is shown by a comparison of the dispersions exhibited by the two quantities, due regard being paid to the relative magnitudes. In general we find $v_{LT} > v_{LS}$.

Throughout the present paper, therefore, we shall henceforth adopt, and in general confine ourselves to, **LS** as a measure of general length, recording **LT** occasionally only for special purposes (*e.g.*, for comparison with data published elsewhere).

LT a Logarithmic Function of LS

The value of the ratio **LT**/**LS** varies with absolute size of the fish: see, under *Growth-Curves* below, equation of relative growth of length of caudal fin (**LT**–$_{L}$S).

A convenient approximation, derived directly from values of $\bar{x}_{LS}$, $\bar{x}_{LT}$ for PC, NPC, TT groups, is

$$\log \bar{x}_{LT} = 1 \cdot 03 \log \bar{x}_{LS}.$$

Larval Characters

(*a*) *Non-Metrical.* McCulloch (1915) has well described, and figured, larval specimens secured when entering a stream near Sydney from the sea on 31st August, 1914: my own observations suggest the following extensions and emendations.

I have previously (Scott, 1936, p. 87) independently observed, and discussed the taxonomic significance of, the upward deflection of the last vertebra, noted by McCulloch in his examples.

'Caudal rays blackish, the others transparent' (McCulloch, 1915, p. 48). Many of my specimens of **LS** < 40, and a few of greater **LS** (up to 47·0), show several distinct rows of spots, mainly on rays, forming distinct forwardly concave, dark arcs on anterior half, or more, of caudal. Similar curved pigment-bands occur among Tasmanian species in, *e.g.*, adult *G.* (*G.*) *affinis* Regan—though not mentioned or figured by Regan (1906, p. 380 and pl. X, fig. 1)—*Saxilaga* (*S.*) *cleaveri* (Scott), *S.* (*S.*) *anguilliformis* Scott. It seems not unlikely that their presence is a primitive family character, retained in the case of *G.* (*G.*) *attenuatus* only in the larval phase.

The **LS** to which general transparency, accompanied by larval pattern of small spots as described by McCulloch, persists, varies considerably, even in individuals of the same sample: its retention (observable in the majority of cases in samples of the major vernal immigration) in individuals that have travelled more than 40 miles inland to Punchbowl Creek is noteworthy. Generally speaking, transparency ceases at about **LS** 40, but well-marked ground-pigmentation may occur (*e.g.*, No. 128/12) at **LS** 36·1, or may be delayed (*e.g.*, No. 86/3) to **LS** 55·6 (note the possible significance of this long retention of larval facies in connexion with status of *G.* (*G.*) *gracillimus* (Canestrini) discussed below).

All specimens of Series 85 (near mouth of Don River; 31/8/35) possessed a pit or furrow. indicating the point of absorption of the yolk-sac, and, just internal to, and dorsad of, this depression a bright red spot, formed by a subspherical vascular plexus, conspicuously visible through the transparent abdominal wall. Evidence of the location of the yolk-stalk, in the shape of midventral furrows or irregular depressions, and of a persistant rete is occasionally traceable in specimens entering Punchbowl Creek about October.

The striking similarity of both non-metrical and metrical characters of larval *G.* (*G.*) *attenuatus* (Jenyns) and those given for *G.* (*G.*) *gracillimus* (Canestrini) suggests the desirability of further investigation of the status of the latter species: *cf.* comments on this point long ago made by Regan (1906, p. 370).

(*b*) *Metrical.* Metrical characters of larval and immediately post-larval phases may be gathered from data given elsewhere in this paper: *cf.*, under EXTREME VARIATES, dimensions of individuals of **LS** 31·1, 33·4; also, under VARIATION OF PROPORTION WITH GROWTH, Table III (38·93, 45·20, **LS**-classes), and GROWTH-CURVES, *passim.*

Frequency Distribution of LS

1 *mm.-Classes.* With $h = 1$, PC, NPC, TT material is distributed, as regards **LS**, over 60, 155, 155 classes; as regards **LT**, over 70, 173, 173 classes, respectively. Data for **LS** recorded in Table II. For compactness, length-classes are not listed in table in unitary succession in region of extreme variates, only those for which there are entries being specified: PC and NPC data only recorded, TT values being obtainable, if required, by addition.

TABLE II.

G. (G.) attenuatus (Jenyns)

FREQUENCY DISTRIBUTION OF **LS** FOR PC, TT MATERIAL; $h = 1$ mm.

Length-Class (mm.)	No. of Individuals				Length-Class (mm.)	No. of Individuals				Length-Class (mm.)	No. of Individuals			
	LS		LT			LS		LT			LS		LT	
	PC	TT	PC	TT		PC	TT	PC	TT		PC	TT	PC	TT
31·5	—	1	—	—	69·5	2	3	11	18	107·5	—	4	—	1
32·5	—	—	—	—	70·5	2	10	7	10	108·5	—	4	—	3
33·5	3	4	—	—	71·5	6	10	6	7	109·5	—	4	—	11
34·5	3	6	—	—	72·5	5	7	5	10	110·5	—	1	—	3
35·5	16	20	—	1	73·5	2	7	6	10	111·5	—	4	—	4
36·5	21	25	—	—	74·5	2	5	5	6	112·5	—	3	—	4
37·5	28	42	1	1	75·5	2	6	3	6	113·5	—	2	—	1
38·5	45	59	1	2	76·5	2	5	4	4	114·5	—	4	—	3
39·5	64	83	3	3	77·5	1	5	1	5	115·5	—	1	—	3
40·5	66	81	8	13	78·5	1	5	4	7	116·5	—	1	—	3
41·5	52	66	16	19	79·5	3	6	—	4	117·5	—	1	—	1
42·5	55	70	25	37	80·5	3	6	2	6	118·5	—	—	—	3
43·5	57	65	40	51	81·5	2	8	4	8	119·5	—	1	—	6
44·5	42	48	63	79	82·5	1	8	8	11	120·5	—	2	—	1
45·5	39	60	43	58	83·5	1	4	2	5	121·5	—	—	—	4
46·5	35	46	61	81	84·5	2	4	—	4	122·5	—	1	—	3
47·5	30	43	50	57	85·5	1	1	3	4	123·5	—	3	—	3
48·5	23	44	47	56	86·5	2	4	2	9	124·5	—	2	—	4
49·5	30	50	44	57	87·5	1	4	1	5	125·5	—	—	—	2
50·5	24	36	39	43	88·5	2	5	1	2	126·5	—	2	—	2
51·5	28	41	34	47	89·5	1	6	1	3	127·5	—	—	—	3
52·5	21	33	27	39	90·5	3	6	2	6	128·5	—	—	—	1
53·5	25	35	30	41	91·5	—	2	2	4	129·5	—	—	—	3
54·5	15	24	27	39	92·5	1	3	4	7	130·5	—	—	—	3
55·5	10	21	16	32	93·5	—	4	1	9	131·5	—	—	—	3
56·5	17	26	26	45	94·5	—	2	—	4	132·5	—	—	—	1
57·5	19	31	22	32	95·5	—	9	2	4	133·5	—	1	—	—
58·5	15	22	26	40	96·5	—	5	1	3	134·5	—	—	—	1
59·5	12	16	19	28	97·5	—	4	1	1	137·5	—	—	—	1
60·5	10	17	26	36	98·5	—	6	1	3	138·5	—	—	—	2
61·5	13	17	15	26	99·5	—	2	3	5	139·5	—	—	—	1
62·5	5	8	13	23	100·5	—	5	1	6	140·5	—	—	—	2
63·5	5	8	11	21	101·5	—	3	—	3	143·5	—	—	—	3
64·5	3	10	15	24	102·5	—	2	1	6	145·5	—	—	—	1
65·5	10	11	15	27	103·5	—	3	—	2	151·5	—	—	—	1
66·5	4	6	15	20	104·5	—	6	2	2	172·5	—	1	—	—
67·5	2	5	12	14	105·5	—	3	—	4	185·5	—	1	—	—
68·5	2	6	9	13	106·5	—	2	1	4	192·5	—	—	—	1
										207·5	—	—	—	1

With $h = 1$, $M_{o_{LS}}$ for PC, NPC, TT material occurs in the following classes :—40·5 (66 cases) ; 45·5, 48·5 (each 21 cases) ; 39·5 (83 cases) ; $M_{o_{LT}}$ in 44·5 (63 cases) ; 46·5 (20 cases) ; 46·5 (81 cases), respectively.

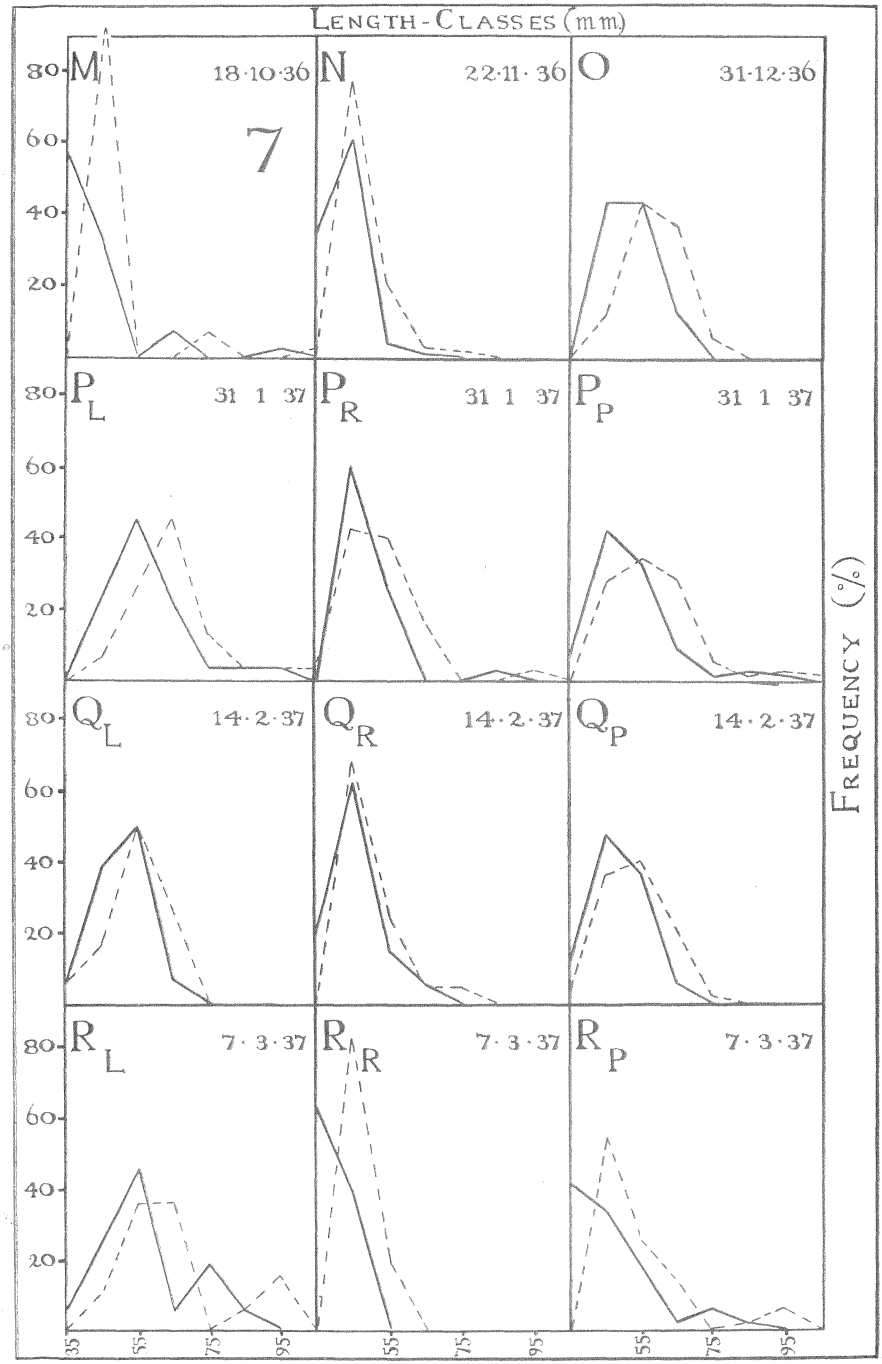
For the investigation and the construction of histograms $h = 1$ gives too fine a grouping (note, *e.g.*, two values for $M_{o_{LS}}$ in NPC material above): results of employment of larger class intervals are discussed below.

PC Material. With $h = 3$, the 20 classes 34, 37..91 yield (f_{LS})=22, 94, 182, 154, 104, 77, 74, 42, 46, 28, 18, 8, 10, 9, 5, 7, 4, 5, 4, 4. Modal class is thus 40. Frequency histogram shown in Fig. 3. The curve is mesokurtic. The decrease in height of successive rectangles is not maintained in classes > 55. With $h = 5$, giving the 13 classes 32·5, 37·5..92·5, with (f_{LS}) giving 6, 174, 272, 157, 113, 73, 36, 20, 17, 9, 9, 10, 1, the right limb approximates closely to a smooth descending curve (Fig. 4). The PC histogram for **LS** with $h = 6$ is implicit in Fig. 5, where PC values are represented by stippled rectangles equivalent to TT − NPC : similarly for $h = 10$ in Fig. 6.

Examining the histogram for $h = 3$ (Fig. 3), we see the distribution has a marked positive skew. Using Pearson's approximate measure of skewness $S_k = \dfrac{3(\bar{x} - M_d)}{\sigma}$, we have $S_k = \dfrac{3(47 \cdot 94 - 43 \cdot 93)}{10 \cdot 45} = 1 \cdot 15$.

With $h = 3$, the 25 classes 34, 37..106 give $(f_{LT}) = 0$, 2, 27, 128, 154, 130, 91, 69, 67, 54, 41, 36, 24, 16, 8, 6, 14, 5, 3, 8, 3, 3, 4, 3, 1. Wit $h = 5$, the 16 classes 32·5, 37·5..107·5 give $(f_{LT}) = 0$, 5, 152, 245, 157, 109, 80, 62, 29, 12, 16, 8, 9, 8, 4, 1.

TT Material. This includes sufficient specimens, exhibiting an interval between extreme variates about 2·5 times that of PC material, to permit of the reasonably satisfactory use of a class″interval twice that employed in the case of PC. With $h = 6$, we have 26 classes, 32·5, 38·5..182·5 with $(f_{LS}) = 30$, 356, 322, 239, 140, 71, 40, 35, 37, 24, 26, 25, 20, 18, 8, 8, 2, 1, 0, 0, 0, 0, 0, 1, 0, 1. Modal class = 44·5. Histogram shown in Fig. 5 (total rectangles, both black and stippled portions). The curve, which does not exhibit successive decrease of (f_{LS}) in classes > 68·5, is more leptokurtic than that for PC material (Fig. 5, stippled areas). With $h = 10$ (Fig. 6), the 16 classes 35, 45..185 give $(f_{LS}) = 240$, 573, 285, 91, 66, 50, 43, 36, 18, 10, 1, 0, 0, 0, 1, 1, the histogram thus exhibiting continuous decrease of ordinate values between M_o (45 class) and 135 class, to the right of which occurs a hiatus of three classes, followed by two classes (175, 185) each with a single entry.


LENGTH-CLASSES (mm)
M 18·10·36
N 22·11·36
O 31·12·36
7
PL 31 1 37
PR 31 1 37
PP 31 1 37
QL 14·2·37
QR 14·2·37
QP 14·2·37
RL 7·3·37
RR 7·3·37
RP 7·3·37
80 60 40 20
35 55 75 95
FREQUENCY (%)

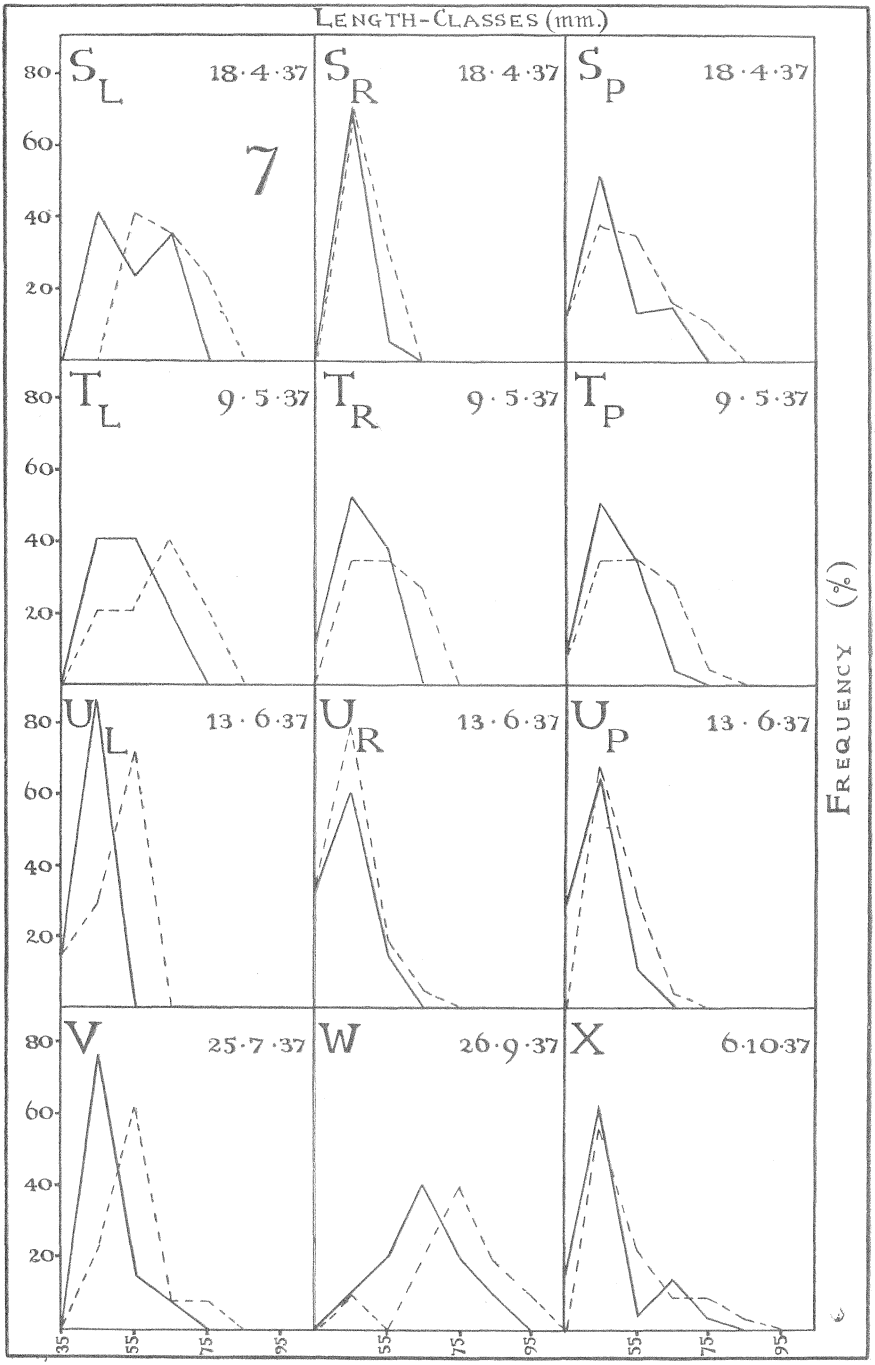
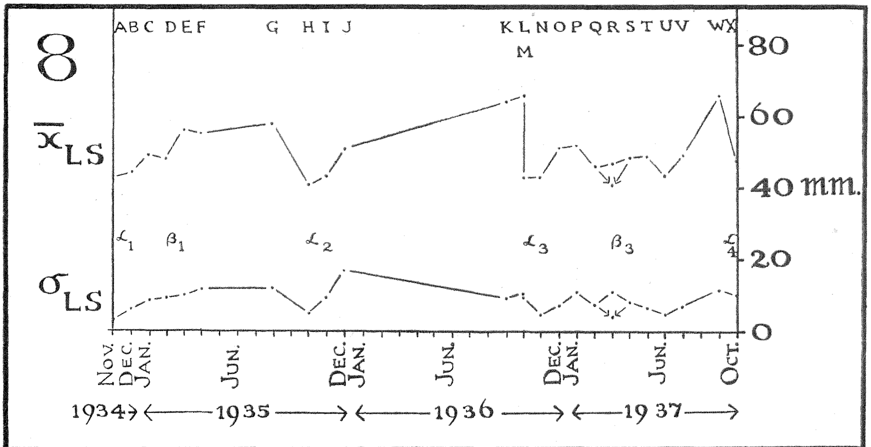

LENGTH-CLASSES (mm.)
FREQUENCY (%)
S_L 18·4·37
S_R 18·4·37
S_P 18·4·37
7
T_L 9·5·37
T_R 9·5·37
T_P 9·5·37
U_L 13·6·37
U_R 13·6·37
U_P 13·6·37
V 25·7·37
W 26·9·37
X 6·10·37
80
60
40
20
35
55
75
95

PLATE XXIII

Fig. 8.—Curves of seasonal variation (Punchbowl Creek) of mean standard length and of standard deviation of standard length.

Fig. 9.—Growth-curves. A, length to origin of dorsal fin; B, length to origin of pelvic fin; C, depth of body (maximum); D, length of caudal peduncle; E, depth of caudal peduncle (minimum); F, length of caudal fin; G, length of head; H, horizontal diameter of eye; I, eye in head; J, depth of caudal peduncle in its length: all plotted against standard length. Direct plotting.


8
ABC DEF G HIJ KLNOPQRSTUV WX
M
$\bar{x}_{LS}$
σ_{LS}
80
60
40 mm.
20
0
NOV. DEC. JAN. JUN. DEC. JAN. JUN. DEC. JAN. JUN. OCT.
1934 ← 1935 → ← 1936 → ← 1937 →

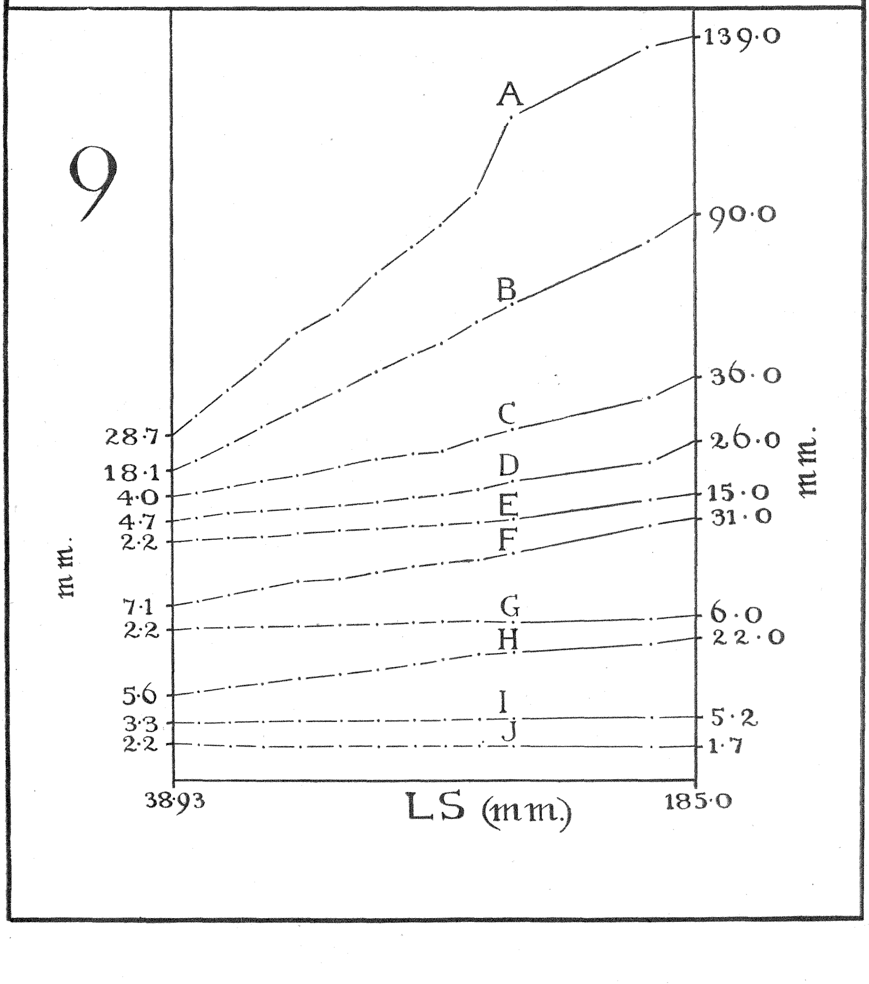

9
A B C D E F G H I J
28·7 18·1 4·0 4·7 2·2 7·1 2·2 5·6 3·3 2·2
139·0 90·0 36·0 26·0 15·0 31·0 6·0 22·0 5·2 1·7
mm.
38·93
LS (mm.)
185·0

PLATE XXIV

FIG. 10.—Growth-curves. Lettering as in Fig. 9. Logarithmic plotting.

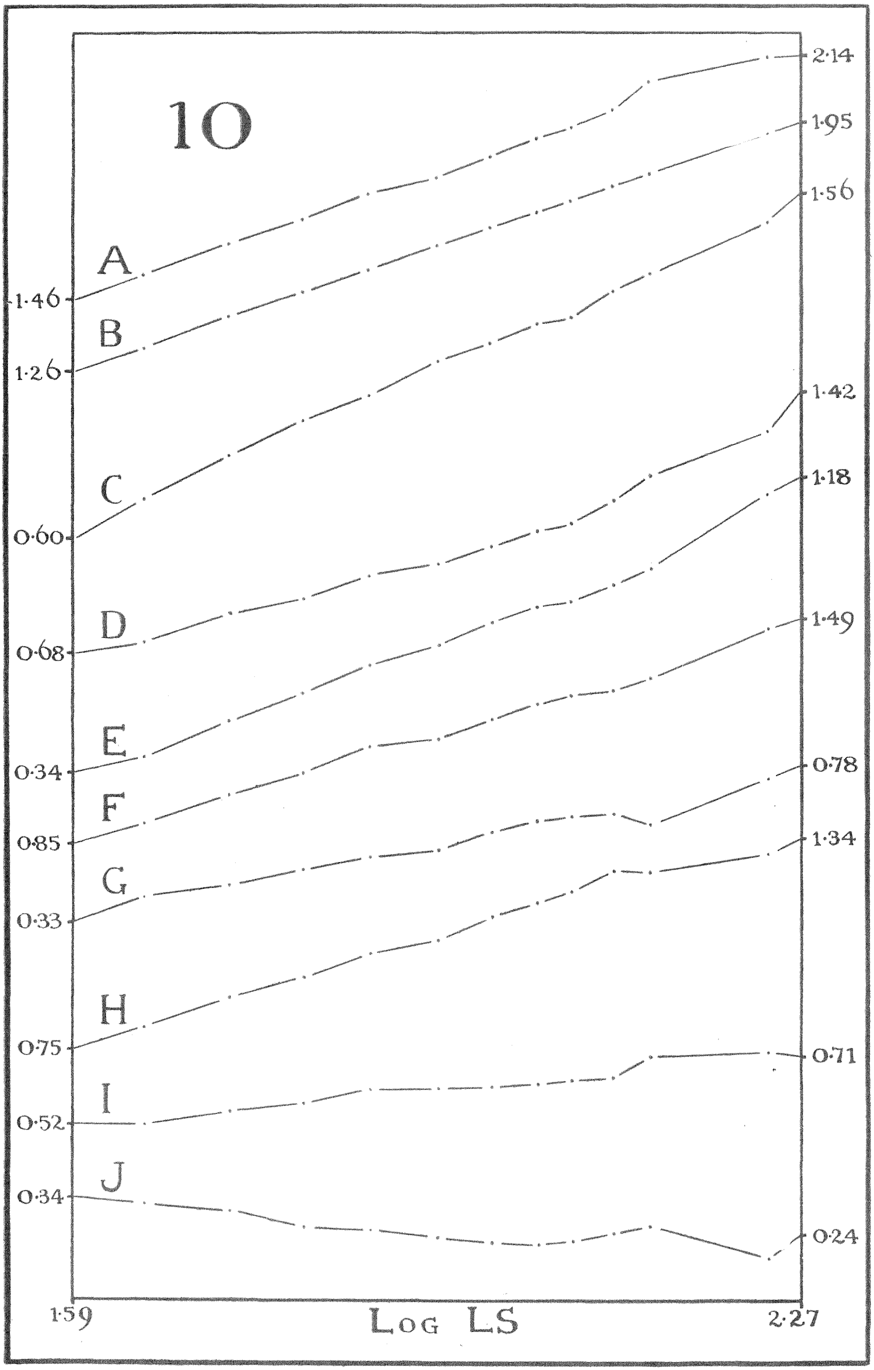
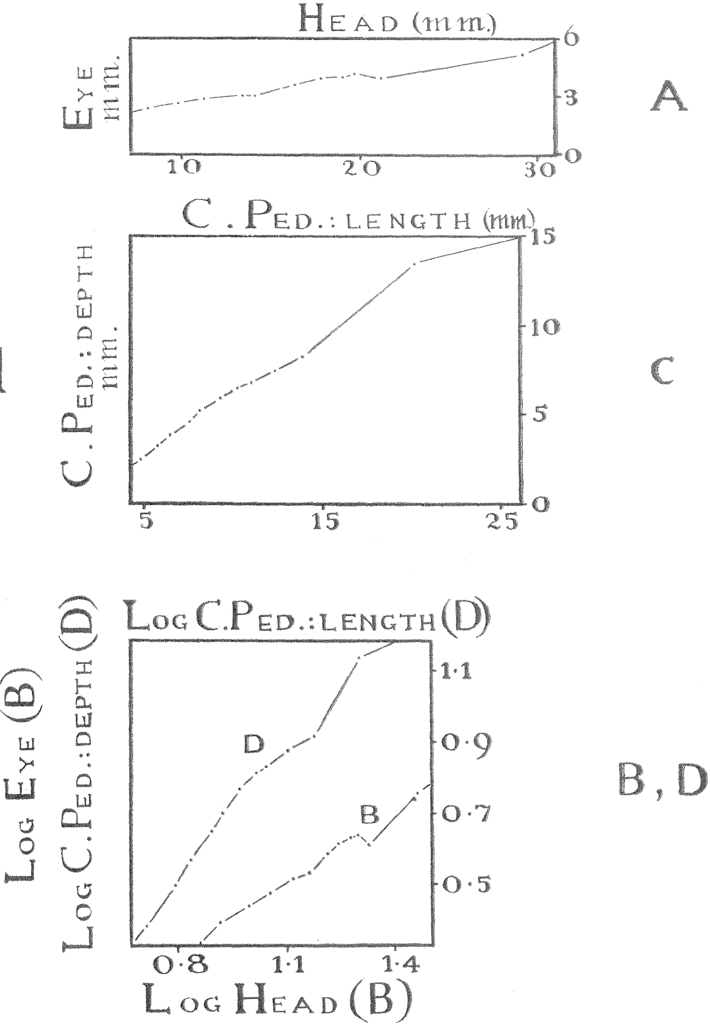

10
A
B
C
D
E
F
G
H
I
J
1·46
1·26
0·60
0·68
0·34
0·85
0·33
0·75
0·52
0·34
2·14
1·95
1·56
1·42
1·18
1·49
0·78
1·34
0·71
0·24
1·59
LOG LS
2·27

PLATE XXV

FIG. 11.—Growth-curves. Eye on head: A, direct plotting; B, logarithmic plotting. Depth of caudal peduncle on length of caudal peduncle: C, direct plotting; D, logarithmic plotting.

FIG. 12.—Axial growth-gradients.

11


HEAD (mm.)
EYE mm.
6
3
0
10
20
30
A
C . PED.: LENGTH (mm.)
C . PED.: DEPTH mm.
15
10
5
0
5
15
25
C
LOG C.PED.: LENGTH (D)
LOG EYE (B)
LOG C.PED.: DEPTH (D)
D
B
1·1
0·9
0·7
0·5
0·8
1·1
1·4
LOG HEAD (B)
B, D

12

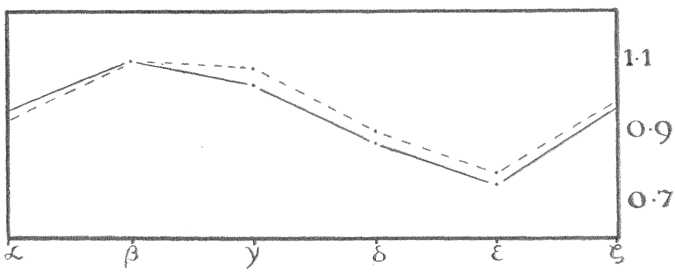

1·1
0·9
0·7
α
β
γ
δ
ε
ζ

PLATE XXVI

FIG. 13.—Duration of extra-aqueous survival. M is weighted average of A-F.

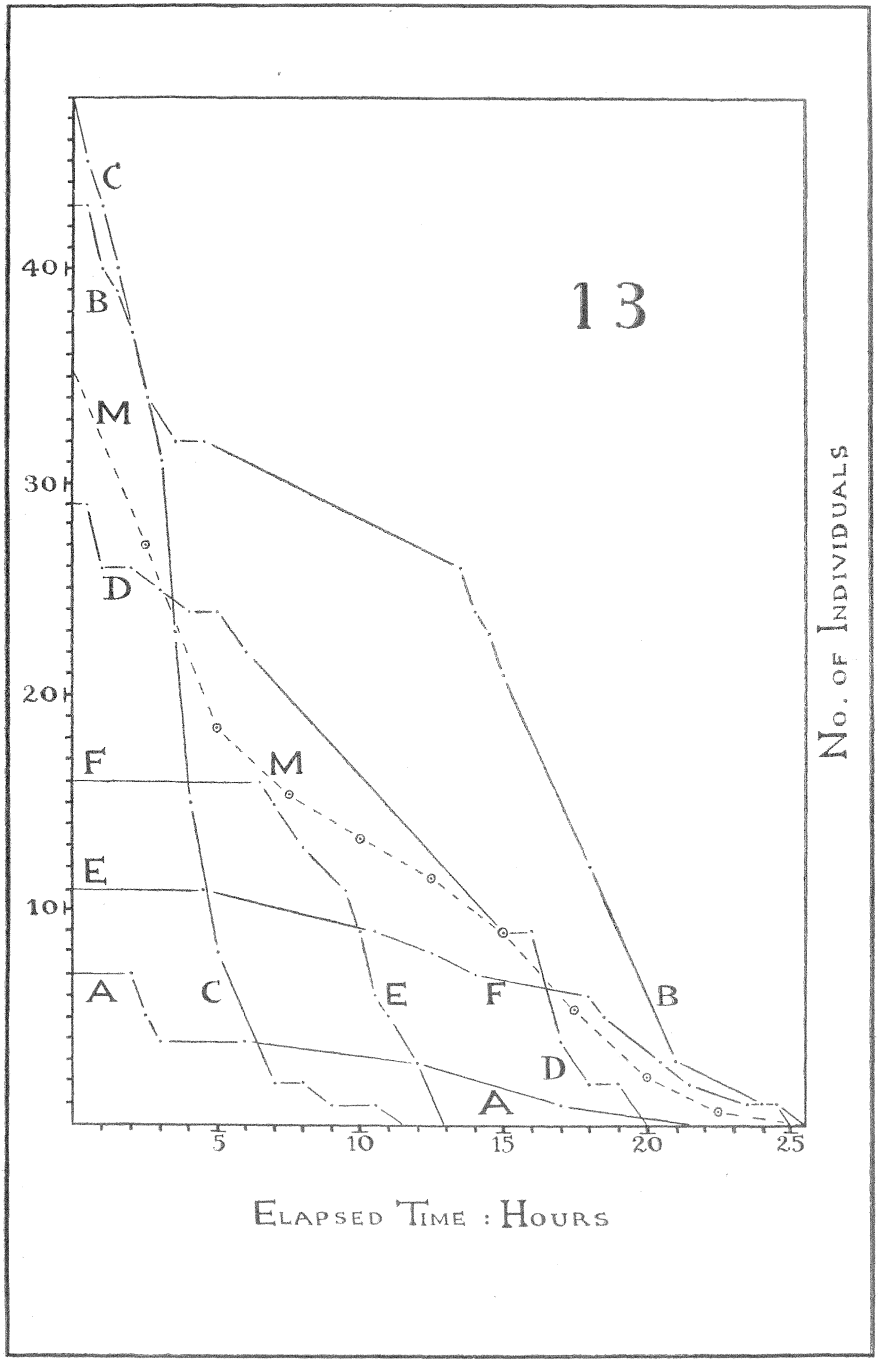
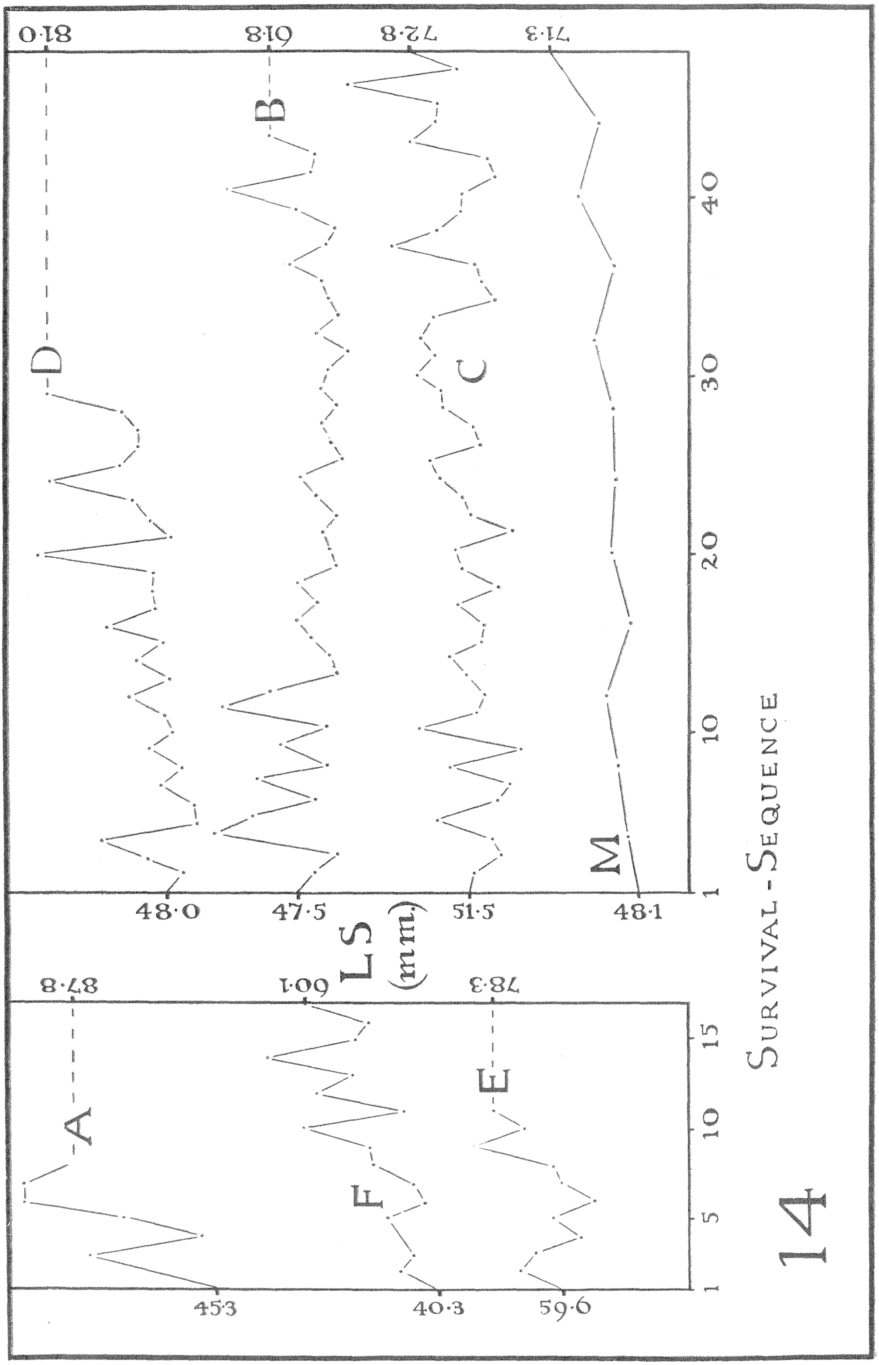

13
C
B
M
D
F
M
E
A
C
E
F
B
D
A
40
30
20
10
5
10
15
20
25
No. of Individuals
Elapsed Time : Hours

PLATE XXVII

FIG. 14.—Standard length plotted against survival-sequence—showing greater viability of larger individuals. M is weighted average of A-F.


14
SURVIVAL - SEQUENCE
LS (mm)
A
B
C
D
E
F
M
81·0
81·9
72·8
71·3
48·0
47·5
51·5
48·1
87·8
60·1
78·3
45·3
40·3
59·6

Notes

Tasmanian Trilobites

Attention is directed to a paper entitled 'Notes on Some Ordovician Faunas of Tasmania', by Teiichi Kobayashi, published in the Japanese 'Journal of Geology and Geography', Volume XIII, Numbers 1 and 2, March, 1936, page 178.

The learned author is a world-famous palaeontologist, and Tasmanian geologists express their appreciation of this interesting contribution to one of our problems.

The conclusion reached by the author from examining material from Caroline Creek and the Florentine Valley is that the trilobite fauna preserved in the sandstones of these localities are of Lower Ordovician age, not Cambrian as previously considered. These sandstones are regarded by Tasmanian geologists to be the lowest members of the extensive series of rocks which lie between the Pre-Cambrian schists and the West Coast conglomerates (base of the Silurian). The effect of this revision of fossil evidence will be to remove *Cambrian* as a term from our successional nomenclature, and confirm the generally accepted view that the very extensive and economically important beds which underlie the West Coast Range Conglomerate Series (e.g., Read-Rosebery Schists, Dundas Slates, Mathinna Slates, Balfour Slates) are of Ordovician age.

Kobayashi describes a new genus under the name *Tasmanocephalus*. This replaces the forms described as *Conocephalites? stephensi* Etheridge. The genus (three species) of *Ptychoparia?* disappear, but the author is not prepared to redescribe these forms from the material available. *Dikelocephalus florentinensis* becomes *Asaphopsis florentiensis* Etheridge, and *Dikelocephalus tasmanicus* Etheridge is regarded as similar to the genus *Tachungshania*, but of uncertain species.

Kobayashi also refers to the occurrence of *Rebeiria* or *Rebeirella* in the Table Cape Conglomerates, and assigns a Silurian age. A note of caution must be sounded here, since these fossils were found in Permian glacial tillite, associated with material some of which has not been found *in situ* in Tasmania.

In an associated paper (*ibid.*, p. 163) the author states interesting views on the distribution of the *Dikelokephalininae*, and shows the relationship between the lower Ordovician fauna of Tasmania and that of Southern Europe, China, and Northern America, suggesting a connecting link in dispersal between Southern Europe and Asia on the one hand, and Northern America on the other, as to which Tasmania can supply vital data.

In view of this recent work, it is suggested that the term *Dikelocephalus Sandstones* should be discontinued, and replaced by the term *Caroline Creek Series*. It is apparent that the interesting fauna of the Caroline Creek and Tim Shea (Florentine) sandstones is worthy of more detailed attention than has hitherto been accorded.

A. N. LEWIS.
8.11.37.

Biological Survey of Tasmania

Early in 1937 a movement was set on foot by a committee of scientists resident in Hobart to undertake a biological survey of the State.

Among the purposes of the projected survey are the determination of the distribution of plants and animals of especial interest within the State; the preparation of lists of the described fauna and flora; ecological surveys of selected districts; and an analysis of the effect of introduced animals and plants on the indigenous fauna and flora. It is expected that the survey will yield information of great interest, and will probably bring to light forms of life previously unknown to science.

The headquarters of the survey are at the Tasmanian Museum, Hobart, and the Director of the Museum, Dr. J. Pearson, is the Chairman of the Executive Committee of the Survey. Funds are being made available by the Australian and New Zealand Association for the Advancement of Science, the Commonwealth Science and Industry Endowment Fund, the State Fauna Board, and by the Forestry Department.